Application of Fuzzy AHP and Fuzzy TOPSIS in Selecting Proper Contractors: Case of Sistan and Baluchistan Province Gas Company

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ABSTRACT

The selection of contractors is, counted to be the most substantial decision of an employer before the execution of a project. During the recent years there have been many problems during the execution of projects leading to waste of lots of capitals. Yet, there is always a significant risk during the selection of contractors. In this research, legal limits and requirements in connection with the organization of governmental tenders are studied to determine effective factors on the selection of contractors by Sistan & Baluchistan Province Gas Company in Iran, and to present proper solutions to choose the most appropriate contractor.

A descriptive - measurement method is used for this research to gather information from experts of the company to analyze them in order to design a fuzzy model to assess if contractors are qualified or not. In this context, a fuzzy method of AHP (Analytic Hierarchy Process) is applied to determine weights of criteria and sub-criteria in selection of contractors. Then, the fuzzy method of TOPSIS (Technique for Order Preference by Similarity to Ideal Situation) is used to classify the top three contractors who achieved highest points of evaluation.

By applying fuzzy AHP method, the relative weight of executive records, good records, financial powers, technical and planning capacities, and equipment and machinery criteria are determined to be 0.215, 0.216, 0.205, 0.186, and 0.178 respectively. Three best qualified liable contractors are then selected based on the given scores in three conditions as the pessimistic, most likely and optimistic to the above criteria using fuzzy TOPSIS technique.

The proposed model in this research, offers a systematic method to identify effective measures for evaluating competence of contractors and selection of contractors that involve and consider the employer's goals; as well as the type of project, available resources and executive constraints.

Keywords: Contractor selection, analytic hierarchy process, TOPSIS, fuzzy set, triangular fuzzy numbers

ÖZ

Bir projenin yürütülmesinden önce işverenin en önemli kararı müteahhitlerin seçimi olarak nitelendirilir. Son yıllarda projelerin yürütülmesi sırasında boşa giden birçok sermaye sorunu ortaya çıkmıştır. Ancak, müteahhitlerin seçimi sırasında her zaman önemli bir risk mevcuttur. Bu araştırma, kamu ihalelerine organizasyonu ile ilgili yasal limitler ve şartlar incelenerek İran Sistan Belucistan Eyaleti & Gaz Şirketi tarafından etkili faktörleri belirleyerek, en uygun müteahhhiti seçmek için uygun çözümlerin sunulmasını içermektedir.

Bu araştırmada bulanık bir model tasırımıyla müteahittlerin nitelikli olup olmadığını değerlendirmek için şirket uzamanlarından bilgi toplamak amaçlı bir tanımlayıcı ölçüm yöntemi kullanılmıştır.

Bu bağlamda, müteahhitlerin seçiminde kriter ve alt kriterlerin ağırlıklarını belirlemek için bir bulanık AHS (Analitik Hiyerarşi Süreci) yöntemi uygulanmıştır. Ardından, en yüksek puanı alan ilk üç müteahhiti sınıflandırmak için TOPSIS (İdeal Duruma Benzerlik için Sipariş Tercihi Tekniği) bulanık yöntemi kullanılmıştır.

Bulanık AHP yöntemi uygulayarak, yönetici kayıtları, iyi kayıtları, mali güç, teknik ve planlama kapasitelerinin ve ekipman ve makine ölçütlerinin göreli ağırlıkları sırasıyla 0.215, 0.216, 0.205, 0.186, ve 0.178 olmak üzere belirlenmiştir. Ardından bulanık TOPSIS tekniği kullanılarak yukarıdaki kriterlere verilen puanlarına göre; kötümser, büyük olasılıklı, ve iyimser olmak üzere üç tane en nitelikli sorumlu müteahhit seçilmiştir.

Bu araştırmada önerilen model; işverenin hedeflerini dikkate müteahhitler seçimi yeterliliğini değerlendirmek için etkili önlemler belirlemek için sistematik bir yöntem sunmanın yanı sıra yanı sıra proje, mevcut kaynaklar ve yönetici kısıtlamaları içermektedir

Anahtar kelimeler: Müteahhit seçimi, Analitik Hiyerarşi Süreci, TOPSIS, üçgensel bulanık sayılar, bulanık dizgi

This thesis is dedicated to my family:

My father, who taught me that the best knowledge is the one which is learnt for its own sake, my mother, who taught me that even the largest task can be done if you doing it step by step, my brothers who were not only brothers but also my team mates and close friends.

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INTRODUCTION

Contractors play important roles in any project. The selection of contractors is, therefore, counted to be the most substantial decision of an employer before the execution of a project. In order to execute a project a contractor with capacities appropriate with the project is needed to avoid unnecessary executive costs and to accomplish the project with expected resources during specified schedules. On the other hand, some contractors resort to anything to win tenders, such as offering too much and unreasonable discounts to the employers. In such cases, there will be numerous problems during the executive procedures of the projects.

During recent years, loss of many financial resources are observed as a result of selecting improper contractors for development projects. One solution for such problems is appropriate introduction of contractors and selection of contractors among the qualified ones. Thus, in this research the problem is discussed from fuzzy approach.

1.1 Research Problem

One part of the decision making process involves evaluation and selection of contractors for tenders, for which there are many regulations and methods. In Iran the office of the vice President of Republic in Strategic Planning and Supervision is in charge of classification and identification of qualified contractors. In this respect, by-law of classification and identification of qualified contractors is prepared. Executive organizations are required to carry out their tenders abiding by the by-law of

organization of tenders and in view of the by-law of identification of qualified contractors. On the basis of existing procedures, for tenders with estimated values exceeding 20 times of the limit of medium range transactions, the contractors will be selected during two steps. At the first step, a list of at least three qualified contractors shall be prepared in view of criteria and sub-criteria specified by the employers. During the second step, a contractor of such list offering the least price will be determined as the winner. During this research, first, the criteria and sub-criteria of selection of contractors are specified in view of library studies and statutory requirements. The weights of such criteria and grading of contractors are usually unclear and indefinite. This research uses a fuzzy method to reduce uncertainty and ambiguity involved in decision making. First, the fuzzy method of AHP (Analytic Hierarchy Process) is applied to determine weights of such criteria and sub-criteria. Next, the fuzzy method of TOPSIS (Technique for Order Preference by Similarity to Ideal Situation) is used to classify contractors to call three contractors achieving most points to call for the second step of a tender. It should be noted that in view of the existing rules and by-laws the method used in this research will apply to the tenders with estimated prices exceeding 20 times of the limits of medium range transactions.

1.2 Description of Problem

Contractors are important aspects in any project. Therefore, it can be concluded that the most crucial decision of an employer before the execution of any project involves the selection of a contractor. There are always a significant risk during the selection of contractors. The employers, therefore; endeavor to reduce the existing risks (Hatush & Skimore, 1997).

During the recent years there have been many problems during the execution of projects leading to waste of lots of capitals. Statistics show that roughly 10% of problems are attributable to disqualified contractors. By considering what is mentioned before, employers have always been interested in development of procedures to resolve such problems.

Initially contractors were selected on the basis of the least prices which are offered. This led to problems during the execution of projects. To resolve such problems, employers need a filter to ban the disqualified contractors to enter to the contracts (Rajaei, Hazrati and Rashidi, 2008). Rules and regulations applicable to tenders with estimated prices higher than 20 times of the limits of medium range transactions require governmental departments and organizations to hold tenders in two steps. During the first step, at least three qualified contractors are selected on the basis of criteria specified by the employers. During the next step, the contractor with the least price offered will be chosen from among the list of qualified contractors.

Development projects constitute always four major stages, including: 1. initial studies, 2. design, 3. execution and 4. operation. Improper management of any of such stages will lead to waste of huge national capitals. However, what nowadays happen and cause heavy losses is the stages of 1 and 3. Because of wrong initial studies and improper definition of problem, many projects fail to realize their objectives and do not proper satisfactory operations, leading to wastes of funds and time. Moreover, one can name big projects in which there are wastes of fund and time arising out of negligence, efficient management and other issues during execution stages. For development projects, most investment occurs during execution. Errors in this stage mean waste of a major part of such investment. Therefore, choosing the most

appropriate contractor may be counted to be the most substantial issue during the execution of development projects. Choosing the most appropriate one decreases the risk of waste of resources, both in term of fund and time. Such projects are ensured to have the highest quality and safety standards both during execution and afterwards (Abbasnia, 2005).

As there are numerous quantitative and qualitative factors when deciding whether a contractor is the most appropriate one or not, a strong theory is required to support procedures of decision making about choosing contractors and studying the mentioned factors taking place simultaneously for different contractors. In this way the factors shall be comparable and one can consider their levels of importance to choose a contractor being efficient and suitable for dimensions and specifications of a project. Therefore, the research embarks first on the task of studying library sources and legal requirements to determine criteria and sub-criteria of choosing contractors.

As the weights of such criteria and grades of contractors are usually unclear and indefinite, our research is carried out with the use of a fuzzy method in order to reduce ambiguities and uncertainties existing in the decisions taking processes.

At first, the fuzzy method of AHP is used to determine weights of such criteria and sub-criteria. Next, the fuzzy method of TOPSIS is used to classify contractors in different grades to call three contractors with most points to bid during the second step of a tender. It should be noted that we have taken into account the existing regulations and by-laws to develop procedures applicable to tenders with estimation prices exceeding 20 times the limit of medium range transactions.

To describe unique characteristics of this research the following issues are pointed out:

1. Taking into account legal requirements of organization of tenders, as well as relevant rules and by-laws to determine criteria and sub-criteria and to classify contractors.

2. Personal appreciation and decision is involved during allocation of points to criteria. There will, therefore; be uncertainties arising out of ambiguous data during the decision taking processes. Consequently, the fuzzy solution is deemed to be required for such issues and was applied during this research.

1.3 Theoretical Plan of Research

The theoretical plan of a research involves a conceptual pattern based on theoretical relations between some factors found out to be of importance for the subject issues of such research, on the basis of which researches found their theories (Khaki, 2004).

The theoretical basis of this research, therefore; deals with the identification of effective criteria and sub-criteria, on the basis of which one can evaluate and choose contractors. Such criteria differ in various organizations and at different times. The present research studies the effective criteria on the selection of executive contractors and used by Sistan & Baluchistan Province Gas Company and determines their weights considering the selection of contractors.

1.4 Significance and Necessity

In recent years there has been many problems during the execution of projects leading to wastes of significant funds. Statistics show that around 10% of such problems originate from disqualified contractors (Rajaei et al, 2008).

On the other hand, increasing growth of development of gas projects in Sistan & Baluchistan Province, and consequently the increase in the number of projects and involvement of a big volume of resources of the province in this field, has doubled the necessity of an integrated research in connection with the selection of the most appropriate contractors in this field. The present research is performed taking into account all the above issues.

1.5 Objectives of the Research

During this research scientific texts and legal limits and requirements in connection with the organization of governmental tenders are studied to determine effective factors on the selection of contractors by Sistan & Baluchistan Province Gas Company and to present proper solutions to choose the most appropriate contractor. The finished product of operations of such contractor will be more durable and better while less time and expenditure will be used. The objectives of the research, therefore; be summarized as follows:

1. To identify the effective criteria and sub-criteria on the evaluation of efficiencies of contractors.

2. To determine the importance of the effective criteria and sub-criteria on the evaluation of efficiencies of contractors.

3. To introduce three qualified contractors to bid during the second step of a tender.

1.6 Research Questions

1. What are the effective criteria and sub-criteria on the evaluation of efficiencies of contractors by Sistan & Baluchistan Province Gas Company?

2. What is the level of importance and weight of each criteria and sub-criteria in the evaluation of efficiencies of contractors?

1.7 Span of Research

Territory: The territory of research constitutes the area of operations of Sistan & Baluchistan Province Gas Company.

Time: The time of research involves the third quarter of 2013 till second quarter of 2014.

1.8 Classification of Research

One of the most important characters that must be considered in any scientific research is the correct implementation of the research that requires the use of an appropriate research methodology. The implementation of proper methodology often depends on the field of research, theoretical and practical training and available tools, or the area in which the research is conducted.

In this chapter by explaining the data collection methods, statistical population, survey sample and methods of doing research will be discussed in details. Brief materials are also mentioned in the field of different categories of research methods.

Research methods can be classified according to various criteria. However, it should be noted that the intended criteria must be comprehensive and it might be categorized on the basis of all available and existing methods.

1.8.1 Classification of Researches According to the Purpose

Generally researches could fall into three categories based on the objective of the study:

- **Fundamental (basic) research**

The main objective of such researches is testing theories, explaining the relationship between the phenomenon and adding to the collection of existing knowledge in a

particular field. Fundamental research, reviews the theories, approves, modifies or rejects it.

- **Applied researches**

Applied research aims to develop practical knowledge for a specific purpose. In other words applied researches involves the practical application of science.

- **Research and development (R&D)**

R&D is a process of formulating and recognizing the proper learning products (designs, methods and curricula). The basic objective of this research is to develop or produce plans, designs and so on. Therefore, the specific indefinite position is clarified initially and based on the research findings and the project or particular program will be developed and produced (Sarmad and et al, 2000).

1.8.2 Classification of Researches According to the Method

Scientific researches which are based on method is divided into four categories: qualitative, quantitative, historical and content analysis. The latter two techniques are discussed here.

- **Qualitative research**

Qualitative research presents a set of techniques that aim to describe the situation or phenomenon under investigation (Phenomenology, Ethnography). Descriptive research can be conducted to better understand existing conditions or it can help the decision-making process (Sarmad and et al., 2000). In this study, the researcher describes and interprets what is existed without interference practically or mentally. The main focus is primarily on the present time, although; events and the previous effects which are concerned with present situation and the fields which are subjected to examination and evaluation are analyzed (Best, 2005).

- **Quantitative research**

Quantitative research involves the use of questionnaire and interviews' result in pre-determined sample to be collected and analyzed and then the required recommendations based on the measured sample, should be generalized to the subjected society (Best, 2005). In addition, other techniques are also applied such as questionnaires, structured interviews, observation as well as content analysis and so on (Khaki, 1999).

1.9 Research Method

The research method which is employed in this thesis is Qualitative – Quantitative method. Since at the beginning, researcher identifies effective criteria and sub-criteria in evaluating eligibility and competence of contractors by means of books and valid scientific works and articles.

Then the author clarifies criteria weights through distributing questionnaires among company experts, and analyzes the gathered data. Finally, the qualified contractors will be selected. This study is an applied research according to the purpose.

1.9.1 Area of Research (Thematic, Temporal and Spatial)

This research analyzes the competence and ranking of Gas Company contractors of Sistan & Baluchistan province and was performed within 2nd half of 2013 to 2014.

1.9.2 Methods and Data Collection Tool

The gathered information for any research must be based on the objectives and methods of the research and the properties of the selective sample. Data collection for this research can be divided into two categories:

1.9.2.1 Library Method

Avoiding rehash is amongst the objectives that can be achieved with study-library. This method utilizes the gathered information to establish general principles of research as key such as the operational definitions, stated requirements, recognition criteria and different procedures related to the subject. Researcher has been also benefited from study-library and tries to collect performed research records on the subject by attending and referring to the various Persian and Latin books and publications and by using authentic and various Internet sites linked to the issue. In addition, by studying directives and regulations of the Office of Vice president of Republic in Strategic Planning and Supervision and the bidding rules, the requirements and limitations of legal tenders have been determined.

1.9.2.2 Field Method

Tools such as interviews and observation are used for this type of research. In this thesis, in addition to the questionnaire study which determines the weight of each criteria and sub-criteria as competency measures, interviews are also used with the selected experts.

1.9.2.2.1 Questionnaire

Questionnaire is a set of questions which can be opened or closed in order to evaluate the participants' perspective related to a reality (Khaki, 2004). In this method a series of questions which are asked from a set of respondents who represent a large population is used.

In this survey, the questionnaire is obtained from the results of research library, with respect to the legal requirements of tenders in which the weight and importance of the criteria and sub-criteria of the competence of contractors. The questions are designed

in such a way that they compare various criteria and sub-criteria mutually. Then the questionnaire is moderated and edited by five of experts and professionals. Finally it has been distributed among the respondents. The purpose of employing this questionnaire is to determine the relative weights of the criteria and sub-criteria via linguistic variables. Linguistic variables are variables by which values of words or phrases could be distinguished and tangible in natural language, in other words; in natural language variables which values are imprecise and vague, are used more than variables whose values are precise and clearly defined (Zadeh, 1975).

- **Questionnaire scale**

The research questionnaire has been adjusted based on five points of the Likert scale. This scale is one of the most common scales measuring phrases (statements) that have been developed in a certain order. These items offer special cases in terms of measuring value with equal distances (Sarmad and et al., 2000).

- **Validity and reliability of questionnaire**

Reliability and validity are among principles of the measurement and evaluation of scientific researches. These two factors are considered in this research. The researcher must be confident with the tools from scientific view of accessing results before the data collecting process (Khaki, 2004).

Validity is derived from word valid or permitted and it means being correct and true. The validity conception answers the question to which extent the instrument could measure the desired traits (Sarmad and et al., 2000). In this survey the initial questionnaire were developed based on the library studies, directives, regulations of tenders and the weight and importance of criteria and sub-criteria of assessing the eligibility of contractors pair wise. The questionnaire is given to the experts and

professionals of the company. Then, it is being corrected and modified by supervisor. Finally, the original questionnaire was developed.

Reliability or trustworthiness is one of the technical characteristics of the measuring instrument. It deals with the concept mentioned in the same measurement tool how to achieve the same result occurs. One way to assess reliability is the use of Cronbach's alpha. (Sarmad and et al., 2000) which is calculated by means of SPSS software. This formula is explained as bellow:

$$r_{\alpha} = j / (j-1) \left[1 - \left(\sum_{i=1}^{j} s_j^2 \right) / s^2 \right] \qquad (1-1)$$

In this formula, where,

j: The number of questions in the questionnaire or test

s_j^2: variance of *j'th* question

s^2: Variance of the whole test

Cronbach's alpha coefficient obtained for the questionnaire were calculated using SPSS software was amount of 0.8322 that is shown at Figure 1 and defines an acceptable rate.

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**** Method 1 (space saver) will be used for this analysis ****


R E L I A B I L I T Y   A N A L Y S I S   -   S C A L E   (A L P H A)

Reliability Coefficients

N of Cases =     10.0                          N of Items = 17

Alpha = .8322
```

Figure 1. Cronbach's alpha

1.9.3 Statistical Population, Research Sample and Sampling Method

Statistical population consists of a set of individuals or entities that have at least one common trait (Sarmad and et al., 2000) .The sample consists of a set of symptoms that are a part of a larger group or community choice pick, so that this defined collection is introduction of the quality and characteristics of the area, the larger the group or community (Khaki, 2004).

It may sometimes be necessary to collect data from some specified individuals instead of those who are available. The reason is that only the selected respondents can provide the adequate information. Or only the selected samples adapt certain criteria that the researcher intends. Such a method is called purpose sampling. Additionally, the judgmental sampling is a type of purpose sampling that involves some kind of subjective selection that are best qualified to provide the desired information (Sakaran, 2002).

In this study the intended population for using points of experts, consisting of 12 experts of the implementation departments of projects, contracts departments and members of the technical and commercial board of Sistan & Baluchistan Province Gas Company whose experience and expertise are connected with the subject of this research. Due to the limited statistical population, the statistical sample is not practical and applied in this research.

1.10 Research Processes

Our proposed method is the following:

First step: Identifying the criteria and sub-criteria to assess the competence of contractors

At this stage, by performing library studies and by reviewing regulations and rules of tenders and considering the legal restrictions of tenders, evaluation criteria for the qualification of contractors have been established 11 billion Rials for tenders with the estimated amount 20 times the medium range transaction according to the circulate in 2013.

Second Step: Determining the importance and weight of criteria and sub-criteria of evaluating the contractor's competency. Initially statistical population was identified which are members of the Technical & Commercial Committee, experts and specialists of the project implementation department of the Gas Company of Sistan & Baluchistan Province. The questionnaire was distributed among the respondents and their ideas are collected accordingly.

Suppose that we have t decision makers that its symbol is k and show it by $k, k=1, 2, 3,\ldots,t$ and so D_k means k'th decision maker whose weight is defined by I_k. If $I_1=I_2=I_3=\ldots=I_k$, the opinions of each individual of decision-making group are affecting equally in decision-making processes and we call the decision making group as homogeneous. But if it they had different weights, then it has been called the heterogeneous decision making group (Shen & Yu, 2009).

In this research the opinions of each individual of decision-making group are considered equally in the decision-making processes. After gathering the collected opinions of the statistical sample individuals, linguistic variables are used in determining the weights of each criteria. Then, according to the fuzzy AHP technique and the application of Extant-Analysis Method (EA), which are described in chapter

two; the weighting of criteria and sub-criteria in order to evaluate contractors' competency are calculated by EXCEL software.

Third step: determining three best qualified contractors to be introduced to the Tenders Commission. In this level, three best qualified contractors have been identified by EXCEL software and the technical by applying fuzzy TOPSIS approach which are presented in chapter two are selected to be introduced to the Tenders Commission.**1.11**

1.11 Analytical Research Model

Completed analytical research model is shown in Figure 2:

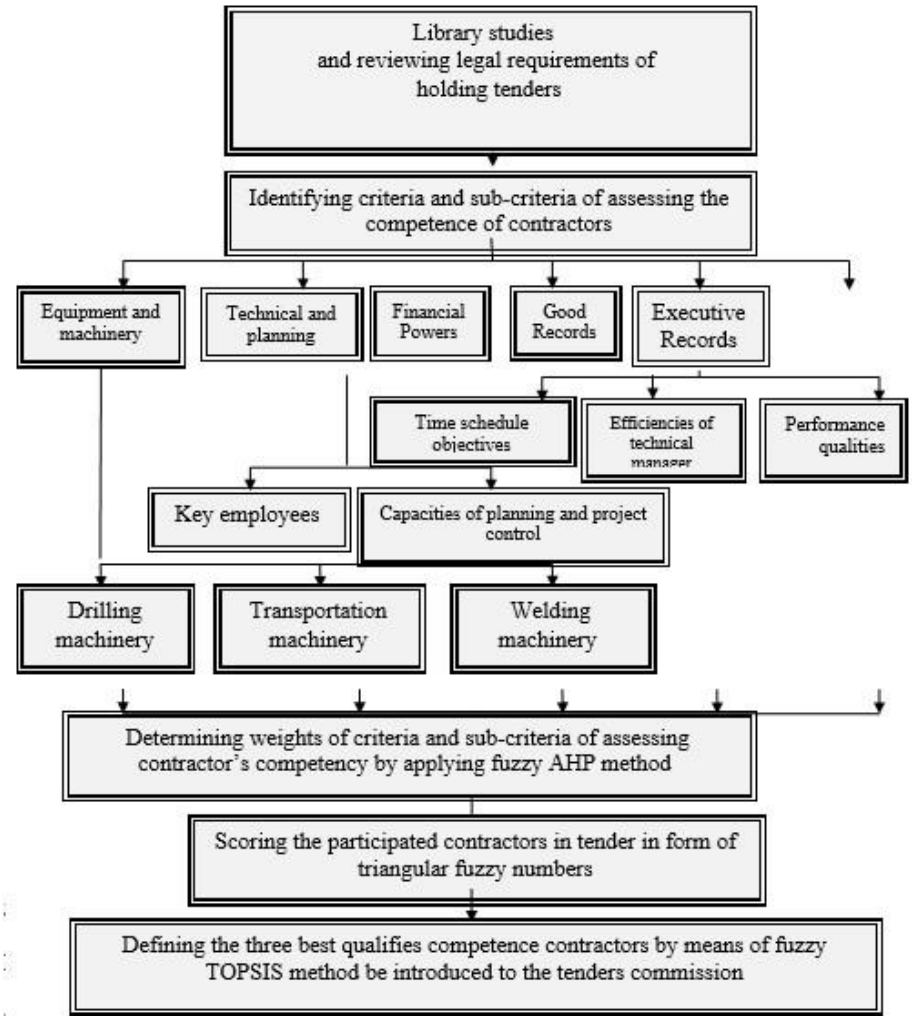

Figure 2. Analytical research model

1.12 Data Analyzing

In this research, the author used EXCEL software for analyzing the data and information. Outcomes resulted from questionnaire inserted EXCEL software and regards to calculative operational performances on cells of this software, the required information were explored and classified in tables.

1.13 Research Limitations

The researchers should note that, the limitations are restricting them from developing. Thus, it would be better if they involve restrictions and draw their attention to limitations along with searching and investigating. By being aware of this, our researches, as well as all surveys have their own limitations, which are as follows:

- Since several factors such as the employer's objectives, required resource and operating limitations have affected determining the weights and importance of criteria and sub-criteria to assess the competence of contractors; according to a newly established Gas Company of Sistan & Baluchistan Province, the above mentioned matters, are not clearly determined.
- Negative feelings generated among individuals especially in establishing the governmental bidding is a barrier against acquiring effective and efficient information.
- Whereas this research has been executed in Gas Company of Sistan & Baluchistan Province, inevitably statistical population research is limited to a small number of people employed in the company.
- Submitting incomplete or untrue information provided by contractors in some cases, which makes their assessment of competence, will not be accomplished in accordance with the facts correctly.
- Limited access to reference books, websites and authentic scientific articles.

In this chapter of thesis, the author has stated about different methods of research, collecting data tools, statistical population, and research sample and sampling method. After that the author have considered validity and reliability of tools and examined the research stages in details, Then data analysis method and restrictions of research have been stated.

1.14 Operation Definitions

Multi criterion group decision making: The topic of multi criterion decision making deals systematically with multipurpose decision making and multi factor decision making for an individual decision maker. The topic of multi criterion group decision making comes after the above topics (Arianezhad and Safakish, 2009). In present conditions, where systems use experts and directors on the same levels, decisions reflect general opinion of the group and decision making body of the system.

In such circumstances, such decision makings are called group decision making and are fully qualified to be applied in multi criterion environments (Rashidi Komijan, 2005)

Fuzzy sets: Terms such as "It is unclear", "Maybe it is so" or "Most likely" are used frequently in the routine life and they show the grades of certainties of the thought of human (Zadeh, 1963).

Fuzzy sets are generalization of classical sets and were used first by Professor Lotfizadeh in 1965 to show a way ambiguities existing in the real world. Each fuzzy set is defined by a membership function which allocates a number in the span of [0 and 1] to each element in a set and such number is called membership grade. If the number is 0, the element does not belong to the considered set, if it is 1, the element

belongs fully to that set. If it is between 0 and 1, such element is only to some extent a member of the set (Wang et al, 2007).

Triangular fuzzy number (TFN): It is a fuzzy number which is represented with three values (l, m, u).l shows the lowest possible value, m shows the most promising value, and u shows the largest possible value that describe a fuzzy set. TFN is an increasing function, $l \le m \le u$ and it should meet the following conditions:

$$M_1 \oplus M_2 = (l_1, m_1, u_1) \oplus (l_2, m_2, u_2) = (l_1 + l_2, m_1 + m_2, u_1 + u_2)$$
$$\lambda \cdot M_1 = \lambda \cdot (l_1, m_1, u_1) = (\lambda \cdot l_1, \lambda \cdot m_1, \lambda \cdot u_1),\ \forall \lambda > 0$$
$$M_1 \otimes M_2 = (l_1, m_1, u_1) \otimes (l_2, m_2, u_2) = (l_1 \cdot l_2, m_1 \cdot m_2, u_1 \cdot u_2),\ l_1, l_2 > 0$$
$$M_1^{-1} = (l_1, m_1, u_1)^{-1} = (\frac{1}{u_1}, \frac{1}{m_1}, \frac{1}{l_1})$$

Figure 3. Operational laws for triangular fuzzy numbers

Linguistic terms: ‘’Linguistic terms are represented by membership functions, valued in the real unit interval, which translate the vagueness and imprecision of human thought related to the proposed problem. In the literature, triangular and trapezoidal fuzzy numbers are usually used to capture the vagueness of the parameters related to the topic. In this research the triangular fuzzy numbers (TFN)s were used to represent the fuzzy relative importance. A TFN is graphically shown in Figure 4 (Javanbarg et al., 2012)’’.

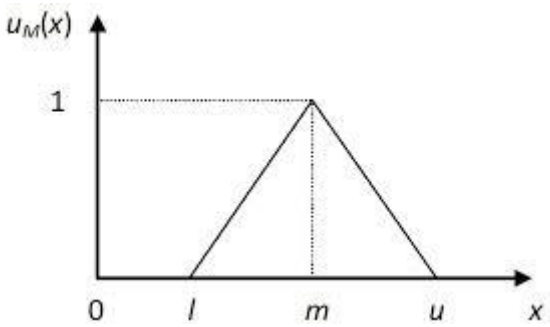

Figure 4. Triangular fuzzy number (Javanbarg et al., 2012)

In Figure 4, l, m and u show the lowest possible value, the most promising value, and the largest possible value that describe a fuzzy set.

Fuzzy linguistic variables are utilized to use non-numerical values instead of exact values. It is highly suitable for the decision maker because of its capability of providing a wide interval for a decision maker instead of exact numbers. This subject is highly used in the fuzzy comparisons judgments especially AHP to solve the problems.

Chapter 2

LITERATURE AND BACKGROUND OF RESEARCH

There were great developments in all scientific and technical fields during recent roughly one hundred years. Development projects played significant roles in such areas. The most important developments were in to areas of material and equilibrium calculations. Before such period, projects were carried out in accordance with only ideas and technical understandings of architects based on their experiences. There were usually no technical calculations.

In 1895 professor Kulman, a professor in Zurich University, founded the basis of equilibrium calculations, which were later expanded and completed. There were substantial developments in construction material too. 1824 the Portland cement was registered in England. Consequently, execution qualities of projects were gradually improved to reach those of today. Executive operations were performed directly. In other words, employers administered the procurement of material and payment of wages. However, the above is now performed in another way and others (contractors) are entrusted with such duties. In the past, development operations were done only by rulers, possessors of funds, and authorities to meet their own necessities or their army requirements. Social requirements were dealt with rarely by projects. At old times the factor of low cost were not so much taken into account in projects. However, now it is the most important one. To achieve low costs, the most substantial parameter is the ways in which contractors are chosen (Feiz Rahnamoun, 2007).

At present, most development projects are realized with cooperation of employers, consultants and contractors, constituting organs of any development projects and enjoying close inevitable relationship one with another. [Figure 5]

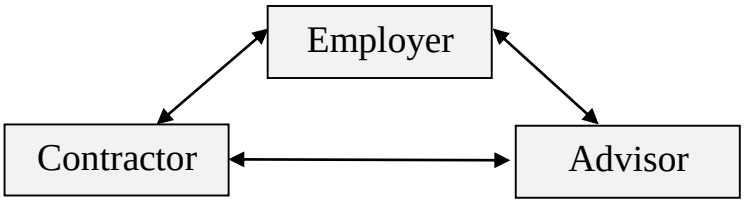

Figure 5. Organs of development projects

An employer announces need for a project, assigns execution of its operations to a contractor, and finances the project. The above may be decided after an exhaustive study of various options. When it was decided to procure material and execute a project, the employer may make use of services of a consulting company to prepare plans and then the employer will use services of contractors to perform executive operations of the project, or will personally perform some of the above if they are in possession of proper factors of design and execution, such as human forces, experts, tools, machinery, and appropriate executive forces.

A consultant is a person whose services may be used by an employer to study, design and control executive processes of projects. A plan which is so much consistent with the project concerned by the employer will constitute a document guiding contractors to execute the project.

A contractor, enjoying a contractor qualification certificate issued by the Registry of Companies and Industrial Ownership or the Registry of Deeds and Real Estate

Properties, will be chosen by the employer through statutory procedures and will undertake to perform executive operations of the project.

Contractual relations and arrangements between these parties vary depending on the nature and sizes of projects. There are cases in which one party plays roles of two or even all the three parties. An employer should choose a contractor who is sufficiently qualified and as much appropriate as possible for meeting requirements of the employer and for specifications of the project to perform the project with the least costs possible and to realize the most possible objectives and wishes of the employer. The contractor, as the executing factor, plays the most crucial role in the progress of the project and in realization of expected objectives.

If the contractor is powerful in terms of executive and technical issues, financial matters and other specifications required for the execution of the project, most of shortcomings existing in drawings of the consultant as well as inefficiencies of the organization of the employer will be set off and the contractor will resolve them during the execution of the project. On the other hand, inefficient performance of the contractor will lead to the staggering of the project and will constitute one of the reasons for delays in projects. The most appropriate way to choose the best contractor will, therefore, be a tender. During a tender, the organizers endeavor to make their final selection in a way that the project will be performed with highest qualities and lowest prices possible.

The creation of tender system goes back to an old time. It was used in the State of New York in 1847. It was used mainly for projects of highways and bridges. The main idea

behind this method was that the lowest offer will win and the public will be protected from corruptions and other inappropriate practices.

The initial function of the system was to insure employers that they will operate and benefit from projects with lowest prices (Thomas & Skitmore, 2001). Along the years, some changes occurred in this system. Some part was added to it to choose acceptable powerful bidders in controlled ways. Other improvements involve the preparation of lists of qualified contractors of that field. The main idea remained the same as it was in the 19th century. However, it is interesting that all countries don't accept the lowest offers (Palaneeswaran& Kumaraswamy, 2001). There are a few countries, such as Portugal, Italy and Peru, where the lowest offer will not be inevitably the winner. The phylosophy here is the fact that the best offer is the most acceptable and not the lowest one; and it is the closest one to the average of offers received (Hatush & Skimore, 1997).

Tenders on the basis of the lowest price offered has generally disadvantages that surpass their advantages. They protect the works from any pressers, whether political, economic, social or others. Nonetheless, as the decision parameter involves offered prices, there may be problems in terms of time, quality or safety.

2.1 The Law of Tender Organization

In this part the rules and regulations of tender in Iran has been discussed briefly. Some important definitions are given here.

2.1.1 Definitions

Tender: A tender is a competitive process to achieve concerned qualities (as per tender documentation), in which subject obligations of the transaction is assigned to a bidder offering the lowest price.

Tender organizer: An ender organizer is an organization which calls for a tender.

Bidder: A bidder is a physical person or legal entity who receives tender documents and bids in the tender.

Technical and commercial committee: The technical and commercial committee is a committee composed of at least three technical and commercial qualified experts who are appointed by the authorized representative of the tender organizer and undertake to evaluate offers in view of technical and commercial matters and to discharge other duties provided under the law of organization of tenders.

Qualitative evaluation: The qualitative evaluation of bidders involves the evaluation by a tender organizer or, if they decide so, by the technical and commercial committee, of powers of bidders to perform obligations.

Technical and commercial evaluation: The technical and commercial evaluation of bids is the procedure of evaluation and assessment of specifications, standards, efficiencies, durability and other technical and commercial features of offers of bidders and selection of acceptable offers.

Financial evaluation: The financial evaluation constitutes a procedure in which the most appropriate price is selected from among offers accepted in terms of technical and commercial matters.

Form evaluation: The form evaluation involves the examination of documents and their signatures to be complete and of offers to be unconditional and legible.

Exclusivity in transaction: The exclusivity in transaction occurs when there is only a bidder in the transaction in cases as follows:

- Announcement by the Council of Ministers for goods and services being within its monopoly.
- Publication of a public notice to require only one applicant to perform the transaction.

Tender schedule: The tender schedule involves a document in which dates and deadlines of different stages of a tender, term of validity of offers, and date of conclusion of contract are specified (Tale Khorsand, 2010).

Classification of transactions: Transactions are classified under three categories in term of limits (of transaction prices):

- Small transactions: Transactions less than IRR 55,000,000 with the fixed prices of the year 2011.
- Medium transactions: Transactions with subject prices exceeding the ceiling of small transactions however not exceeding IRR 550,000,000.
- Big transactions whose initial estimation prices exceed IRR 550,000,000 (http://tec.mporg.ir).

Classification of various tenders:

1. Tenders are classified under the following categories as regards evaluation stages:

- One stage tender: It means a tender in which there is no need to technical and commercial evaluation of offers. In such tenders, pockets of tender bids are opened in a session and the winner of tender will be determined during the same session.
- Two stage tender: It means a tender in which the tender organizer decides that technical and commercial evaluation of offers in necessary. In such a tender, a technical and commercial committee will be formed to report the results of technical and commercial evaluation of offers to the tender committee to determine the winner of tender.

2. Tenders are classified under the following categories as regards the ways in which bidders are called:

- Public tender: a tender in which bidders are notified by a public notice.
- Limited tender: a tender in which the highest authority of the tender organizer decides with their own responsibility that there will be limitations in a public tender and provides reasons for the above. The call for tender will be communicated to bidders by sending invitations to qualified bidders (Tale Khorsand, 2010).

2.1.2 Organizing Tenders

For organizing tenders, it should be noted that the tender committee and their function should be intelligible.

2.1.2.1 Tender Committee

The tender committee is composed of members as follows:

1. Chairman of tender organizer body or their representative

2. Accountant of the highest financial authority of the tender organizer body

3. Technical director of the tender organizer body or a unit requesting the tender (Tale Khorsand, 2010).

2.1.2.2 Functions of the Tender Committee

Major functions of the tender committee are as follows:

1. To hold meetings of the tender committee on the date specified under the call for tender

2. To examine proposals of bidders and their signatures to be complete and price offers to be legible and unconditional (form evaluation)

3. To evaluate proposals and to specify acceptable ones in accordance with the conditions and documents of the tender

4. To refer proposals to the technical and commercial committee to examine them in term of technical matters if the tender is a two stage one

5. To determine the first and second winners

6. To prepare minutes of meeting of the tender

7. To decide if it is necessary to renew or cancel the tender (TaleKhorsand, 2010).

2.1.3 Holding Tenders

In order to hold tenders some activities should be done which are studied here. Thus, in this part the procedures for holding tenders has been discussed briefly.

2.1.3.1 Procedures of Organization of Tenders

The procedures of organization of tenders are as follows:

1. To provide financial resources

2. To determine the category of a tender in big transactions (one stage or two stage and public or limited invitation)

3. To procure tender documentation

4. To perform qualitative evaluation of bidders if necessary

5. To call for tender

6. To evaluate proposals

7. To determine tender winner and to conclude a contract (Tale Khorsand, 2010)

2.1.3.2 Holding Tenders Method

Tenders are held in 3 methods as follows:

1. In small transactions, a procurer or purchase officer should enquire price quotations of the subject matter of transaction (goods, services or rights) in view of its quality and quality and to perform the transaction in observance of interests with his own responsibility achieving qualities with the lowest price, receiving invoices.

2. In medium transactions, a procurer or purchase officer should enquire price quotations of the subject matter of transaction (goods, services or rights) in view of its quality and quality, receive at least three enquiry responses in writing, and to perform the transaction in observance of interests achieving considered qualities if an offered price is accepted by the director of procurement unit or an authority at the same level. A contract should be concluded or an invoice should be received. If it is impossible to receive three written enquiry responses, any available number will suffice provided, however, that the director of procurement unit or an authority at the same level approves the same.

3. In big transactions, one of the following ways will be followed:

- Holding a public tender by publication of the call in a widely circulated daily
- Holding a limited tender (Tale Khorsand, 2010).

2.1.3.3 Qualitative Evaluation of Bidders

During qualitative evaluation of bidders, issues should be considered are as follows:

1. Quality insurance of services and products

2. Experiences and knowledge in the considered fields

3. Good records

4. Work permits or qualification certificates if necessary

5. Financial power of the applicant to perform the work if necessary

The qualitative evaluation of bidders are composed of stages as follows:

- To determine evaluation criteria and relative importance of criteria
- To prepare evaluation documents
- The applicants receive, fill out and send back evaluation documents.
- To evaluate received documents and to determine points achieved by each one of the bidders and to allocate a grade to each of them
- To announce names of qualified bidders to the employer accompanied with their pints and grades (preparation of a short list)
- To prepare documents of qualitative evaluation of bidders (Tale Khorsand, 2010).

2.1.3.4 Call for Tenders

A call for tender will contain the following:

1. Names and addresses of bidders

2. Nature, quantity and quality of goods and services

3. Type and amount of guarantee for bidding

4. Place, date and deadline to receive or return back documents, and to open proposals

5. Estimated price of transaction and its bases. In cases where there is a basis price list, the relevant estimation will be prepared on the basis of such list (Tale Khorsand, 2010).

2.1.3.5 Tender's Documents

Tender's documents are as follows:

1. Name and address of bidder

2. Type and amount of guarantee for bidding

3. Place, date and deadline to receive or return back documents, and to open the same

4. Amount of advance payment and good performance guarantee

5. Validity duration of proposal

6. Description of work, technical and commercial specifications, standards, and nature, quantity and quality of goods or services

7. Schedule of performance of work or delivery of goods

8. Criteria and method of qualitative evaluation of bidders

9. How to prepare and deadline to submit proposals and number of their copies

10. Contract including agreement, general and private conditions and enclosures of the same (Tale Khorsand, 2010).

2.1.3.6 The Sequence of Preparing and Submitting Proposals

After receiving or buying documents, the bidders are to prepare and provide the tender organizer with their proposals as follows:

1. To prepare and fill out documents and proposals

2. To submit proposals before the deadline specified under the call for tender

3. To receive a receipt against the handover of proposals

4. Deadlines to accept proposals in domestic and international tenders will not be less than respectively 10 days and one month following the deadline to receive tender documents (Tale Khorsand, 2010).

2.1.3.7 Conditions of Submission and Handover of Proposals

1. No bidder may present more than one proposal, except in cases where otherwise is provided under the tender documents.

2. The bidders put tender documents and their proposals in separate sealed pockets as follows: guarantee (packet A), technical and commercial proposal (packet B) and price offer (packet C). Then they put all the above packets in a proper sealed wrapper.

3. The tender organizer is bound to receive and register all proposals presented in time by the bidders and to protect the same until the meeting of opening.

4. Any submission, delivery, replacement and/or withdrawal of proposals shall be made in acceptable ways and in places and before deadlines provided under the tender documents (Tale Khorsand, 2010).

2.1.3.8 Offering Proposals

The proposals will be offered as follows:

1. To prepare a list of names of receivers of documents (bidders), attendees and participants of the session

2. To open guarantee packets (Packets A) and to control the same

3. To open technical and commercial packets

4. To open price offers and to control the same for completeness of documents and their signatures and to put aside unacceptable offers in one stage tenders

5. To handover technical and commercial packets to the technical and commercial committee in two stage tenders

6. The tender committee will prepare, draw up and sign minutes of the meeting for opening the proposals.

7. To provide the tender organizer with packets of price offer and guarantee for rejected proposals to be returned back to beneficiaries (Tale Khorsand, 2010).

2.1.3.9 Evaluation of Proposals in Terms of Technical and Commercial Matters

The categories of the evaluation of proposals in terms of technical and commercial matters:

1. In two stage tenders, the tender organizer is required to perform qualitative evaluation of bidders and to evaluate proposals in terms of technical and commercial issues and to announce results.

2. If it is required to examine proposals as regards technical and commercials issues, the results will be announced by the technical and commercial committee in a later session, where the packets of price offers of bidders who get required points will be opened.

3. Any technical and commercial evaluation are permissible only before the opening of price offers.

4. Bidders not accepted during technical and commercial evaluation will receive their packets of price offers unopened (Tale Khorsand, 2010).

2.1.3.10 Financial Evaluation and Determination of Tender's Winner

The procedure of financial evaluation and determination of tender's winner are as follows:

1. During financial evaluation, the bidder who offered the most proper price will be announced the first winner. A second winner will be announced if his price offer differs less than the guarantee amount with the first winner's offer. The way in which financial evaluation is performed will be stated in detail under the tender documents indicating how technical and commercial evaluation effects on prices.

2. If it required to examine prices and their analyses and bases after price packets have been opened, the tender committee may request the technical and commercial

committee to examine the same and to notify the tender committee of evaluation results within two weeks.

3. After the price offer packets have been opened, the tender organizer will retain guarantees of the two first winners and return back guarantees of other bidders.

4. In international tenders, domestic bidders will be preferred over foreign ones. The tender documents will indicate how domestic bidders are give priority to. If it is not appropriate to observe such rule in a tender, such practice is to be approved by the Economic Council (Tale Khorsand, 2010).

2.1.4 By-law of Classification and Qualification of Contractors

Provisions under this by-law applies to qualification process of contractors to receive certificate to work in plans and projects which:

1. All or parts of their financial resources are provided by public budget of the Government.

2. Are required to use government guarantees or facilities for their finance or execution inside the country or abroad.

Regulations of this by-law apply only to the qualification of contractors as follows:

- Iranian physical persons or legal entities intending to work in Iran.
- Foreign legal entities wishing to work in Iran.
- Iranian physical persons and legal entities needing governmental guarantees or facilities to work abroad.

Terms used in this by-law are defined as follows:

Organization: State Organization for Management and Planning

Qualification points: A number designating experience and specialty, financial powers, periodical evaluation results, and legal guarantee in performance of services.

Long term debts: Loans with or without securities and loans receivable from affiliated companies or member of the group.

Current debts: Bank loans and debits, current allotments, long term debts payable (payable commercial notes and accounts, payable to directors, member companies or subsidiaries, income tax, payable profit …).

Long term financial powers: A number designating financial powers of a contractor to perform his obligations and to guarantee his contracts determined as follows:
Long term financial powers = long term assets - long term debts

Current financial powers: A number designating the financial powers of a contractor for short term investment in projects being in process of execution to be determined as follows:
Current financial powers = current assets - current debts

Contractor: A physical person or legal entity who has received a certificate of qualified contractors to perform works as per rules and conditions provided under this by-law.

Legal entity contractor: A contractor who has required conditions and has received a certificate of qualified contractors after being registered by the Registry of

Companies and Industrial Ownership and/or by the Registry of Deeds and Real Estate Properties.

Physical person contractor: A person who has required conditions and has received a certificate of qualified contractors.

Fixed assets: Capital, properties, machinery, equipment, land, building, accumulated amortization, long term investments (in subsidiary and affiliated companies), long term receivables (accounts and notes receivable and commercial, receivables from directors and subsidiaries and members of the group, and other receivables), good will moneys, patents, trademarks and expenses carried to the next periods.

Current assets: Cash in vault, investments in shares and stocks other than long term investments and receivables and inventories of goods and material.

Corporate capital: Total contributions, in cash or kind, of partners recorded as the corporate capital in the Registry of Companies and Industrial Ownership or the Registry of Deeds and Real Estate Properties.

Iranian company: Any company registered in Iran and with head office located in Iran is counted to be an Iranian company.

Foreign company: A company whose head office is located outside the I.R. of Iran may do businesses in trade or industrial affairs by their branch or agency if such company is recognized as a legal company in their own country and their branch or agency is registered by the Registry of Companies in Tehran.

Employees: Employees whose work contracts are subject to the social security insurance (as per the Labor Code and the law of Social Security or Civil Employment) and whose social security duties have been paid since three years before the date of application for the certificate.

Performed works: Works completed or in process of execution in any branch which have been temporarily accepted or indicated in statements.

Certificate of qualified contractors: A certificate issued by the organization on the basis of rules of this by-law to prove qualification to act as a contractor in accordance with this by-law. Such certificate will be amended or extended as per arrangements provided under this by-law.

Financial turnover: Total incomes and expenses of a contractor during one fiscal year.

Subject matter of company: Operations specified in the charter of company, among which there are contractors' services of the requested fields. The company is incorporated on the basis of the above (Tale Khorsand, 2010).

2.1.4.1 Classification of Contractors Based on Powers (Base)

Contractors are classified on the basis of powers (base) as follows:

Type 1: Iranian private sector contractors, physical persons or legal entities, whose partner portions belong entirely (100%) to Iranian physical persons.

Type 2: Contractors whose partner portions or shares belong entirely (100%) to the Government, Municipalities, Islamic Revolution institutes, corporations or organizations or other public or charitable institutes.

Type 3: Partnership groups or other contractors not enjoying conditions of the types 1 and 2 are counted to be of the type 3 (Tale Khorsand, 2010).

2.1.4.2 Classification of Contractors Based on Operation

Contractors are classified on the basis of their types of operations (fields) as follows:

1. Construction field: It involves contractor businesses relating to construction of buildings, including wooden, brick, stone, concrete, metal and other similar ones.

2. Hydraulics field: It involves contractor businesses relating to construction of systems and treatment and filtering of water, wastewater, dams, water deviation tunnels, water tanks, water or wastewater networks, water carrying canals, offshore and shore structures and the like.

3. Transportation field: It involves contractor businesses relating to construction of ways, such as main roads and branches, highways, railways, airport bands, air transfer systems based on stands, airports, tunnels, bridges, underground ways and transportation systems (procurement, installation, maintenance and repair of equipment), road maintenance, asphalt operations and the like.

4. Industry field: : It involves contractor businesses relating to industries of food, textile, clothing, leather, wood, glass, cellulose, extraction, process, storage, conversion of raw material and production in the industry of oil, gas, petrochemical, chemicals, non-metal minerals, heavy industries, mine and metal industries (iron and steel, non-ferrous metals, metal products), construction of factories, tools, machinery, measurement and control equipment, auxiliary industrial installations, manufacture of laboratory tools, pharmaceuticals, manufacturing plants of transportation tools, equipment and the like.

5. Electricity field: : It involves contractor businesses relating to manufacture, distribution and transmission of power, such as power plants, electricity networks,

electrical installations, public and private electronic and distribution sub-stations and the like.

6. Installation and equipment field: : It involves contractor businesses relating to carrying lines (of water, oil or gas), mechanical and hydro mechanical installations, installations and welfare affairs of buildings, chilling or heating systems of buildings, procurement and installation of equipment of electricity, water, gas, wastewater, transmission of wastes, transmission tools (lifts, escalators …), information and warning systems, kitchen systems, self-services and laundries, contractor businesses of communication systems, computer networks of buildings and the like.

7. Land explorations field: : It involves contractor businesses relating to exploration, drilling, extraction, transport, operation and use of non-living material existing in the crust of earth (in land or sea), indirect explorations in land, offshore drillings, hydrocarbon material, injection of material, burying wastes, offshore explorations, drilling of seabed, geotechnical matters, extraction of seabed material (except hydrocarbons), fixed systems of transmission of material in the sea and their stations, including those for water, wastewater, hydrocarbons and other material, preparation, construction and operation of open mines (in land) and preparation, construction and operation of underground mines (in land) and the like.

8. Communication field: : It involves contractor businesses relating to audio, visual and data telecommunication, construction of main transmission and distribution stations, various wire, wireless, radio, TV, satellite networks and the like.

9. Agriculture field: : It involves contractor businesses relating to cultivation of forests and trees, irrigation, improvement of lands, construction of basins and pools for breeding and reproduction of fish, pouring march and stabilizing moving sands, operations to improve agriculture, seeding and harvest of major and strategic products,

keeping pastures, creation of manmade pastures, veterinary works, creation and maintenance of green spaces, veterinary works including aviculture, cow breeding, beekeeping, ship keeping, fishery and sea animals and the like.

10. Services field: : It involves contractor businesses relating to removal of pollution from land and sea areas, fire extinguishing (urban, industrial, sea and forest), relief operations (in land, sea …), contractor businesses relating to urban and building cleaning, gardening, transportation and its services (urban, intercity and international), services of banking, education, insurance, procurement of food, guarding, protection, tourism, health, treatment, administrative and art services, repair of ancient works, sandblast, cathode protection and the like (Tale Khorsand, 2010).

2.1.4.3 Grading Contractors Based on Qualification Criteria

Contractors are graded in view of qualification criteria in five categories from bigger ones to smaller ones on the basis of powers and capacities as follows:

1. Contractors of grade 1

2. Contractors of grade 2

3. Contractors of grade 3

4. Contractors of grade 4

5. Contractors of grade 5 (Tale Khorsand, 2010)

2.1.4.4 Qualifying Contractors

Qualification criteria of contractors are as follows:

- Evaluation
- Specialty and experience
- Financial powers

Qualification points *(S)* are calculated and determined on the basis of the following formulation:

(2-1) $S = C_e\ (0.3\ E + 0.5\ P)$

In which:

C_e is evaluation index

E stands for specialty and experience

P designates financial powers

Evaluation index (C_e) is a number determined on the basis of procedures and standards of evaluation instructions. In the first period of qualification and until no instruction is communicated, the evaluation index is counted to be 1.

The points of specialty and experience are calculated and determined as follows:

(2-2) $E = E_p + E_w + E_c$

In which

E_p is points of directors and employees

E_w is points of works performed and

E_c is points of continuous operations of the contractor

The points of directors and employees *(Ep)* are calculated and determined as follows:

(2-3) $E_p = \sum_{i=1}^{n}(mi + hi.fi)$

In which

m_i= points of education

h_i= index of experience being 20 for the board of directors and managing director and 10 for the employees

f_i = yearly experiences

n = number of employees

m_i is calculated on the basis of the following table:

Table 1. Calculation of index of points for education of contractors

Education level	In the same field	Related fields	Unrelated fields
Bachelor's	250	125	80
Master's	275	135	90
Doctorate	300	150	100

F_i = Duration of operations in related fields proved by documents of Social Security Insurance given maximum 15 points. n = 15 at most.

Education is verified by reliable education credentials. Credentials of foreigners will be acknowledged by competent institutes in the Ministry of Science, Research and Technology, otherwise by the Office of Consultants and Contractors Affairs of the organization.

It is obligatory for the managing director and at least two thirds of the members of the board of directors of companies to have at least bachelor's degrees. Points for each director or employee will be allocated only to one company.

Points for amounts of executed works (Ew) performed during last 15 years are calculated and determined by the following formulation:

(2-4) $$E_w = 0.03 \sum_{k=1}^{n} (1.2^{(Yc-((Ys + Yf)/2))}) P_k$$

In which:

n = Number of researches completed or being in process of execution by the contractor during the last 15 years in the same field

P_k = Cost price or the last confirmed statement of the project K in million Rials

Y_c = Current year

Y_s = Beginning year of the project K

Y_f = End year of the project K

Points for experience and continuous operations of the contractor (Ec) will be calculated on the basis of the continuous period of operations of the contractor in accordance with amounts of performed works as follows:

(2-5) $E_c = (0.01)\ (L)\ (E_w)$

In which:

L = Number of years during which the contractor operated to be verified by the year of incorporation $(L < 15)$.

Points for financial powers (P) will be calculated and determined on the basis of the following relation:

(2-6) $P = 0.5\ P_t + 1.5\ P_c + P_l$

In which:

P_t = Financial turnover in million rials

P_c = Current financial powers (the difference between current assets and current debts) in million rials

P_l = Long term financial powers (the difference between the long term assets and long term debts) in million rials (TaleKhorsand, 2010).

2.1.5 Qualitative Evaluation of Contractors

For qualitative evaluation of contractors, the criteria should be clear. Therefore, some of these criteria are discussed here.

2.1.5.1 Criteria of Evaluation of Contractors

General criteria of qualitative evaluation of bidders in tenders are at least as follows:

1. Experience (executive records)
2. Good records in former works
3. Financial powers

In addition to criteria mentioned under paragraph A, at least the following criteria will also be considered in tenders with estimated prices exceeding 20 times the limit of medium transactions:

1. Equipment powers
2. Technical and planning powers

In addition to criteria mentioned under paragraphs A and B of this clause, at least the following criteria will also be considered for qualitative evaluation of bidders in tenders of "design and construction" and tenders of "exploitation":

1. Technical knowhow in the field of study and design
2. Experience in the field of procurement of goods
3. Management powers

- In addition to criteria mentioned under paragraphs A to C of this clause, the amount or percentage of financial partnership may also be considered in general tenders.
- Contractor joint groups are to introduce their key employees and executive organization in all tenders with any prices. Contractors will be removed from

the short list if their executive organizations are not complete or if obligations of parties of the partnership are not consistent with the execution conditions of the work.

- Points of sub-contractors will be calculated during the qualitative evaluation of the main contractor (Tale Khorsand, 2010).

2.1.5.1.1 Evaluation of Experiences of Contractors

1. The evaluation of experiences of a contractor (executive records) will be made on the basis of data about the number and types of similar works performed in that branch and field of work during the last 5 years. The maximum points are received if 4 similar works with not less than the same volume of the subject matter of the tender have been executed by the contractor. The experience points will fall proportionally for lesser amounts.

2. During the evaluation processes for tenders with estimated prices more than 100 times the medium transactions, a lesser number and volume of relevant works than those under paragraph A of this clause may be specified for receiving points for experiences (Tale Khorsand, 2010).

2.1.5.1.2 Evaluation of Good Records in Former Works

- To allocate points for good records in former works, it is required to enquire to gather information of maximum 5 last years, including addresses of informed authorities in employer organizations, subject matters and prices of contracts, names and addresses of supervising bodies of such contracts.
- The points for former employers will be determined in view of issues such as work qualities, efficiencies of technical managements and schedules of

projects. For the purpose of this clause, the organization is required to prepare instructions for the evaluation of contractors' works by former employers.

- The mentioned points will be determined on the basis of the average of evaluation by former employers in connection with former works during the last 5 years.
- Points relating to the periodical evaluation of reliable authorities subject matter of note under article 10 of the directive ref. H 23251 T/ 48013 dated 02.03.2003 about the contractor's performance may replace subject information of paragraph B of this clause (Tale Khorsand, 2010).

2.1.5.1.3 Evaluation of Financial Powers of Contractors

The financial powers of the contractor will be evaluated on the basis of the information of maximum 5 last years.

The maximum points are given for financial powers if the estimated price of the tender is equal or less than anyone of the following:

1. 50 times average annual tax or 70 times final payment or down payment of social security duties.

2. Three times gross annual income proved by final or temporary statements.

3. Five times fixed assets proved by tax returns or certificates of the insurance of assets or legal books.

4. Certification of credit by reliable banks or financial and credit institutes up to the ceiling of the price of the subject matter of the tender.

Note 1: The highest figures of paragraphs 1 to 3 of the sub-clause B of this clause will be used as the basis of calculations. If the highest calculated figure is less than the estimated price of the tender, the financial points fall proportionately.

Note 2: In necessary cases, the above indexes will be updated in view of economic and executive circumstances with recommendation of the organization and approval of the Council of Ministers (Tale Khorsand, 2010).

2.1.5.1.4 Evaluation of Equipment Powers

- Points for equipment powers of contractors will be determined in view of the nature of work, and required machinery and equipment indicated in the evaluation enquiry responses. If it is established that it is possible to provide the least machinery and equipment required for the project, the contractor will be given the most points of the equipment powers.
- If the project needs especial machinery, the employer may ask the contractor how the latter will provide such machinery. In such cases, the contractor may provide the employer with lease contracts of machinery with reliable documents instead of title deeds (Tale Khorsand, 2010: 179).

2.1.5.1.5 Evaluation of Technical and Planning Powers

A contractor is evaluated for their technical and planning powers on the basis of the least required criteria as follows:

1- Efficiencies of key employees

2- Powers to plan and control the project

- If the report recommends a particular organization to execute the project, the points of paragraph 1, sub-clause A of this clause is allocated to the applicant introducing key employees and such points are calculated on the basis of completeness of the organization of key employees.
- If there are at least two projects with no delays (until the temporary acceptances) in the records of the contractor during 5 last years, the most points are allocated for planning and controlling the project.

2.1.5.2 Certificate of Qualified Contractors

1. In tenders for domestic contractors, the contractors should have certificates of qualified contractors.

2. In international tenders, the tender organizer should request from domestic bidders to present reliable certificates of qualification and from foreign bidders cooperating with domestic contractors to present certificates issued by the Chamber of Commerce of their own countries, registration documents, documents of insurance or financial performances, especial statutory permits, and work records from former employers, as the case may be.

Note: For qualitative evaluation, foreign bidders are required to have a work record of at least two years or to have performed a work similar and related to the subject matter of the tender (Tale Khorsand, 2010).

2.1.5.3 Work Capacity of Contractors

- The capacities of contractors will be determined on the basis of the by-law of classification and qualification of contractors subject matter of the directive ref. H 23251 T/ 48031 dated 02.03.2003 and further amendments thereof and will be updated and published on the National Information Site of Tenders.
- The tender organizer will be bound to evaluate work capacities of contractors as per evaluation enquiry responses using self-declared information as well as data published on the National Information Site of Tenders in accordance with criteria as follows:

1- Grades and branches of contractors

2- Financial, equipment and procurement powers

3- Number of works being in process of execution

A contractor may be given more works than their work capacity in cases as follows:

1. Giving works up to 25% higher than the work capacity of the contractor provided that it is approved by the Technical and Commercial Committee.

2. If the number of contractors of the short list enjoying capacities in the considered field and grade are less than the least mentioned under the paragraph 1 of sub-clause A, the tender organizer may perform qualitative evaluation to add other contractors whose work capacities are full or contractors of further grades to the short list (Tale Khorsand, 2010).

2.2 Project Life Cycle

In general, each project has its own life cycle. The life cycle of a project is composed of definite and definable stages from the beginning to the end. Different works and operations are performed during various stages of execution of a project depending on the subject matter, type, nature and dimensions thereof. The life stages of each project may, therefore, differ from other ones.

The life cycle of a project consists of a general procedure which may be classified under three main sections or phases. The details of phases of a project are as follows (Lotfi, 2006).

2.2.1 Phase Zero: Technical and Economic Justification Studies

What occurs in this stage is as follows:

1. To specify objectives of the project
2. To identify constituents
3. To do feasibility study of the project
4. To estimate roughly the investment and the time of execution
5. To perform economic calculations and to determine output

6. To determine economic, social, political and environmental effects of the execution of the project

7. To determine interactions and relationships with other projects

(Lotfi, 2006)

2.2.2 Phase 1: Preliminary Studies

Major operations performed during this phase are as follows:

1. Preliminary design

2. To prepare preliminary plans

3. To determine general specifications

4. To determine proper locations of the execution of the project

5. General estimation of dimensions and volumes of the work

6. To prepare lists of the main and substantial material, tools and equipment

7. To prepare the preliminary schedule of the execution of the project

8. To prepare reports about:

- Results of studies
- Bases of calculations
- Estimations (Lotfi, 2006)

2.2.3 Phase 2: Preparation of Drawings and Executive Details

Major operations performed during this phase are as follows:

1. To prepare the plan of land location

2. To determine results of tests

3. To determine technical specifications

4. To prepare executive drawings

5. To prepare the schedule of work execution

6. To specify resources to procure material

7. To estimate work amounts

8. To determine price units

9. Private conditions of the contract

10. To estimate more precisely execution costs

11. To prepare documents relating to the contract

(Lotfi, 2006)

2.2.4 Phase 3: Executive Phase

This phase consists of the selection of contractors, conclusion of the contract, executive operations and supervision of good performance until the stage of the acceptance by the employer of the project to operate.

2.2.4.1 Services of Consulting Engineers

The part of the phase 3 which is relating to the services of consulting engineers are as follows:

1. To prepare and make copies of the documents and papers of the tender

2. To cooperate with executive organization to select qualified contractors to be invited to the tender, to follow tender procedures, to specify the winner and to enter into contracts with contractors

3. To supervise the good performance of works and to compare performed operations with technical specifications and the schedule of the execution of operations and to prepare and send required reports

4. To prepare complementary drawings and details required for the execution of work

5. To recommend alterations and to increase/ decrease work quantities if necessary

6. To examine claims of contractors and to comment about the same

7. To supervise the performance of required tests to control qualities of operations performed

8. To prepare and approve statements

9. To prepare minutes of meeting and relevant instructions

10. To perform services relating to temporary acceptance and to supervise the correction of defects and final acceptance

11. To supervise the tentative operation during the period of temporary acceptance

12. To prepare operation instructions

(Lotfi, 2006)

2.2.4.2 Selection of Contractors and Conclusion of Contracts

This part of phase 3 which is related with the selection of contractors and conclusions of contracts consists of few steps as follows:

2.2.4.2.1 Specification of Effective Factors on Qualification of Contractors

Behnam Jadidi (1994) indicated the most important factors effective on the selection of contractors of high voltage sub-stations as follows:

1. Records of contractors

2. Careful procurement of tools and parts required during the project life cycle

3. Cooperation in presentation of technical data requested by the employer

4. Observance of the contract

5. Flexibility in necessary cases

6. Qualities of training received by the personnel of the operator

7. To respond properly and in a timely manner to correspondence

8. Consistency of technical specifications of constructed equipment with requested specifications

Xhee Wong and Gery Holt (2001) did and are doing numerous researches in the field of classification and selection of contractors. They concluded that the most substantial factors effective on the qualification and evaluation of contractors are as follows:

1. Appropriate equipment and machinery of the project
2. Efficiencies especially in terms of costs and time during the execution of former projects
3. Communication with the employer and consultant
4. Good fame and records

Anna Seager Meriaux and Bengt Hansson (1995) concluded during their researches that the offered price should not be the only basis for evaluation and selection of contractors and that other quantitative and qualitative criteria should not be overlooked. They indicate the most important criteria as follows:

1. Offered price
2. Project control system
3. Capacity to complete the work (both physically and economically)
4. Qualities of the execution of former projects
5. Specialties and experiences of personnel
6. Procedures of choosing sub-contractors
7. Execution time
8. How to protect the environment
9. Esthetics (in projects such as bridges)
10. Secondary recommendations (leading to the reduction of the employer's costs)

Abbas Bidi (2002) indicates the criteria of selection of contractors on the basis of his studies as follows:

1. Financial powers
2. Work records and experiences
3. Equipment and machinery
4. Ability to support the project
5. Existing employees
6. Location of the head office as regards the project site
7. Qualities of the execution of former projects
8. How much safety rules were abided by in former projects?
9. How much other work is being executed by them?
10. Capacity of performance of works
11. Organization structure

It should be noted that there may be further factors for other projects or a number of the mentioned factors may be less important for some projects, because factors effective on the evaluation of contractors and their importance depend on different circumstances of projects. Therefore, it's better to conduct studies in connection with the said factors on the basis of group decisions in scientific logical ways and to determine the importance level of each of them before embarking on the organization of a tender.

2.2.4.2.2 Effective Factors on the Selecting and Prioritizing the Factors of Qualification of Contractors

Factors are selected depending on the fact whether the employer is a private or governmental one. As per statutory and governmental regulations, governmental

employers are required to consider particular factors. The said factors and their levels of importance are provided under relevant instructions.

- **Objectives of employer**

  An employer has objectives on the basis of their own organization. For example, if it matters when a project should be operated, the execution rapidity and observance of schedule will be considered substantial factors.

- **Type of project**

Projects differ one from another depending on their complexities, dimensions and technologies required for execution, needed budgets etc. For example, if a projects needs lots of funding, financial powers of contractors are evaluated as a substantial factor.

- **Required resources**

By required resources of projects, we mean financials resources, equipment and machinery. For instance, if a project needs lots of machinery, the factor of equipment and machinery of contractors will be more important.

- **Execution restrictions**

Execution restrictions constitute factors such as government laws, geographic location of project, access to resources etc. For instance, if a project is located in a mountainous area, the ability of contractors to procure material will involve an important factor during decisions taking processes.

2.2.4.2.3 Preliminary Qualification and Grading of Contractors

By preliminary qualification and grading of contractors before bidding in a tender we aim at crossing out of a number of contractors taking part in the tender and being inappropriate for the tender (enjoying no required financial and technical powers).

Therefore, the number of bidders who are evaluated by the employer for selection are reduced.

A specialty committee will conduct the qualification and grading processes of all contractors. Contractors will be graded in view of qualification criteria such as financial and technical powers. They will present information requested by the committee as well as relevant documents and papers and the said committee will examine the qualification of contractors on the basis of standards and procedures relating to the least financial and technical requirements and will specify their grades which designate ranges of work capacities and technical powers. A list of qualified contractors will be prepared after the above qualification and grading. In the said list there will also be indicated further information such as capacities, bases and work fields.

2.2.4.2.4 Organization of Tender

After executive plans and all documents and papers of a tender have been prepared, the executive operations of the project may be started if the employer is ready in all aspects. The executive operations begin with the selection of contractors and will last until the project is handed over to the employer to be operate the same.

2.3 Selection of Contractors

To select contractors there are numerous ways. Some of them are discussed in the following paragraphs.

2.3.1 Based on Lowest Price

In this method, all received offers will be first studied for the observance of all rules indicated by the employer for bidding in the tender. Offers inconsistent with such rules will be rejected and the remaining offers will be compared with each other on the basis

of prices offered. A contractor offering the lowest price will be announced the winner. In this method, selection will depend on nothing but the offered price and no further quantitative or qualitative factors, such as financial powers, rapidity of doing works, efficiencies during former projects etc., will be taken into account. Disadvantages of this method include, among others, conspiracies of contractors for the winning of a particular contractor, risk of offering a price less than actual prices and then claims of the contractor during the project (Bidi, 2002).

2.3.2 Bracketing Method

To remove disadvantages of selection of contractors on the basis of lowest price a method was devised called bracketing. In this method, prices outside the secure range estimated by the employer will be crossed out. In other words, if the estimated price of the employer is X rials, prices outside the range of $X \pm \delta$, in which δ is considered tolerance, will be crossed out and the lowest price of the remaining offers will be chosen the winner. In this method, prices too higher or too lower than the estimation of the employer will be rejected. δ or the tolerance will be determined in view of the price of work and precision of the estimation of the employer (Bidi, 2002: 9).

2.3.3 Based on Soft Parameters

To evaluate contractors, some parameters are used. Each parameter will be given a certain value depending on how much such parameter meets requirements of the employer. Different levels of importance or weighs are designated for parameters depending on the nature of the project. Each contractor will be given a total value of parameters on a scale of 1 to 5 or 1 to 10. The highest total value will show the winning contractor. Weighs are in the form of numbers showing relative or absolute importance in the evaluation and may be defined in different methods: in one method, each factor

is given a monetary value. In another method, all will be compared and decision will be taken on the basis of the importance of parameters (Bidi, 2002).

2.3.4 Weighting Method

In this method, the employer will first define a number of criteria and will allocate a weight to each of them depending on the nature of the project and objectives of the employer. Then all contractors will be evaluated on the basis of the said criteria. Finally, points allocated to each contractor will be multiplied by the weights of relevant criteria. The result will show the final points of each contractor. After the calculation of the points of contractors, the offered prices of contractors with the highest points close to each other will be examined and the winning contractor will be selected.

In this method, the employer may specify the least points considered and cross out the names of contractors failing to achieve such specified least points (Bidi, 2002: 26).

2.3.5 Best Value Method

The winning contractor will be specified on the basis of technical offers and price offers. Technical and price factors are given different weights; for example, 60% to technical factors and 40% to price ones. A contactor will be acknowledged the winning one if they achieve the best value of the combination of different factors such as offered price.

In this method, efficiencies of contractors are frequently considered as one of the most substantial technical factors (Rounde & Sunayama, 1999).

2.3.6 Two-step Method

The first step constitutes technical proposals in which contractors offer their prices and indicate technical capacities, biographies of personnel, and names of several persons or organizations which may provide the employer with information about works of the

contractor in similar projects. Technical proposals are generally assessed on a scale of 1 to 100 with specification of a least acceptable value (for example 70). Contractors achieving points not less than the least value are invited to the tender of project and others will be crossed out of the list. During the second step, a contractor will be winner if they offer the lowest price (Rounde & Sunayama, 1999).

2.3.7 A + B Method

The method of *A + B* involves a composition of prices of contract items (*A*) and daily costs relating to the time required for completion of the works (*B*). This method, which is also called Cost-Time Bidding, the employer will convert the time offered by the contractor to complete the project to money values on the basis of the values in rials of each day (*B*) and adds it to their offered price (*A*). The resulting figures designate total prices offered by the contractors and will be compared and the lowest amount of *A + B* will show the winning contractor. The employer will determine the value in rials of each day on the basis of considered objectives and strategy. Contractors will endeavor to calculate the shortest possible time (during which they may complete the project) to win the tender. This method may reduce the time of executive operations of the project, because the longer the term of project the higher the amount of *B*, being disadvantageous to them in final assessment.

2.3.8 Bid Average Method (BAM)

In this method, a contractor will be selected the winner if their offered price is closest to the average of all offers. The idea was first appeared in Europe and its proponents wanted to devise a way in which the contractors offer for projects realistic acceptable prices which they believe to be properly calculated. In this way, there would be less further claims by contractors and extensions and costs to defend against such claims,

and no one could simply offer lower prices to win. The best achievements of RAM are in cases when there are lots of bidders in a tender.

2.3.9 Formula Method

Rasel recommended a formula to select contractors based on decision making factors as follows:

(2-7) $AR_k = \sum_{i=1}^{n} W_i \left[\sum_{j=1}^{m} (w_{ij}) (R_{ijk}) \right]$

In which:

AR_k: Final points of the contractor k

n: Number of the main criteria

W_i: Weight of each main criterion i; $i = 1, 2, 3, \ldots, n$

m_i : The number of sub-criteria of the main criterion i

w_{ij}: The weight of the sub-criterion j; $j = 1, 2, 3, \ldots, m$

R_{ijk}: The points allocated to the contractor k in connection with the sub-criterion j of the main criterion I during the evaluation of that contractor.

(2-8) $$\omega_{ij} = \frac{DFMI_{ij}}{\sum_{j=1}^{m_i} DFMI_{ij}}$$

(2-9) $$\overline{CF_1} = \frac{\sum_{j=1}^{m_i} DFMI_{ij}}{m_i}$$

(2-10) $$W_i = \frac{\overline{C}F_i}{\sum_{i=1}^{n} CF_i}$$

$DFMI_{ij}$ is the number or value given by the employer to criteria depending on the importance of each sub-criterion j on the basis of a single scale (Bidi, 2004).

2.4 Decision-making

Everyone is encountered with various circumstances for decision making every day. Decision may be needed to select one of the choices of study, swimming, TV watching, walking etc. to spend free times on a holiday or selection of a contractor from among applicants to build a dam, selection of a scenario from among those ones sent to produce a film, and/or determination of the price of goods in view of expected profits.

Decision making is counted to be the basic element of all duties and operations of management, because any manager is always encountered with situations needing decisions to execute his duties, planning, organization, leading and supervision. All decisions of directors are not of the same importance for the organization. Some decisions effect on so many members of the organization and need lots of funds to be executed and/or have long term effects on the organizations.

Other decisions may be of no much importance and effect on a few members of the organization and need a little fund for execution and have only short term effects on the organization. In any case, nature of decisions of managers is a decisive factor of their success in the management of the organization and realization of the objectives of the organization (Feizi, 2008).

- **Definition of decision making**

Decision making means the selection of one way from among various ones and, in fact, the selection of the best way to achieve objectives. This is a very simple definition of decision making. On the other hand, decision making is a process composing of different stages rather than a simple action. So, decision making may be defined as a process consisting of definition of problem, evaluation of solutions, decision making

(choosing solutions), execution of a decision, and assessment of results. Decision making is related to all management duties. However, it is counted to be the basis of planning, because one cannot say that there is a plan except he admits that a decision has been made (Feizi, 2008).

Decision making is the process of finding the best case from among available options. He in nearly all cases of decisions making, The decision maker is not ensured whether the results of various solutions are correct, because there are numerous criteria. Therefore, the decision maker wishes to select a method of execution of operations to achieve more than one objective (Zeleny, 1982).

- **Various problems**

Usually when the existing circumstances differ from those expected or wished by a director, there is a problem to be resolved by the director. Management problems are of different dimensions and forms. The type of problem a manager is encountered with during decision making usually defines how to face with such problem.

Some problems in the organization are known, easy and with no complexity. Objectives of such decision makings are clear and there are complete accessible information about them. For instance, the returning back of purchased goods to a retail shop within specified deadline, application for deletion of a university course in the faculty, and down payments to applicant needy employees are problems faced by managers and called good structured problems.

Nonetheless, directors are frequently encountered with bad structured problems. Such problems are new and unusual and there are only ambiguous insufficient information about them. For instance, an architect who wants to choose a design for the façade of

a building is encountered with several problems. A company wishing to invest in the field of a new unknown technology is also encountered with a bad structured problem (Feizi, 2008).

- **Various decisions**

Directors decide about various issues. However, all the decisions are not similar. Some decisions are made repeatedly. Therefore, they need much farsightedness. Others are repeated less frequently and are not counted to be routine decisions. They may occur only once during the carrier of a director. Decisions are generally classified under two categories of planned and unplanned.

Planned decisions are used more to resolve good structured problems. On the other hand, when a problem is bad structured, directors are forced to rely on unplanned decisions to find unique solutions.

When circumstances happen frequently or such circumstances are good structured and regular, a director will make planned decisions. Planned decisions are made easily on the basis of written or unwritten procedures, rules or policies in repeated circumstances with applying restrictions or exceptions on solutions. For instance, directors are seldom worried about salaries of new employees, because organizations have usually regulations about salaries and remunerations of all positions. There are usually uniform procedures to take actions about routine issues such as cleaning of buildings, preparation of orders of clients, balance of cash in vault etc. When a problem repeats and its components are analyzable, foreseeable and definable, a plan may be devised to handle such problem.

Of course, planned decisions restrict our maneuvers, because the organization decides instead of the individual. Nevertheless, such plans help directors to have more free times to handle other problems. Procedures, rules and policies used by directors in connection with planned decisions contribute to the saving of time and allow directors to allocate their time to more important operations. For example, making decisions about how to deal with complaints of clients one by one leads to waste of time and fund. However, a policy which states that: "All purchased goods may be replaced within 14 days" considerably facilitates the issue.

Unplanned decisions deal with unusual, exceptional and bad structured issues. If a problem is not sufficiently repeated to specify a policy or if it is so important to require a particular policy, such problem should be resolved with unplanned decisions; for example, how to allocate human resources, how to deal with defects in production lines, how to present a new product to the market.

In fact, most important problems directors are encountered with require unplanned decisions. Furthermore, the higher position a person occupies in an organization the more important are unplanned decisions for him (Feizi, 2008).

2.4.1 Multiple Criteria Decisions-making

There are many cases where decisions are desirable and satisfactory for their makers which are examined and analyzed on the basis of several criteria. For instance, when choosing a carrier, one considers criteria such as monthly income, place of work, social status … and when planning the production, one considers objectives such as maximizing incomes, minimizing costs, reducing wastes, increasing satisfaction of employees, ….

Only one criterion, such as profit, cost, efficiency, time etc. is considered in models such as linear planning, integer planning, nonlinear planning, allocation, and most classical models of operational research. On the other hand, in multiple criteria decision making models, several criteria are simultaneously used to determine the best choice.

Criteria may be quantitative or qualitative and may be incomparable because there are different measurement scales. In some issues, criteria may be opposite each other. In other words, the rise of one factor may cause the fall of another one. During multiple criteria decision making we are usually in search of a choice presenting the most advantages for all the criteria.

In determination of different options of a decision, criteria mean factors considered by the decision maker to increase desirability and his own satisfaction. In other words, criteria constitute standards and rules used for judgment and to indicate effectiveness of decisions. Criteria may be presented as attributes or objectives.

Attributes are characteristics, qualities or parameters of operations considered for selection of options of decisions. Attributes may be quantitative or qualitative. Qualitative attributes are usually expressed in terms of words. Words such as few, many, average, low price, high price, small, big …, are those expressing how much an attribute is achieved. On the other hand, quantitative attributes are expressed in terms of numbers.

To examine or compare qualitative attributes, we may convert them to numbers. To do this, we arrange works such as few, average, many, so many. Then we assign numbers

to the beginning and end points and we allocate numbers to other points on the same basis. We compare attributes to determine the importance of every one of them in the selection of options. Finally, after determination of the weights of attributes in decision making, the selection will be made in view of points an option has as compared with other options. If a decision is made on the basis of several attributes, then we are encountered with issues known as "multiple attribute decision making".

Objectives involve desires or wishes of the decision maker which may be expressed with terms such as maximizing profit, minimizing costs … When encountered with problems decision makers may follow simultaneously several objectives. Such problems may be examined as "multiple objective decision making". In dealing with such problems, the decision maker's objectives are expressed as several functions of objectives and solution constitutes the optimization of such functions. Objectives may be expressed with different measurement scales such as money, time, number … For example an objective may be the minimization of costs and another may be maximization of production. Another point is that objectives may differ in terms of importance and priority and this point should be taken into account during solution of problems (Mehregan, 2009).

2.4.1.1 Multiple Attribute Decision-making

In such cases, several options are analyzed and prioritized. Sometimes, instead of .options, its synonyms are used, such as strategies, solutions … As we can understand from the term "multiple attribute decision making", there are several attributes and the decision maker should specify them precisely in problems. Such attributes are examined in connection with every option.

Models of multiple attribute decision making are divided into two major categories:

- **Non trade-off model**

It involves methods in which no trade-off is permissible between attributes. In other words, disadvantages of an attribute will not be traded off with advantages of another one. Hence, in such methods, every attribute is considered alone and comparisons will be made for every attribute alone (Asgharpour, 2004).

Non trade-off methods are as follows:

1. Dominate method
2. Maximin method
3. Conjunctive satisfying method
4. Special satisfying method
5. Lexicographic method
6. Elimination method
7. Permutation method

- **Trade-off model**

It constitutes methods allowing trade-offs between attributes. For instance, disadvantages of an attribute may be traded off with advantages of another one. This model is classified under three subgroups as follows:

1. Scoring subgroup

In this subgroup we try to estimate a satisfaction function for every option. Then, we will select an option with the most satisfaction. Therefore, the problem with this subgroup is the estimation of multiple attribute satisfaction function. There are methods for this subgroup as follows:

- Simple additive weighting method

- Hierarchical additive weighting method
- Interactive simple average weighting method (Asgharpour, 2004).

2. Compromising subgroup

The second subgroup of the trade-off model is known as compromising subgroup. An option will be preferred in this subgroup that is closest to the ideal solution. The methods of this subgroup are as follows:

- Linear programming for multidimensional preferences (LINAMP)
- Technique for order preference by similarity to ideal solution (TOPSIS)
- Marginal rate of substitution of attributes (MRS)
- Multidimensional scaling with ideal point (MDS) (Asgharpour, 2004).

3. Concordance subgroup

The third subgroup of the trade-off model is the concordance subgroup, whose output is a set of ranks so that there will be the most appropriate concordance. This subgroup includes methods as follows:

- Elimination and choice translating reality (ELECTRE)
- Linear assignment (Asgharpour, 2004).

Analytic hierarchy process (AHP)

The analytic hierarchy process was proposed by an Iraqi named Saaty in 1970. This process analyzes problems in the same way it is done in the human brain. Analytic hierarchy process enables decision makers to determine interactive and simultaneous effects of many complex indefinite circumstances. This process helps decision makers to arrange priorities on the basis of their own objectives, knowledge and experiences, so that they may consider all their feelings and judgments. To solve problems of decision making by analytic hierarchy process,

one should define and describe problems carefully with all details and illustrate details as a hierarchical structure.

On the basis of analytic hierarchy process, the subject matter of decision making has a tree whose first level is objective, the last level is competing options, and the middle level(s) will be decision attributes. To gather data, one should evaluate elements existing on every level as compared with related elements of higher levels from the lower levels to the higher ones (Zaree, 2006). Analytic hierarchy process is founded on three principles:

- **Illustration of hierarchy tree**

On the basis of this principle, it is difficult to understand a problem in its general complex form and one may overlook different important dimensions of the problem. Therefore, it will be very helpful to understand problems if we divide a general problem to the smaller ones. In fact, when a big problem is divided into smaller ones, the existing relationships between smaller elements are expressed in way to understand subject relationships and concepts of decision making and to understand also relations of every element with other ones. Doing so, there will be the hierarchy tree of decision and it is so helpful to understand the problem (Momeni, 2010).

- **Specification of priorities**

One cannot understand a problem in its general form. Therefore, one divides it to smaller ones and compares every couple of them in view of definite criteria and determines priorities of one option to another one. Then such results are inserted into various models of decision making to present a better understanding of the entire system.

- **Reasonable consistency of judgments**

The human brain may establish relations between elements in a way that there will be reasonable consistency between them (Momeni, 2010). Algorithm of classical analytic hierarchy process: First, problems should be analyzed and divided to several simpler parts. After options and attributes have been specified, we compare couple attributes with each other. Then, we compare couple options with each other for every attribute. Then we follow the following algorithm:

1. To normalize the matrix of comparison of couple elements
2. To calculate arithmetic mean of each row of normalized matrix of comparison of couple elements
3. To multiply relative weights of attributes by the arithmetic mean of options
4. To grade options

Then we deal with the measurement of rate of inconsistency. To do this we follow steps as follows:

First step: To calculate weighted sum vector *(WSV)*

We multiply the matrix of comparison of couple elements by vector of relative weights. The resulting vector is called weighted sum vector *(WSV)*

(2-11) $WSV = D * W$

Second step: To calculate consistency vector *(CV)*

We divide elements of the weighted sum vector by the vector of relative weights.

Third step: To determine the highest Eigen value of the matrix of comparison of couple elements (λ_{max})

To determine the heist Eigen value of the matrix of comparison of couple elements, we will calculate the average of elements of the consistency vector.

Fourth step: To determine inconsistency index *(II)*

(2-12) $II = (\lambda_{max} - n) / (n-1)$

Fifth step: To determine inconsistency ratio *(IR)*

(2-13) $IRR = II / IRI$

Here, *IRI* (inconsistency random factor) is a value received from table 2.

Table 2. Determination of inconsistency random factor

N	1	2	3	4	5	6	7	8	9	10
IRI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.51

If the consistency ration is lower than or equal to 0.10, there is consistency between couples and we may continue the work. Otherwise, the decision maker should revise compared couples. It should be noted that the scale of 1 to 9 is used to insert numbers in the matrix of compared couples to determine relative importance of every element as compared with other elements (Momeni, 2010).

Classical TOPSIS

TOPSIS was proposed by Hwang & Yoon on 1981. This method is one of the best multi attribute decision making methods and is used frequently. In this method, m options are evaluated by n attributes. The option selected in this method should be closest to the positive ideal and farthest from the negative ideal (Hwang and Yoon, 1981).

To solve the problem one is required to follow six steps as follows:

1. To quantify and neutralize scales of the decision matrix (N)

2. To determine the weighted non-scale matrix (V)

We multiply the non-scale matrix by the diagonal weight matrix (W_{n*n})

3. To determine positive ideal solution and negative ideal solution

[The vector of the best values of each attribute of matrix V] = positive ideal solution (V_j^+)

[The vector of the worst values of each attribute of matrix V] = negative ideal solution (V_j^-)

4. To determine distances of every option to positive and negative ideals:

The Euclidean distance of every option to the positive ideal and the distance of every option to the negative ideal will be calculated on the basis of formulations as follows:

(2-14) $d_i^+ = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^+)^2} \quad i = 1, 2, ,..., m$

(2-15) $d_i^- = \sqrt{\sum_{j=1}^{n}(v_{ij} - v_j^-)^2} \quad i = 1, 2,,...,m$

5. To determine relative closeness (CL_i) of an option to the ideal solution

(2-16) $CL_i = d_i^- / (d_i^+ + d_i^-)$

6. To grade options

The bigger the CL_i of an option the better such option (Momeni, 2010)

2.4.1.2 Fuzzy Multiple Attribute Decision-making

In real problems, as there is not sufficient proper information for decision making, and as most priorities and judgments are ambiguous and unclear and as they may not be converted to proportionate numerical values, the weights of criteria and ratios of options are expressed with language variables. In these circumstances, the theory of fuzzy sets is one of the best tools to express certainty.

The theory of fuzzy sets, whose leading proponent was Lotfizadeh, is a mechanism to express uncertainty in precise or mental determination of priorities, restrictions

and objectives which is merged with the multiple criteria decision making method in many concepts and processes when we are encountered with uncertain circumstances (Wang and Elhang, 2006).

2.4.1.2.1 Fuzzy AHP

Mr. Professor Saaty defines two types of fuzzy cases. One is fuzzy perception of phenomena and precision and the other is fuzzy meaning which depends on the operation of phenomena. Nonetheless, Mr. Saaty does not use directly fuzzy numbers, but he uses indirect fuzzy of proportions of a_{ij} together with a hierarchy structure.

In 1983 the method of AHP was developed by researchers in a way that if for example the option A_1 is considered to be more important than A_2, then $a_{12} = w_1 / w_2$ may be expressed approximately for example 3 / 1 or 5 / 1 or between 6 / 1 and 8 / 1. This type of approximation may be consistent with trapezoid or triangle fuzzy numbers.

Furthermore, researchers may use several decision makers to compare couples of elements. In this way the opinions of all of them should be combined with each other to form the basis of decision making. Laarhoven & Pedrycz use the method of least logarithm squares to calculate fuzzy AHP with several decision makers on 1983. The proportions of a_{ij} are expressed as triangle fuzzy numbers in this method, as follows:

(2-17) $$Min: \sum_{i<j}^{l_{ij}} \sum_{k=l}^{l_{ij}} (\ln a_{ijk} - \ln(w_i / w_j))^2; k = 1,2,...,l_{ij}$$ (Asgharpour, 2004)

Another researcher, named Buckley, used trapezoid fuzzy numbers to determine weights of elements by geometric mean of rows of matrix (Asgharpour, 2004).

(2-18) $W_i = [\prod_{j=1} a_{ij}]^{(1/n)}$ $u_i = \sum (w_i)\ (n_{ij})$

In 1996 a Chinese researcher, Chang, developed another method called Extent Analysis (EA). Numbers used in this method are triangle fuzzy numbers (Momeni, 2010).

The method developed by Chang was based on arithmetic mean of comparisons. In EA, for each rows of the matrix of compared couples, a value of S_k, which is itself a triangle number, is determined as follows:

(2-19) $S_k = \sum_{j=1}^{n} M_{kj} [\sum_{i=1}^{m} \sum_{j=1}^{n} M_{ij}]^{-1}$

In which *K* indicates the row number and *i* and *j* designate respectively options and attributes.

In the method of EA, after calculation of S_k, we should determine their relative largeness degree as compared with each other. In general, if M_1 and M_2 are two triangle fuzzy numbers, we show the largeness grade of M_1 to M_2 with V ($M_1 \geq M_2$) defined as follows:

(2-20) $V (M_1 \geq M_2) = 1$ *if* $M_1 \geq M_2$

$V (M_1 \geq M_2) = hgt (M_1 \cap M_2)$ *otherwise*

Furthermore,

(2-21) $hgt (M_1 \cap M_2) = (u_1 - l_2) / [u_1 - l_2] + (m_2 - m_1)]$

The largeness grade of a triangle fuzzy number is determined from *k* other triangle fuzzy number as follows:

(2-22) $V (M_1 \geq M_2, \ldots, M_k) = Min [V (M_1 \geq M_2), \ldots V (M_1 \geq M_k)]$

In EA, to determine weights of attributes in the matrix of compared couples we will do as follows:

(2-23) $W'_{(xi)} = Min\ [V\ (S_i \geq S_k)]$ $\quad k = 1, 2, \ldots, n, k \neq i$

Hence, the vector of attribute weights will be as follows:

(2-24) $W' = [W'(c_1, \ldots, W'(c_n)]^T$

Which is the same vector of fuzzy abnormal indexes of AHP (Momeni, 2010).

2.4.1.2.2 Fuzzy TOPSIS

In today's world, where complexities and uncertainties are increasing, it was tried to use the model of TOPSIS in accordance with such conditions using speech and language variables, in other words non-numerical variables. In fuzzy TOPSIS, before any calculation, qualitative words are first converted to fuzzy numbers with appropriate criteria (Opricovic and Tzeng, 2004).

Existing fuzzy TOPSIS are more involved in arithmetic operations of fuzzy numbers (Lo et al, 2010). The fuzzy theory is of course used fully successfully in production management. Use of fuzzy theories as a methodology in modeling and analysis of decision making systems is particularly interesting for researchers dealing with decision making for difficult problems. The technique of fuzzy TOPSIS, introduced by Chen consists of following steps in view of the nature of this research.Suppose the decision matrix is as follows:

$$D = \begin{pmatrix} x_{11}, \ldots, x_{1n} \\ . \\ . \\ x_{m1}, \ldots, x_{mn} \end{pmatrix}$$

In which $x_{ij} = (a_{ij}, b_{ij}, c_{ij})$.

First step: Formation of fuzzy normalized matrix

During this step, we will normalize the matrix or make it independent from scales. The method we used in this research was a linear method as Chen & Huang did (1992). To do this the maximum value of each column x_j^+ and the minimum value of each column x_j^- should be determined and, using the following relation, we will calculate the scale free value of X_{ij}. When X_{ij}s are fuzzy, they will be as triangle numbers: $x_{ij} = (a_{ij}, b_{ij}, c_{ij})$. r_{ij} will be fuzzy too. Now, if $c_j^+ = max\ c_{ij}$ and $a_j^- = min\ a_{ij}$ are respectively the maximum and minimum points, we will have:

(2-25) $r_{ij} = [a_{ij} / c_j^+, b_{ij} / c_j^+, c_{ij} / c_j^+]$

$r_{ij} = [a_j^- / c_{ij}, a_j^- / b_{ij}, ca_j^- / a_{ij}]$

The first relation happens when the j^{th} criterion has a positive aspect and the 2nd relation happens when the j^{th} criterion has a negative aspect.

Hence, the matrices of D is converted to the normalized matrices of D':

$$D = \begin{pmatrix} r_{11},\ldots,r_{1n} \\ . \\ . \\ r_{m1},\ldots,r_{mn} \end{pmatrix}$$

Second step: Creation of normalized balanced matrix

This matrix is created by multiplying the column elements of the matrix D' by the corresponding weights of the criteria of each column and the elements of normalized balanced matrix may be calculated for triangle fuzzy numbers using the following relation:

(2-26) $V_{ij} = r_{ij} * w_j = [a_{ij} / c_j^+, b_{ij} / c_j^+, c_{ij} / c_j^+] * (\alpha_j, \beta_j, \gamma_j)$

$= [a_{ij} / c_j^+ * \alpha_j, b_{ij} / c_j^+ * \beta_j, c_{ij} / c_j^+ * \gamma_j]$

$V_{ij} = r_{ij} * w_j = [a_j^- / c_{ij}, a_j^- / b_{ij}, ca_j^- / a_{ij}] * (\alpha_j, \beta_j, \gamma_j)$

$= [a_j^- / c_{ij} * \alpha_j, a_j^- / b_{ij} * \beta_j, ca_j^- / a_{ij} * \gamma_j]$

The results of the calculations are inserted in the matrix *v* as follows:

$$v = \begin{pmatrix} v_{11},\ldots,v_{1n} \\ . \\ . \\ v_{m1},\ldots,v_{mn} \end{pmatrix}$$

Third step: Specification of fuzzy positive ideal and fuzzy negative ideal

The positive ideal and negative ideal are shown respectively with A^+ and A^-.

(2-27) $A^+ = (v_1^+, v_2^+, \ldots, v_n^+)$

$A^- = (v_1^-, v_2^-, \ldots, v_n^-)$

In this research the fuzzy positive ideal and fuzzy negative ideal presented by Chen are used. Such values are as follows:

(2-28) $v_j^+ = (1, 1, 1)$

$v_j^- = (0, 0, 0)$

Fourth step: Calculation of total distances of each component from the fuzzy positive ideal and the fuzzy negative ideal

If *A* and *B* are two fuzzy numbers as follows:

$A = (a_1, b_1, c_1)$

$B = (a_2, b_2, c_2)$

Then, the distance between the two fuzzy numbers are determined by relation (2-25).

(2-29) $D(A, B) = [1/3 [(a_2 - a_1)^2 + (b_2 - b_1)^2 + (c_2 - c_1)^2]]^{1/2}$

In view of the above explanations about the way in which the distance between the two fuzzy numbers are calculated, the distance of each component from the positive ideal and the negative ideal is determined as follows:

(2-30) $d_j^+ = \sum_{j=1}^{n} d(v_{ij} - v_j^*) \qquad i = 1, 2, \ldots, m$

$d_j^- = \sum_{j=1}^{n} d(v_{ij} - v_j^-) \qquad i = 1, 2, \ldots, m$

Fifth step: Determination of relative closeness of each option to the ideal solution

The relative closeness of each option to the ideal solution may be calculated as follows:

(2-31) $CC_i = d_j^- / (d_j^+ + d_j^-)$

Sixth step: Grading of options

The final stage of the technique of fuzzy TOPSIS will be the grading of options in the descending order of $CC_i s$ (Chen, 2000).

2.5 Brief Introduction of the Sistan & Baluchistan Province Gas Company

Gas Company of Sistan & Baluchistan has been established in 2008 in the largest province in Iran with an area of over 187,502 square kilometers, which is including 11.4 percent of the country's total area. In order to launch and initial implementation of gas delivery projects, the gas company in Tehran was chosen as specified province and in the same year, the first group of technical staff in the company were employed through written tests and interviews and the first project of gas supplying by the company was carried out.

Sistan & Baluchistan province is supplied gas through seventh overall pipeline with length of 907 km and diameter as 56 inches, which across the Bushehr, Hormozgan and Kerman provinces. Now the city of Iranshahr as the first city is in favor of natural gas. Gas delivering to the south of this province in order to export gas to the neighbor country Pakistan, with a diameter of 56 inches of shaft 250, as well as gas supplying to the cities of Sarbaz, Nikshahr, Sib and Suran, Chabahar, Kenarak, Saravan and other cities to employ natural gas in residential, commercial, office, industrial, petrochemical goals and plants equipment which are needed. The following project is to supply gas to the north of this province to exploit the gas as residential, commercial,

office, industrial, power plants etc uses. These cities are Khash and Zahedan, Zabul, Hirmand, Zahak and it is also connected to the gas network in South Khorasan province which is the north neighbor of Sistan & Baluchistan province to boost the gas network progress.

Selection of contractors by governmental companies involves particular restrictions and should be made as per the rules and regulations of the organization of tenders as well as decisions of the Vice President of Republic in Planning and Strategic Supervision. On the other hand, contractors should be chosen in a way leading to the selection of qualified ones to prevent wastes of capitals and time arising out of inabilities and inefficiencies of contractors. Therefore, executive organizations should pay serious attention to the importance of criteria and sub-criteria for qualification of contractors. In view of the provisions of the by-law of organization of tenders, such criteria may be applied to transactions with prices exceeding 20 times the price of average transactions.

Taking into account the conditions and requirements of executive body, importance of criteria and sub-criteria vary. Therefore, relevant criteria and sub-criteria should be used in each organization considering corresponding weights in accordance with circumstances of such organization. In view of the importance of group decision making and also the ambiguous and indefinite natures of criteria and sub-criteria, the best choices are use of group decision making and application of fuzzy methods to determine the importance of criteria and to select qualified contractors. Therefore, in view of the above, we have dealt first with the description of statutory requirements of the organization of tenders in this chapter. Then, project structures were examined and reviewed. Next, we studied methods of selection of contractors. Finally, there were the

important topics of decision making and different methods thereof, particularly fuzzy methods and numerous models of application of fuzzy methods.

Chapter 3

DATA ANALYSIS AND RESULTS

Data analysis is a multistep process in which the data is provided through the use of tools of collecting statistical sample (population), summary, coding and classification, and finally they would be processed. By analyzing and studying the relation between theses collected data the hypothesis can be tested. In the process, data are refined both conceptually and empirically and various statistical techniques play a significant role in inference and generalization (Khaki, 2004).

3.1 Determining the Criteria and Sub-criteria to Assess the Competence of Contractors

Initially statistical population consisted of 12 experts of the unit of implementation of projects, members of the technical, commercial ,contract affairs committee are determined. Questionnaires were distributed among the selected respondents. Ten of the selected experts completed the survey, while; two of them rejected to participate. Four of the experts who filled questionnaires were from the executing department, three were from the contract committee and the other three were from the technical and commercial committee. It should be mentioned that the criteria and sub-criteria of competency measures via library studies and considering the constraints and requirements of the law of tenders which are previously specified and respondents determine rate of the importance of criteria and sub-criteria by linguistic variables. In the next step, each of the linguistic variables which are used in the questionnaire was adjusted and equivalent with triangular fuzzy numbers. These equivalent triangular

fuzzy numbers are shown in [Table 3].

Table 3. Equivalent triangular fuzzy number with linguistic variables

Number	Linguistic variable	Triangular fuzzy number		
		l	*m*	*u*
1	Very less important	0.25	0.33	0.5
2	Less important	0.33	0.5	1
3	Equally important	0	1	2
4	More important	1	2	3
5	Very more important	2	3	4

The data which are gathered from questionnaires are inserted to the EXCEL software and the related criteria and sub-criteria tables are obtained according to the equivalent linguistic variables. As the weight of each respondent is equal to the others, the average of the answers are shown in form of triangular fuzzy numbers. These tables are illustrated in the followings.

Table 4 illustrates the participants' answer to the first question of the questionnaire related to the importance of executive records compared to the good records criteria.

Table 4. Importance of executive records compared with good records

The criteria of executive records compared with the criteria of good records				
Equivalent triangular fuzzy number			**Linguistic variables**	**Experts**
l	***m***	***u***		
0.33	0.5	1	Less important	1
0.33	0.5	1	Less important	2
1	2	3	More important	3
0	1	2	Equally important	4
1	2	3	More important	5
0.33	0.5	1	Less important	6
0	1	2	Equally important	7
0.25	0.33	0.5	Very less important	8
1	2	3	More important	9
0	1	2	Equally important	10
0.424	1.083	1.85	**Average**	

Table 5 shows the participants' answer related to the importance of executive records compared to the financial powers criteria.

Table 5. Importance of executive records compared with financial powers

The criteria of executive records compared with the criteria of financial powers				
Equivalent triangular fuzzy number			**Linguistic variables**	**Experts**
l	***m***	***u***		
0,33	0,5	1	Less important	1
0,33	0,5	1	Less important	2
0	1	2	Equally important	3
0	1	2	Equally important	4
1	2	3	More important	5
1	2	3	More important	6
1	2	3	More important	7
0,33	0,5	1	Less important	8
0	1	2	Equally important	9
1	2	3	More important	10
0,499	1,25	2,1	**Average**	

Table 6 shows the participants' answer related to the importance of executive records compared to the technical and planning capacities criteria and Table 7 compares executive records with equipment and machinery.

Table 6. Importance of executive records compared with technical and planning

The criteria of executive records compared with the criteria of technical and planning capacities				
Equivalent triangular fuzzy number			**Linguistic variables**	**Experts**
l	***m***	***u***		
0	1	2	Equally important	1
2	3	4	Very more important	2
1	2	3	More important	3
0,33	0,5	1	Less important	4
0	1	2	Equally important	5
1	2	3	More important	6
1	2	3	More important	7
0,33	0,5	1	Less important	8
2	3	4	Very more important	9
0,33	0,5	1	Less important	10
0,799	1,55	2,4	**Average**	

Table 7. Importance of executive records compared with equipment and machinery

The criteria of executive records compared with the criteria of equipment and machinery				
Equivalent triangular fuzzy number			**Linguistic variables**	**Experts**
l	***m***	***u***		
0	1	2	Equally important	1
1	2	3	Very more important	2
0	1	2	More important	3
1	2	3	Less important	4
0	1	2	Equally important	5
0,33	0,5	1	More important	6
1	2	3	More important	7
1	2	3	Less important	8
0,33	0,5	1	Very more important	9
0	1	2	Less important	10
0,466	1,3	2,2	**Average**	

Table 8 shows the participants' answer related to the importance of good records compared to the financial powers criteria and Table 9 compares good records with technical and planning.

Table 8. Importance of good records compared with financial powers

The criteria of good records compared with the criteria of financial powers				
Equivalent triangular fuzzy number			**Linguistic variables**	**Experts**
l	***m***	***u***		
1	2	3	More important	1
1	2	3	More important	2
0.33	0.5	1	Less important	3
1	2	3	More important	4
0	1	2	Equally important	5
0.33	0.5	1	Less important	6
0	1	2	Equally important	7
1	2	3	More important	8
0	1	2	Equally important	9
0	1	2	Equally important	10
0,466	1,3	2,2	**Average**	

Table 9. Importance of good records compared with technical and planning capacities

The criteria of good records compared with the criteria of technical and planning capacities				
Equivalent triangular fuzzy number			**Linguistic variables**	**Experts**
l	***m***	***u***		
1	2	3	Less important	1
1	2	3	Less important	2
0.33	0.5	1	Equally important	3
0.33	0.5	1	Equally important	4
0	1	2	More important	5
1	2	3	More important	6
2	3	4	More important	7
1	2	3	Less important	8
1	2	3	Equally important	9
0.33	0.5	1	More important	10
0,799	1,55	2,4	**Average**	

Table 10 shows the participants' answer related to the importance of good records compared to the equipment and machinery criteria and Table 11 compares financial powers with technical and planning capacities.

Table 10. Importance of good records compared with equipment and machinery

The criteria of good records compared with the criteria of equipment and machinery				
Equivalent triangular fuzzy number			**Linguistic variables**	**Experts**
l	***m***	***u***		
1	2	3	More important	1
1	2	3	More important	2
0.33	0.5	1	Less important	3
1	2	3	More important	4
0	1	2	Equally important	5
0	1	2	Equally important	6
1	2	3	More important	7
0	1	2	Equally important	8
2	3	4	Very more important	9
0.33	0.5	1	Less important	10
0,666	1,5	2,4	**Average**	

Table 11. Importance of financial powers compared with technical and planning

The criteria of financial powers compared with the criteria of technical and planning capacities				
Equivalent triangular fuzzy number			**Linguistic variables**	**Experts**
l	***m***	***u***		
0	1	2	Equally important	1
1	2	3	More important	2
1	2	3	More important	3
0.33	0.5	1	Less important	4
0	1	2	Equally important	5
1	2	3	More important	6
1	2	3	More important	7
0.33	0.5	1	Less important	8
1	2	3	More important	9
0	1	2	Equally important	10
0,566	1,4	2,3	**Average**	

Table 12 shows the participants' answer related to the importance of financial powers compared to the equipment and machinery criteria and Table 13 compares technical and planning capacities with equipment and machinery.

Table 12. Importance of financial powers compared with equipment and machinery

The criteria of financial powers compared with the criteria of equipment and machinery				
Equivalent triangular fuzzy number			**Linguistic variables**	**Experts**
l	***m***	***u***		
1	2	3	More important	1
0	1	2	Equally important	2
0	1	2	Equally important	3
1	2	3	More important	4
0	1	2	Equally important	5
0.33	0.5	1	Less important	6
0.33	0.5	1	Less important	7
1	2	3	More important	8
2	3	4	Very more important	9
1	2	3	More important	10
0,666	1,5	2,4	**Average**	

Table 13. Importance of technical and planning capacities compared with equipment and machinery

The criteria of technical and planning capacities compared with the criteria of equipment and machinery				
Equivalent triangular fuzzy number			**Linguistic variables**	**Experts**
l	***m***	***u***		
1	2	3	More important	1
0	1	2	Equally important	2
1	2	3	More important	3
0	1	2	Equally important	4
0	1	2	Equally important	5
0	1	2	Equally important	6
1	2	3	More important	7
0.33	0.5	1	Less important	8
1	2	3	More important	9
1	2	3	More important	10
0,533	1,45	2,4	**Average**	

Each of the following tables compare a pair of sub-criteria related to the main criteria.

Table 14 and Table 15 compare two sub-criteria of good records.

Table 14. Importance of performance quality compared with efficiencies of technical manager

Criteria of good records				
The importance of sub-criteria performance qualities compared to the sub-criteria efficiencies of technical manager				
Equivalent triangular fuzzy number			**Linguistic variable**	**Experts**
l	***m***	***u***		
1	2	3	More important	1
0	1	2	Equally important	2
1	2	3	More important	3
0	1	2	Equally important	4
0	1	2	Equally important	5
0	1	2	Equally important	6
1	2	3	More important	7
0,33	0,5	1	Less important	8
1	2	3	More important	9
1	2	3	More important	10
0,533	1,45	2,4	**Average**	

Table 15. Importance of performance quality compared with realization of time schedule objectives

Criteria of good records				
The importance of sub-criteria performance qualities compared to the sub-criteria realization of time schedule objectives				
Equivalent triangular fuzzy number			**Linguistic variable**	**Experts**
l	***m***	***u***		
0	1	2	Equally important	1
0	1	2	Equally important	2
1	2	3	More important	3
1	2	3	More important	4
1	2	3	More important	5
0	1	2	Equally important	6
0	1	2	Equally important	7
1	2	3	More important	8
0	1	2	Equally important	9
0,33	0,5	1	Less important	10
0,433	1,35	2,3	**Average**	

Table 16 compares the answers of the respondents related to two sub-criteria which are efficiency of technical manager and realization of time schedule objectives. Table 17 compares efficiency of key employees with efficiency of technical manager.

Table 16. Importance of efficiency of technical manager compared with realization of time schedule objectives

Criteria of good records				
The importance of sub-criteria efficiencies of technical manager compared to the sub-criteria realization of time schedule objectives				
Equivalent triangular fuzzy number			**Linguistic variable**	**Experts**
l	***m***	***u***		
0	1	2	Equally important	1
0,33	0,5	1	Less important	2
2	3	4	Very more important	3
1	2	3	More important	4
1	2	3	More important	5
0	1	2	Equally important	6
0,33	0,5	1	Less important	7
1	2	3	More important	8
0,33	0,5	1	Less important	9
0,33	0,5	1	Less important	10
0,632	1,3	2,1	**Average**	

Table 17. Importance of efficiency of key employees compared with capacities of planning and project control

Criteria of technical and planning capacities				
The importance of sub-criteria efficiencies of key employees compared to the sub-criteria capacities of planning and project control				
Equivalent triangular fuzzy number			**Linguistic variable**	**Experts**
l	***m***	***u***		
0	1	2	Equally important	1
0	1	2	Equally important	2
2	3	4	Very more important	3
1	2	3	More important	4
1	2	3	More important	5
0	1	2	Equally important	6
0	1	2	Equally important	7
0,33	0,5	1	Less important	8
1	2	3	More important	9
1	2	3	More important	10
0,633	1,55	2,5	**Average**	

Table 18, 19 and 20 are comparing sub-criteria of equipment and machinery pairwise.

Table 18. Importance of drilling machinery compared with transport machinery

Criteria of equipment and machinery				
The importance of sub-criteria drilling machinery compared to the sub-criteria transport machinery				
Equivalent triangular fuzzy number			**Linguistic variable**	**Experts**
l	***m***	***u***		
1	2	3	More important	1
1	2	3	More important	2
1	2	3	More important	3
0	1	2	Equally important	4
0	1	2	Equally important	5
1	2	3	More important	6
0	1	2	Equally important	7
0	1	2	Equally important	8
2	3	4	Very more important	9
0,33	0,5	1	Less important	10
0,633	1,55	2,5	**Average**	

Table 19. Importance of drilling machinery compared with welding machinery

Criteria of equipment and machinery				
The importance of sub-criteria drilling machinery compared to the sub-criteria welding machinery				
Equivalent triangular fuzzy number			**Linguistic variable**	**Experts**
l	***m***	***u***		
0	1	2	Equally important	1
1	2	3	More important	2
1	2	3	More important	3
0	1	2	Equally important	4
0	1	2	Equally important	5
0	1	2	Equally important	6
0,33	0,5	1	Less important	7
0	1	2	Equally important	8
2	3	4	Very more important	9
1	2	3	More important	10
0,533	1,45	2,4	**Average**	

Table 20 compares the answers of participants related to the importance of the sub-criteria transport machinery compared to sub-criteria welding machinery.

Table 20. Importance of transport machinery compared with welding machinery

Criteria of equipment and machinery				
The importance of sub-criteria transport machinery compared to the sub-criteria welding machinery				
Equivalent triangular fuzzy number			**Linguistic variable**	**Experts**
l	***m***	***u***		
0	1	2	Equally important	1
0	1	2	Equally important	2
0	1	2	Equally important	3
0	1	2	Equally important	4
0,33	0,5	1	Less important	5
0,33	0,5	1	Less important	6
0,33	0,5	1	Less important	7
0,33	0,5	1	Less important	8
1	2	3	More important	9
1	2	3	More important	10
0,332	1	1,8	**Average**	

In the next step, according to the results which are concluded from the above tables, the matrices of dual comparison between criteria and the dual comparisons of the sub-criteria of competent contractors, are developed. The results are shown in the following tables.

Table 21. Paired comparison matrices of criteria to assess the competence of contractors

Criterions	Executive records			Good records			Financial powers			Technical and planning capacities			Equipment and machinery		
	l	*m*	*u*	*l*	*m*	*u*	*l*	*m*	*u*	*l*	*m*	*u*	*l*	*m*	*u*
Executive records	1	1	1	0,424	1,083	1,85	0,499	1,25	2,1	0,799	1,55	2,4	0,466	1,3	2,2
Good records	0,5405	0,9234	2,359	1	1	1	0,466	1,3	2,2	0,799	1,55	2,4	0,666	1,5	2,4
Financial powers	0,4762	0,8	2,004	0,4545	0,769	2,1459	1	1	1	0,566	1,4	2,3	0,666	1,5	2,4
Technical and planning capacities	0,417	0,645	1,252	0,417	0,64516	1,2516	0,4348	0,7143	1,768	1	1	1	0,533	1,45	2,4
Equipment and machinery	0,454	0,769	2,146	0,4167	0,67	1,5015	0,4167	0,67	1,5015	0,4167	0,6897	1,876	1	1	1

Table 22. Paired comparisons matrices for sub-criteria of good records

Sub-criteria of good records	Performance qualities			Efficiencies of technical manager			Schedule objectives Time		
	l	*m*	*u*	*l*	*m*	*u*	*l*	*m*	*u*
Performance qualities	1	1	1	0,533	1,45	2,4	0,433	1,35	2,3
Efficiencies of technical manager	0,417	0,69	1,876	1	1	1	0,632	1,3	2,1
Schedule objectives Time	0,435	0,741	2,31	0,476	0,77	1,58	1	1	1

Table 23. Paired comparisons matrices for sub-criteria of Technical and planning capacities

Sub-criteria of technical and planning capacities	**Efficiencies of key employees**			**Capacities of planning and project control**		
	l	*m*	*u*	*l*	*m*	*u*
Efficiencies of key employees	1	1	1	0,633	1,55	2,5
Capacities of planning and project control	0,4	0,645	1,58	1	1	1

Table 24. Paired comparisons matrices for sub-criteria of Equipment and machinery

Sub-criteria of equipment and machinery	**Drilling machinery**			**Transport machinery**			**Welding machinery**		
	l	*m*	*u*	*l*	*m*	*u*	*l*	*m*	*u*
Drilling machinery	1	1	1	0,633	1,55	2,5	0,533	1,45	2,5
Transport machinery	0,4	0,645	1,58	1	1	1	0,332	1	1,8
Welding machinery	0,4	0,69	1,88	0,56	1	3,012	1	1	1

By applying EA method and by means of below equation, M_{ij} , M_{kl} , S_k are calculated for each criteria and sub criteria.

(3-1) $$S_k = \sum_{j=1}^{n} M_{kj} \left[\sum_{i=1}^{m} \sum_{j=1}^{n} M_{ij} \right]^{-1}$$

In the above formula, *M* specifies fuzzy number, *i* and *k* mean the row number and *j* means column number.

After calculating S_ks, the comparison magnitude degree should be obtained. Generally, if M_1 and M_2 are two triangular fuzzy numbers, magnitude degree of M_1 to M_2 that we show as $V(M_1 \geq M_2)$ defined as follows:

(3-2) $V(M1 \geq M2) = 1$ if $m1 \geq m2$

$V(M1 \geq M2) = hgt(M1 \cap M2)$ otherwise

And it can be calculated as:

(3-3) $hgt(M1 \cap M2) = (u1 - l2) / [(u1 - l2) + (m2 - m1)]$

The amount of magnitude of a triangular fuzzy number compared to the *k* number of triangular fuzzy number can be calculated by the following formula:

(3-4) $V(M1 \geq M2, \ldots, Mk) = Min [V(M1 \geq M2) , \ldots , V(M1 \geq Mk)]$

After calculating and assessing the amount of magnitude of fuzzy number in comparison with the other fuzzy numbers, the following formula should be obtained in order to explore and assess the weight of indices in the paired comparison matrix:

(3-5) $W'_{(xi)} = Min\ [V\ (S_i \geq S_k)]$ $\quad k= 1,2,\ldots,n, \quad k\neq i$

Thus, the outcome vector of criteria weights are as bellow:

(3-6) $W' = [W'(c_1), \ldots, W'(c_n)]T$

These above values represent the non-normal weight of the criteria, now based on the equation (4-7), the amount of normalized weights of the criteria can be obtained (Momeni, 2010).

(3-7) $W_i = W'_i / \sum W_i$

3.1.1 The Calculation of Each Criteria

By utilizing the information of the table 21 the following results can be calculated. [Table 25]

Table 25. Calculation M_{ij}s for executive records

$[\sum_{i=1}^{5}\sum_{j=1}^{5} Mij]^{-1}$			$\sum_{j=1}^{5} M1j$			$\sum_{j=1}^{5} M2j$		
l	*m*	*u*	*l*	*m*	*u*	*l*	*m*	*u*
0.022	0.03821	0.06524	3.188	6.183	9.55	3.47154	6.2734	10.3585
$\sum_{j=1}^{5} M3j$			$\sum_{j=1}^{5} M4j$			$\sum_{j=1}^{5} M5j$		
l	*m*	*u*	*l*	*m*	*u*	*l*	*m*	*u*
3.163	4.47	9.85	2.8	4.4547	7.67	2.7045	3.79222	8.0251

Table 26. Calculation of $S_k s$ for executive records

S_1			S_2			S_3			S_4			S_5		
l	*m*	*u*	*l*	*m*	*u*	*l*	*m*	*u*	*l*	*m*	*u*	*l*	*m*	*u*
0.07	0.23	0.62	0.07	0.24	0.67	0.07	0.21	0.64	0.06	0.17	0.5	0.06	0.14	0.52

The magnitude of each $S_k s$ compared to the others can be obtained.

Table 27. Comparison of the magnitude of $S_k s$ for executive records

$V(S_1 \geq S_2)$	0,993	$V(S_2 \geq S_1)$	1
$V(S_1 \geq S_3)$	1	$V(S_2 \geq S_3)$	1
$V(S_1 \geq S_4)$	1	$V(S_2 \geq S_4)$	1
$V(S_1 \geq S_5)$	1	$V(S_2 \geq S_5)$	1
$W'_1 = V(S_1 \geq S_2, S_3, S_4, S_5)$	0,993	$W'_2 = V(S_2 \geq S_1, S_3, S_4, S_5)$	1
$V(S_3 \geq S_1)$	0,954	$V(S4 \geq S1)$	0,867
$V(S_3 \geq S_2)$	0,948	$V(S4 \geq S2)$	0,859
$V(S_3 \geq S_4)$	1	$V(S4 \geq S3)$	0,917
$V(S_3 \geq S_5)$	1	$V(S4 \geq S5)$	1
$W'_3 = V(S_3 \geq S_1, S_2, S_4, S_5)$	0,948	$W'4 = V(S4 \geq S1, S2, S3, S5)$	0,859
$V(S5 \geq S1)$		0,832	
$V(S5 \geq S2)$		0,825	
$V(S5 \geq S3)$		0,876	
$V(S5 \geq S4)$		0,948	
$W'5 = V(S5 \geq S1, S2, S3, S4)$		0,825	

Finally, the weight of each criteria according to table 27 is accessible.

Table 28. Weight of each criteria

The weight of executive records in the capacity evaluation	$W'_1/\sum W'$	0,214788
The weight of good records in the capacity evaluation	$W'_2/\sum W'$	0,216145
The weight of financial powers in the capacity evaluation	$W'_3/\sum W'$	0,20502
The weight of technical and planning capacities in the capacity evaluation	$W'_4/\sum W'$	0,185709
The weight of equipment and machinery in the capacity evaluation	$W'_5/\sum W'$	0,178338

- Calculating the weights of good record sub-criteria

By applying the information of the table 22 the following results can be calculated

Table 29. Calculation $M_{ij}s$ for good records

$[\sum_{i=1}^{3}\sum_{j=1}^{3} Mij]^{-1}$			$\sum_{j=1}^{3} M1j$			$\sum_{j=1}^{3} M2j$			$\sum_{j=1}^{3} M3j$		
l	m	u	l	M	u	l	m	u	l	m	u
0.06	0.107	0.168	1.966	3.8	5.7	2.049	2.99	4.976	1.91	2.51	4.9

Table 30. Calculation $S_k s$ for good records

S_1			S_2			S_3		
l	m	u	l	m	u	l	m	u
0.126	0.41	0.96	0.131	0.321	0.84	0.123	0.27	0.825

The magnitude of each $S_k s$ compared to the others can be obtained.

Table 31. Comparison of the magnitude of $S_k s$ for good records

V(S1≥S2)	1
V(S1≥S3)	1
W´1= V(S1≥S2,S3)	1
V(S2≥S1)	0,891
V(S2≥S3)	1
W´2= V(S2≥S1,S3)	0,891
V(S3≥S1)	0,834
V(S3≥S2)	0,931
W´3=V(S3≥S1,S2)	0,834

The weight of sub-criteria for good records is being counted by using the following table. [Table 32]

Table 32. Weights of each sub-criteria for good records

The weight of performance qualities (sub-criteria of good records)	$W'_1/\sum W'$	0,367
The weight of efficiencies of technical manager (sub-criteria of good records)	$W'_2/\sum W'$	0,327
The weight of time schedule objectives (sub-criteria of good records)	$W'_3/\sum W'$	0,306

- Calculating the weights of technical and capacity planning sub-criteria

By applying the information of the table 23 the following results can be calculated.

Table 33. Calculation $M_{ij}s$ for technical and capacity planning

$[\sum_{i=1}^{2}\sum_{j=1}^{2} Mij]^{-1}$			$\sum_{j=1}^{2} M1j$			$\sum_{j=1}^{2} M2j$		
l	*m*	*u*	*l*	*m*	*u*	*l*	*m*	*u*
0.165	0.236	0.33	1.633	2.55	3.5	1.4	1.645	2.58

Table 34. Calculation $S_k s$ for technical and capacity planning

S_1			S_2		
l	*m*	*u*	*l*	*m*	*u*
0,268	0,601	1,154	0,23	0,388	0,851

The magnitude of each $S_k s$ compared to the others can be obtained.

Table 35. Comparison of the magnitude of $S_k s$ for technical and capacity planning

V(S1≥S2)	1
W´1= V(S1≥S2)	1
V(S2≥S1)	0.732
W´2= V(S2≥S1)	0.732

The weights of sub-criteria related to technical and capacity planning are calculated in table 36.

Table36. Weights of each sub-criteria for technical and capacity planning

The weight of efficiencies of key employee(sub-criteria of technical and planning capacities)	$W'_1/\sum W'$	0,577
The weight of capacities of planning and project control (sub-criteria of technical and planning capacities)	$W'_2/\sum W'$	0,423

- Calculating the weights of equipment and machinery sub-criteria

By applying the information of the table 24 the following results can be calculated:

Table 37. Calculation $M_{ij}s$ for equipment and machinery

$[\sum_{i=1}^{3}\sum_{j=1}^{3} Mij]^{-1}$			$\sum_{j=1}^{3} M1j$			$\sum_{j=1}^{3} M2j$			$\sum_{j=1}^{3} M3j$		
l	*m*	*u*	*l*	*m*	*u*	*l*	*m*	*u*	*l*	*m*	*u*
0.061	0.107	0.171	2.166	4	6	1.732	2.645	4.38	1.96	2.69	5.89

Table 38. Calculation $S_k s$ for equipment and machinery

S_1			S_2			S_3		
l	m	u	l	m	u	l	m	u
0.133	0.428	1.025	0.106	0.283	0.748	0.12	0.29	1.006

The magnitude of each $S_k s$ compared to the others can be obtained.

Table 39. Comparison of the magnitude of $S_k s$ for equipment and machinery

V(S1≥S2)	1
V(S1≥S3)	1
W′1= V(S1≥S2,S5)	1
V(S2≥S1)	0,81
V(S2≥S3)	0,99
W′2= V(S2≥S1,S3)	0,81
V(S3≥S1)	0,86
V(S3≥S2)	1
W′3=V(S3≥S1,S2)	0,86

Finally, the weights of sub-criteria related to equipment and machinery are calculated in table 40.

Table 40. Weights of each sub-criteria for equipment and machinery

The weight of drilling machinery (sub-criteria of equipment and machinery)	$W'_1/\sum W'$	0,374
The weight of transport machinery (sub-criteria of equipment and machinery)	$W'_2/\sum W'$	0,303
The weight of welding machinery (sub-criteria of equipment and machinery)	$W'_3/\sum W'$	0,323

3.2 Selecting Three Best Qualified Contractors to Present to the Commission Tenders

- Obtaining the data and information of decision making matrix

In this step, primarily, the evaluation criteria Scores of executive experience, reputation, financial strength, technical ability, planning and equipment for contractors who are participating in the tender, defined as the triangular fuzzy numbers which describe three forms of pessimistic, optimistic and possible rates.

In this research, eight participating contractors in the tender are examined and the information about their evaluation criteria is collected in a decision making matrix that corresponds to [Table 41].

- Obtaining weighted normalized decision matrix

After the formation of the decision matrix, the elements of this matrix are normalized using the (equation 2-25) which belongs to the second chapter. Since the criteria for assessing the competence of contractors have positive aspects, therefore the score of each evaluation criteria in the decision matrix are divided to the highest point that allocated/given to that criteria among the participating contractors. The result score is normalized and is the base criteria for other calculations. Then the column components are multiplied by corresponding weight of criteria of each column and the weighted normalized decision matrix of this research as table 42 are achieved.

Table 41. Decision making matrices

Contractor	Executive records			Good records			Financial powers			Technical and planning capacities			Equipment and machinery		
	l	***m***	***u***	***l***	***m***	***u***	***l***	***m***	***u***	***l***	***m***	***u***	***l***	***m***	***u***
A	30	40	60	40	50	60	30	50	60	25	35	45	25	35	50
B	20	35	50	70	80	85	40	50	60	40	50	60	40	50	60
C	70	75	85	50	60	70	25	35	50	70	80	90	60	70	80
D	40	40	50	25	35	45	70	85	100	50	60	70	60	75	90
E	40	50	55	80	90	100	70	80	90	70	85	100	40	50	60
F	20	25	35	60	70	90	75	75	90	25	35	50	60	70	80
G	80	90	100	70	90	100	50	65	75	80	90	100	20	25	35
H	70	90	100	80	90	100	80	90	100	50	70	80	60	75	90
MAX	100			100			100			100			90		
Weight	0,21479			0,21614			0,20502			0,18571			0,17834		

Table 42. Weighted normalized decision matrices

Contractor	Executive records			Good records			Financial Strengths			Technical and planning capacities			Equipment and machinery		
	l	***m***	***u***	***l***	***m***	***u***	***l***	***m***	***u***	***l***	***m***	***u***	***l***	***m***	***u***
A	0,064	0,086	0,129	0,086	0,108	0,129	0,061	0,102	0,123	0,046	0,064	0,0835	0,049	0,069	0,099
B	0,043	0,075	0,107	0,151	0,172	0,183	0,082	0,102	0,123	0,074	0,092	0,111	0,079	0,099	0,118
C	0,15	0,161	0,182	0,108	0,129	0,151	0,051	0,071	0,102	0,129	0,148	0,167	0,118	0,138	0,158
D	0,086	0,086	0,1074	0,054	0,075	0,097	0,143	0,174	0,205	0,092	0,111	0,129	0,118	0,148	0,178
E	0,086	0,107	0,118	0,172	0,194	0,216	0,143	0,164	0,184	0,129	0,157	0,185	0,079	0,099	0,118
F	0,043	0,053	0,075	0,129	0,151	0,194	0,153	0,153	0,184	0,046	0,064	0,092	0,118	0,138	0,158
G	0,172	0,193	0,215	0,151	0,194	0,216	0,102	0,133	0,153	0,148	0,167	0,185	0,039	0,049	0,069
H	0,15	0,193	0,215	0,172	0,194	0,216	0,164	0,184	0,205	0,093	0,129	0,148	0,118	0,148	0,178

- Calculating the interval valued intuitionistic from the positive and negative ideal.

In this study, the interval of fuzzy positive ideal and the fuzzy negative ideal which are introduced by Chen are used. These values are:

$v_j^* = (1,1,1)$ $v_j^- = (0,0,0)$

These interval valued intuitionistic from positive ideal and negative ideal are obtained by equation 2-30 of the second chapter. Table 43 for interval valued intuitionistic positive-ideal solution and table 44 for interval valued intuitionistic negative ideal solution related to this survey are used.

Table 43. Interval valued intuitionistic fuzzy negative-ideal solution

Contractor	Executive Records	Good records	Financial powers	Technical and planning capacities	Equipment and machinery
A	0,096854175	0,1095015	0,0990341	0,066743737	0,07545539
B	0,079646264	0,1698453	0,1038678	0,094084921	0,10039012
C	0,165216192	0,1308793	0,0780693	0,149339787	0,1396493
D	0,09362479	0,0776802	0,1760667	0,112452989	0,15058519
E	0,104675698	0,1953249	0,164868	0,1594837	0,10039012
F	0,058822664	0,1607787	0,1646554	0,070716261	0,1396493
G	0,194104888	0,1892511	0,1315434	0,167825405	0,05426713
H	0,188069058	0,1953249	0,1852758	0,12595465	0,15058519

Table 44. Interval valued intuitionistic fuzzy positive ideal solution

Contractor	Executive Records	Good records	Financial powers	Technical and planning capacities	Equipment and machinery
A	0,907319898	0,8921046	0,9046854	0,935124444	0,92756641
B	0,925197561	0,8307997	0,8976461	0,907271719	0,90106749
C	0,83543505	0,8704949	0,9250658	0,85156701	0,86144306
D	0,906980853	0,9245195	0,8261147	0,888703367	0,85172916
E	0,896284926	0,8056673	0,8361516	0,84245359	0,90106749
F	0,942817819	0,841929	0,8361097	0,932101634	0,86144306
G	0,806879612	0,8131256	0,8704089	0,83299902	0,94723912
H	0,814289447	0,8056673	0,8156538	0,876499424	0,85172916

3.3 Calculation of the Top Ranked Contractors and Selecting Best Three Contractors

At this point, using the "equation 2-31" of the second chapter, the relative closeness of each option to the ideal solution have been determined and after ranking each options in a descending order of their relative closeness to the ideal solution, 3 premier contractors will be introduced for presenting to the tenders Commission and during next bidding procedures. Finally the rated eight contractors who are participating in the bidding are illustrated in [Table 45].

Table 45. Rate of participating contractors in the tender

Contractor	Cci	Rate
A	0,089261	8
B	0,109352	7
C	0,132441	4
D	0,121876	5
E	0,144764	3
F	0,11871	6
G	0,147173	2
H	0,168737	1

Thus, according to the information in [Table 45] Contractors H, G and E are qualified as three best contractors and are introduced to the bidding committee.

After identifying the research method in chapter three, in this chapter it turns to the analysis of data which is collected from the appropriate tools which are detailed in Chapter 1. Data analysis and information process in this research was performed by using Multi Criteria Decision Method with EXCEL software.

Chapter 4

DISCUSSIONS AND CONCLUSION

In this chapter through combining the findings of the previous chapters using the ideas and opinions of the professionals and to analyze them, we discuss the final results and answer the questions which are mentioned in the first chapter. Then the author expresses some new ideas and indicates the advantages of applying this model. Finally constructive suggestions for the company, as well as areas where additional researches are needed to serve as a base for other researchers are given.

4.1 Research Questions' Answers

According to the library studies and assessing the rules and requirements of the bidding, qualification evaluation criteria and sub criteria of gas company contractors in Sistan and Baluchistan have been all established by using fuzzy AHP method to determine the their relative weight with the above information. The relevant considerations are given in [Table 46].

Table 46. Comparing the weight of each criteria and sub-criteria of Gas Company in Sistan and Baluchistan

Criteria		**Sub-criteria**		**Considerations**
Criteria	**Weight**	**Sub-criteria**	**Weight**	
Executive records	0,214788	----	---	Performing four similar projects over the past 5 years with an equal or more tender consider as a full score
Good records	0,216145	Performance qualities	0,367	Scoring based on a 5-year basis
		Efficiencies of technical manager	0,327	Scoring based on a 5-year basis
		Time schedule objectives	0,306	Scoring based on a 5-year basis
Financial powers	0,20502	----	---	Providing a bank guarantee in the estimated amount of the tender consider as a full score
Technical and planning capacities	0,185709	Efficiencies of key employee	0,577	Scoring based on a 5-year basis
		Capacities of planning and project control	0,423	Scoring based on a 5-year basis
Equipment and machinery	0,178338	Drilling machinery	0,374	Submitting a photocopy of the original document for machinery which belongs to company or the board of directors is required.
		Transport machinery	0,303	Submitting a photocopy of the original document for machinery which belongs to company or the board of directors is required.
		Welding machinery	0,323	Submitting a photocopy of the original document for machinery which belongs to company or the board of directors is required.

4.2 The Proposed Model

• In this research, according to the library studies and reviews of legal requirements and essentials of tenders, evaluation criteria of qualification of contractors, considered relevant sub criteria and maintained considerations are presented as follows:

• Executive records criteria

By using fuzzy AHP method, the relative weight of this criterion is maintained 0,215. The score for executive record of companies which have performed four similar projects over the past 5 years with an equal or more tender is consider as a full score.

• Good records criteria

By using fuzzy AHP method, the relative weight of this criterion is maintained 0,216. The sub-criteria for good records are:

1. Performance qualities with relative weight of 0,367
2. Efficiencies of technical manager with relative weight of 0,327
3. Time schedule objectives with relative weight of 0,306

The scoring is based on the projects which are performed by the company during the last five years. With regards to the number of projects, the average of scores is a base for the performance of the companies.

- Financial power criteria

By using fuzzy AHP method, the relative weight of this criterion is maintained 0,205 and the full score is allocated to the company which provides a bank guarantee in the estimated amount of the tender.

- Technical and planning capacities criteria

By using fuzzy AHP method, the relative weight of this criterion is maintained 0,186. The sub-criteria for technical and planning capacities are:

1. Efficiencies of the key employee with relative weight of 0,578
2. Capacities of planning and project control with relative weight of 0,422

- Equipment and machinery criteria

By using fuzzy AHP method, the relative weight of this criterion is maintained 0,178. The sub-criteria for equipment and machinery criteria are:

1. Drilling machinery with relative weight of 0,374
2. Transport machinery with relative weight of 0,303
3. Welding machinery with relative weight of 0,323

Scoring is based on the submission of a photocopy of the original document for machinery which belongs to the company or to the board of directors.

The second phase of this research introduces three best qualified liable contractors to the Commission tenders which is performed and conducted based on the given scores in three conditions as the pessimistic, most likely and optimistic to the above criteria for every participated bidder and contractor in tender using fuzzy TOPSIS technique which is introduced by "Chen".

By using EXCEL software, all the necessary calculations according to formulas of the above technique were performed on cells (cells of matrices) and the tables are also provided and only by inserting the scores of participating contractors of tender in the

relevant table, 3 qualified contractors will be introduced. The Excel file is attached to the research.

It should be noted that all the above calculations is only possible when according to the law of tenders, bids, and the assessed amount of tender, the contractor who have proper field, rank and degree for participating in the tender and the contractor whose estimation price exceeds 20 times the limit of medium range transactions.

4.3 The Advantages of the Proposed Model

Reducing the dimensions of decision-making in an appropriate way results in increase of the efficiency of the decision making process, a large number of criteria and their interrelations in the decision-making process confuses the decision makers.

The proposed model in this research, offers a systematic method to identify effective measures for evaluating competence of contractors and selection of contractors that involve and consider the employer's goals; as well as the type of project, available resources and executive constraints of Gas Company of Sistan & Baluchistan province and regulatory requirements of holding tenders. In this research the linguistic variables have been used to determine the weight of the importance of criteria and sub criteria. In the current conditions, in order to determine the qualified contractors, the score of the criteria of competency measures are allocated to a certain number.

Due to the uncertainty of the decision maker in determining this number, it cannot be a comprehensive base. Thus, in this research, fuzzy triangular numbers are employed and represent three conditions which are pessimistic, optimistic and likely levels. Therefore, by considering the application of EXCEL software and its simplicity and convenience to deal with, allows users to apply and employ the results of this research

conveniently and easily. According to the calculations that are applied in each cell of the EXCEL software, it is only enough for the user to enter simply the scores of the relevant criteria for different contractors in three forms of pessimistic, most likely and optimistic types to find three qualified contractors.

4.4 Suggestions

- Suggestions for Gas Company in Sistan and Baluchistan province

1. Whereas for identifying and prioritizing the criteria for qualification of contractors, the employer's goals, type of projects, available resources and administrative constraints are affective factors, thus; it is been recommended that the gas company of the province take steps in order to clarify the above factors.
2. As the bids which are below the 20 times of the average of transactions are not subjected to the quality assessment. The lack of quality assessment increases the risk of selection of improper contractors, therefore; it is recommended that at least by combining administrative works the possibility of quality assessment and applying the suggested method is being provided.
3. In cases where using a qualitative assessment is not possible because of the tender amount, the author recommends to use methods such as determining the appropriate price range, and to put aside the contractors who offer exotic prices.
4. It is recommended that the gas company of Sistan & Baluchistan province to create a database to assess the competence of contractors in order to avoid requalifying the competence of contractors who participate in prior tenders and during a specified temporal interval.

- Suggestions for future researches

1. It is suggested that the method used in this research can be investigated and considered in other public and governmental companies which are required to use the law of holding tenders like as electric company and Water Company and so on.
2. Further researches can be done to compare the results of the suggested method with the common techniques of selecting the qualified contractors.
3. It is suggested to the researchers to find additional criteria to evaluate contractors during the decision making process.
4. Additionally, the evaluation of the companies is limited to the base indices to find contractors. Further researches can be done to analyze the base indices to qualify the contractors to solve these limitations. In this respect the maximum number of project for each contractor is clearly identified.
5. It is recommended to separate the contracting fields and construction disciplines according to their natural activities and define distinguished and segregated field that requires essential researches relatively.
6. It is recommended to conduct and investigate the uncertainty in decision making for different official environments and appropriate fuzzy methods should be applied.

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APPENDIX

APPENDIX A: Sample of Questionnaire

Dear respondent

The following questionnaire is designed to study criteria of selection of contractors. The information you present assists us to determine the weights of the criteria of "good records", "financial powers", "capacities of planning and project control", "technical and planning capacities" in selection of contractors as well as the weights of relevant sub-criteria in connection with the above criteria, because you are among those who may provide us with proper images of the said criteria and sub-criteria.

I thank you very much for and honestly appreciate the time you spend to contribute to this research.

In this research the relative values of criteria and sub-criteria as compared with each other are designated with options A to E as follows:

A: Very more important

B: More important

C: Equally important

D: Less important

E: Very less important

The following questions compare with each other the importance of the following criteria in selection of contractors: "executive records", "good records", "financial powers", "technical and planning capacities" and "equipment and machinery". Please specify the relative importance of criteria check marking appropriate boxes.

1- How important is the criterion of "executive records" as compared with the criterion of "good records"?

A □ B □ C □ D □ E □

2- How important is the criterion of "executive records" as compared with the criterion of "financial powers"?

A □ B □ C □ D □ E □

3- How important is the criterion of "executive records" as compared with the criterion of "technical and planning capacities"?

A □ B □ C □ D □ E □

4- How important is the criterion of "executive records" as compared with the criterion of "equipment and machinery"?

A □ B □ C □ D □ E □

5- How important is the criterion of "good records" as compared with the criterion of "financial powers"?

A □ B □ C □ D □ E □

6- How important is the criterion of "good records" as compared with the criterion of "technical and planning capacities"?

A □ B □ C □ D □ E □

7- How important is the criterion of "good records" as compared with the criterion of "equipment and machinery"?

A □ B □ C □ D □ E □

8- How important is the criterion of "financial powers" as compared with the criterion of "technical and planning capacities"?

A □ B □ C □ D □ E □

9- How important is the criterion of "financial powers" as compared with the criterion of "equipment and machinery"?

A □ B □ C □ D □ E □

10- How important is the criterion of "technical and planning capacities" as compared with the criterion of "equipment and machinery"?

A □ B □ C □ D □ E □

The following questions compare with each other the importance of the following sub-criteria relating to the criterion of "good records": "performance qualities", "efficiencies of technical managers", and "realization of time schedule objectives". Please specify the relative importance of sub-criteria check marking appropriate boxes.

11- Under the criterion of "good records", how important is the criterion of "performance qualities" as compared with the criterion of "efficiencies of technical managers"?

A □ B □ C □ D □ E □

12- Under the criterion of "good records", how important is the criterion of "performance qualities" as compared with the criterion of "realization of time schedule objectives"?

A □ B □ C □ D □ E □

13- Under the criterion of "good records", how important is the criterion of "realization of time schedule objectives" as compared with the criterion of "efficiencies of technical managers"?

A □ B □ C □ D □ E □

The following question compares with each other the importance of the following sub-criteria relating to the criterion of "technical and planning capacities": "efficiencies of key employees" and "capacities of planning and project control". Please specify the relative importance of sub-criteria check marking appropriate boxes.

14- Under the criterion of "technical and planning capacities", how important is the criterion of "efficiencies of key employees" as compared with the criterion of "capacities of planning and project control"?

A □ B □ C □ D □ E □

The following questions compare with each other the importance of the following sub-criteria relating to the criterion of "equipment and machinery": "drilling machinery", "transport machinery", and "welding machinery". Please specify the relative importance of sub-criteria check marking appropriate boxes.

15- Under the criterion of "equipment and machinery", how important is the criterion of "drilling machinery" as compared with the criterion of "transport machinery"?

A □ B □ C □ D □ E □

16- Under the criterion of "equipment and machinery", how important is the criterion of "drilling machinery" as compared with the criterion of "welding machinery"?

A □ B □ C □ D □ E □

17- Under the criterion of "equipment and machinery", how important is the criterion of "transport machinery" as compared with the criterion of "welding machinery"?

A □ B □ C □ D □ E □

Maybe the questions raised under this questionnaire don't allow you to indicate all your ideas about the selection criteria of contractors. If this is the case please don't hesitate state your views inside the following box.

Personal data:

Name: Surname:

Place of service: Organizational position:

Work record:

Date when the questionnaire was filled out:

Your highest educational degree:

High school diploma □ Associate's degree □

Bachelor's degree □ Master's or a higher degree □

Lower □

In which one of the following fields do you have experiences?

Technical and commercial committee □ Contract affairs □

Project execution □ Practices of contractors □

How long did you work in the above fields?

Less than a year □ One to three years □

More than three years □

We acknowledge your honest cooperation. Please check out the questionnaire again to ensure that no question was missed, and, then, return it back.