**T.C.**

**ISTANBUL AYDIN UNIVERSITY**

**INSTITUTE OF GRADUTE STUDIES**

# RANKING OF CONSTRUCTION CONTRACTORS OFMUNICIPALITY BASED ON MULTI CRITERIA DECISION MAKING IN HERAT PROVINCE

**THESIS**

**Baktash RAOUF**

**Department of Business Administration**

**Business Administration Program**

**JANUARY 2020**

**T.C.**

**ISTANBUL AYDIN UNIVERSITY**

**INSTITUTE OF GRADUATE STUDIES**

# RANKING OF CONSTRUCTION CONTRACTORS OFMUNICIPALITY BASED ON MULTI CRITERIA DECISION MAKING IN HERAT PROVINCE

**THESIS**

**BAKTASH RAOUF**

**(Y1612.130026)**

**Department of Business Administration**

**Business Administration Program**

**Thesis Advisor: Assist Prof Dr. Ögr. Üyesi Özge EREN**

**JANUARY 2020**

Baktash Raouf, a M.Sc. student of IAU Institute of **Social Sciences Business Administration Department**, successfully defended the thesis entitled **"RANKING OF CONSTRUCTION CONTRACTORS USING (FUZZY-TOPSIS) MULTI CRITERIA DECISION MAKING TECHNIQUE IN HERAT PROVINCE"**, which he prepared after fulfilling the requirements specified in the associated legislations, before the jury whose signatures are below.

**Thesis Advisor:**

**Original Members:**

**Original Members:**

**Substitute members:**

**Substitute members:**

**Date of Submission:**

**Date of Defense:**

## DECLARATION

I declare that this thesis titled as “Ranking Construction Contractors of Municipality Based On (Fuzzy-Topsis) Multi Criteria Decision Making in Herat Province” has been written by me in accordance with the academic rules. I also declare that all materials benefited in this thesis consist of the mentioned resources in the reference list. I verify all these with my honor.

**Baktash RAOUF**

## FOREWORD

I offer my thanks to Allah, who gave me the capability to do this project efficiently and successfully, the most merciful and the most compassionate and the entire source of all knowledge and wisdom.
The writing of this thesis has been one of the most significant academic projects with the guidance, and support of my lovely mom and wife, also a lot of thanks to my dear advisor Dr. Özge EREN, this study would not have been completed without them. It is to them that I owe my gratitude.
I also would like to offer my thanks to my lovely brothers who are supported me in every moment of life.

**January, 2020** **Baktash RAOUF**

**TABLE OF CONTENTS**

**Page**

**ABBREVIATIONS**

**AHP** : Analytical Hierarchy Process
**APP** : Appendix
**DEA** : Data Envelopment Analysis
**MAUT** : Multi Attribute Utility Theory
**MAX** : Maximum
**MCDM** : Multi Criteria Decision Making
**MIN** : Minimum
**SAW** : Simple Additive Weighting
**SMART** : Simple Multi Attribute Rating Technique
**TOPSIS** : Technique for Order Preference by Similarity to Ideal solution

## LIST OF TABLES

**Page**

**LIST OF FIGURES**

**Page**

# RANKING OF CONSTRUCTION CONTRACTORS USING (FUZZY-TOPSIS) MULTI CRITERIA DECISION MAKING TECHNIQUE IN HERAT PROVINCE

## ABSTRACT

In this research, efforts have been made to introduce comprehensive indicators for the selection of contractors of municipal construction projects with a comprehensive overview of the literature on the selection of contractors. The growth and development of the business market over the last few decades, also the increasingly competitive business market, caused the organizations and large corporations have to be more specialized and scientific approaches to the contractor selection process of projects.

What is certain is that the selection of the contractor will ensure that the project is successful and, on the contrary, the inability to identify and select the appropriate contractor will result in inefficiency and losses.

According to the municipality's policy of outsourcing activities every day more contracting companies to participate in various municipal projects and including construction projects; and this multiplicity contracting companies have led to the selection of the right contractor a crucial and decisive thing for the municipality as an employer.

Therefore, choosing the right contractors is the first step towards achieving the desired goal employers that mean executing the project within the desired timeframe at a specified cost and quality that is desired.

After reviewing the literature that belongs on identifying the criteria and interview with experts, 13 primitive criteria for contractor selection and evaluation then, 7 criteria were identified as the most important criteria affecting contractors were selected.

Then, the fuzzy analysis technique was used to determine the criteria and finally, by fuzzy TOPSIS method, 13 municipal construction’s contractors were evaluated and ranked.

**Keywords:** *Contractor, Fuzzy Logic, TOPSIS.*

## RANKING OF CONSTRUCTION CONTRACTORS USING (FUZZY-TOPSIS) MULTI CRITERIA DECISION MAKING IN HERAT PROVINCE

## ÖZET

Bu araştırmada, belediyelerdeki inşaat projelerinin yüklenicilerin seçimi ile ilgili önce literatüre kapsamlı bir bakış atılmış daha sonra ise yüklenici seçim problemi olarak kurgu senaryo üzerinden analizler yapılmıştır. Son yıllarda iş piyasasının büyümesi ve gelişmesi, aynı zamanda gittikçe daha rekabetçi hale gelen iş piyasasını, gerek devlet gerekse özel firmaların, yüklenici seçim projelerine daha özel ve bilimsel yaklaşımlar oluşturmasına neden olmuştur.

Yüklenici firmaların doğru seçimi projenin başarılı olmasını sağlayacak iken aksine, uygun yükleniciyi belirleyememe ve seçememenin verimsizlik ve kayıplarla sonuçlanacağıdır.

Çalışma da kurgu senaryosu için belediyeler üzerinden yaratılmıştır. Bununda en önemli sebebi, belediyenin dış kaynak kullanımı politikasına göre her gün daha fazla yüklenici firma çeşitli belediye projelerine katılmakta ve inşaat projeleri dahil; ve bu çokluk müteahhitlik şirketleri, doğru yüklenicinin seçilmesine işveren olarak belediye için çok önemli ve belirleyici bir şey sağlamıştır. Bu nedenle, doğru yüklenicilerin seçilmesi, istenen hedef işverenlere ulaşmanın ilk adımıdır; bu, projenin istenen zaman aralığında istenen bir maliyet ve kalitede yürütülmesi anlamına gelir.

Kriterlerin belirlenmesi ve uzmanlarla görüşme ile ilgili literatür incelendikten sonra yüklenici seçimi ve değerlendirmesi için 13 alternatif, müteahhitleri etkileyen en önemli 7 kriter seçilmiştir. Ardından en iyi alternatifi bulabilmek için bulanık analiz tekniği kullanılmış ve son olarak bulanık TOPSIS yöntemi ile 13 belediye inşaatı yüklenicisi değerlendirilmiş ve kendi aralarında sıralanmıştır.

Anahtar Kelimeler: Belediye Yüklenici Firmalar; Bulanık Mantık; TOPSIS

# 1. INTRODUCTION

In this research, efforts have been made to show the comprehensive indicators selection of contractors in municipal construction projects with a comprehensive overview of the literature on the selection of contractors. This is the first step in providing a practical and effective contractor selection model. The criteria and indicators should be formulated in such a way as to cover the concepts of Cost, Quality, time, and etc. Based on these three basic concepts, a list of criteria can be created of these three indicators; quality is a more complex category, which determines how much it requires extensive research. The scope of the implementation of a project in a timetable is determined by the employer, which means that the failure of this period will usually result in heavy fines for the contractor. The cost is generally interpreted as the cost the employer pays to finalize the project, cost is also important, but it is not limited to the failure of the contractor to complete the contract, the re-execution parts of the project, the conduct of the tender also be made.

Also, in the real world, due to incomplete and vague information for decision making is usually inaccurate. In these circumstances, for more realistic decision making theory of fuzzy sets is more efficient. In this study, the fuzzy-TOPSIS method is used for evaluating and selection of the contractor.

In this chapter, we try to provide a proper definition of the research problem, goals and questions.

Choosing the appropriate contractor will be a guarantee of success in the implementation of the project, and vice versa, the inability to identify and select the appropriate contractor will result in inefficiencies and losses. Each employer, according to his/her strategy, defines the expectations of the contractor and the various aspects of a project. An organization's strategy determines the organization's attitude to the primary concepts of selecting a contractor, i.e. time, cost, and quality, and ultimately, the employer's expectations from the contractor of a project determine the framework for the selection.

The employer's commitment to successful implementation of the project is an important factor in achieving the expected results.

The trend of growth and development over the last few decades, as well as the more competitive business market, has led large companies to find a specialized and scientific approach for the process of contractor selection and implementation of projects. Today advertisements for tender’s small or large, public or private projects can be viewed on daily basis in newspapers and magazines. For an organization, the first step in achieving the desired outcomes for outsourced projects is to choose the right contractor. A time-consuming project will be successful at a given time; its cost will be determined within the framework and ultimately meet the expected quality. By using these three basic concepts we can make a list of criteria.

Time: The completion time of the project is defined as making it possible to use the design near a certain day determined by the employer's future plans. The degree of employer's willingness to use only contractors that match the purpose of the date distinguishes them from each other. Some contracts are awarded for rewards in order to encourage contractors to increase the speed of the construction process and avoid for delays.

Cost: Historically, cost is considered as the most important factor by employers. Most employers are looking for the value of money they spend. One of the results of this is that the cost calculated through the price offered by the contractor is often considered as the sole criterion of contractor selection. The vast majority of projects, however, end up at a higher cost than the original bid.

Quality: Quality in the project is defined as "the general characteristics of a product or service in order to meet a particular need." There is always an alternative relationship between cost, time, and quality, so that the employer tries to put the balance between these variables and the importance assigned to each one that has the ability to overcome the decision to choose the contractor (Holt and Colleagues, 1995).

In this research, we will try to build comprehensive indicators for choosing a contractor for the municipal construction projects with a comprehensive overview of the subject matter of contractor selection. This is the first step in providing a functional and effective model of contractor selection.

With regard to the above, it can easily be concluded that the nature of the contractor's choice is raised as a multi-criteria issue. As a result, selection and prioritization of options are based on selected criteria and multi-criteria decision-making models. TOPSIS is one of the multi-criteria decision-making methods first proposed by Huang in 1981. But what's important is that data in today's world is not usually clear, and human judgment is sometimes ambiguous and cannot be quantified by numerical values. Therefore, it can be said that decision-makers are confronted with uncertainty about the choice of contractor; in this regard, the use of inaccurate logic, or so-called Fuzzy Logic, can work. Using this logic and this kind of attitude toward natural phenomena was first proposed by Dr. Lotfollah Asgarizadeh in 1965 (Kasko, 1998).

In this research, we specifically seek for criteria weighting we used the Fuzzy Method and for ranking we used the TOPSIS Method.

In general, for evaluation and ranking of municipality contractors with Fuzzy TOPSIS method, after identifying contractors and determining criteria by experts and managers, appropriate language variables for weighting and ranking should be used. Linguistic variables should be converted to fuzzy numbers using tables containing linguistic expressions (Chen and colleagues. 2005). Different scales are used to translate linguistic terms into fuzzy numbers. The purpose of introducing different scales is one of the forms in terms of numbers the language is the language that the decision makers use (Momeni, 2006).

### 1.1 Necessity and Importance of Research

In a highly competitive market today and the policy given by the governments every day, all contracting companies are taking steps to participate in various municipal projects, including construction projects. The managers have to made the selection of the contractor deserves to be regarded for the municipality as an employer. Therefore, the right choice of contractors is the first step in achieving the desired goal. The implementation of the project in the desired time range and at a specified cost and quality.

Managers are faced with a multi-criteria decision-making process to choose appropriate contractor which it include many elements. On the other hand, having a large number of contractors in the selection of eligible contractors for the

municipality managers it is very important to make compression. Therefore managers have to choose a sample and precise method for selection process of contractors.

Nowadays unfortunately mostly selection of the contractors processing without a scientific and non-logic method, the selection happening with proposed price of the contractors and the other criteria doesn't consider.

By considering the problems mentioned above, this research is looking for a method to remove the current trend for the selection of contractors in the municipality from the tastes and to give them a scientific structure. Therefore, in order to select the appropriate contractor the index collected and used to cover all aspects of the implementation of a project (cost, time, and quality), and the final choice of the contractor should be made in a way that gives the right answer to the more integral the guarantor of the business, a good result for the municipality.

In general, the necessity of doing this research can be summarized as follows:

A) More competitive business conditions, increasing contracting companies and more complex management practices require more precise and scientific knowledge of contractor selection. Choosing the appropriate contractor in the municipality that runs government plans with government funds is critical issue.

B) The systematic review of contractor selection methods is an activity that needs to be done in a scientific and specialized way to achieve applied results in order to provide a solution to existing problems. Collecting and editing of important and functional indicators of contractor selection with a comprehensive overview on the subject matter can be a source of many current problems in this area. A set of indicator to contractor selection will certainly be a useful list for future activities in this area.

C) Each of the decision-making models has the strengths and weaknesses, and sometimes each one is used in a specific field. In this research, an attempt is made to provide a functional and effective model for selecting contractors.

## 1.2 Research Questions

- The main question

What is the ranking of construction contractors on municipal construction projects with regard to related criteria and indicators?

- Sub Questions

1) Criteria and indicators that provide a comprehensive assessment of the suitability of contractors for municipality projects

2) What is the importance and weight of each of the selected criteria for selecting a contractor for municipal projects in the unit under study?

## 1.3 Research Objectives

The objectives of this research are divided into two categories:

- Main Purpose

Presentation of a model for choosing the appropriate contractor using multi-criteria decision making methods in government sectors especially in municipalities.

- Sub-goals

A) Identification and categorization of comprehensive criteria and indicators for assessing municipal contractors.

B) Determining the weight and importance of selected criteria for selecting a contractor for municipal projects.

## 1.4 Methodologies

### 1.4.1 Type of Research Based on the Purpose

The research in terms of research purpose is an applied research type.

### 1.4.2 Type of Research Based on Method

The research method used in this study is descriptive-survey. In descriptive research, the researcher wants to know what phenomenon, variable or subject is. In other

words, this research examines the status quo and provides a systematic description of its current status. Studying its features and attributes and studying the relationship between variables (Hafez Nia, 2001).

### 1.4.3 Method of Collecting Data

In this research, a part of the information which is the basis of theoretical and research literature content is collected through a library study including researches done in books and articles and searches on the Internet sites, and another part of the information that forms the scientific aspect of the research. It is obtained through interviews with senior experts and relevant directors and surveys through a questionnaire.

### 1.4.4 Statistical Population in Herat city, Sampling Method and Sample Size

The study population in this study can be defined at two levels. At one level, in order to determine the criteria for selection and extraction of weights, the importance of the criteria affecting the selection of contractors in municipal projects is used by experts and decision makers in the municipality. On the other hand, in order to evaluate and select the contractors, information is available on the contractors participating in the scheme that previously interacted with the municipality.

### 1.4.5 Data Analysis Method

In this section, the data analysis method is briefly described:

Early studies and studies have suggested that research on selecting contractors and related articles, although covering a wide range of criteria and indicators, however, has led to a very different categorization and classification of these indicators and criteria. Of course, many similarities can be found, but this does not mean that there is an accepted pattern for categorizing the criteria.

According to the above, at the beginning of the research, a set of indicators and criteria that are capable of evaluating the various dimensions of the capabilities and competencies of the contractors is necessary. In order to achieve this goal, first of all, the history of the research has to be done and the books and related articles have been examined and a set of indicators that are most frequent to be identified. Then we classify the criteria using experts' opinion. In the next step, the opinion of the

experts and managers of the municipality should be considered for the 13 selected contractors according to the criteria set.

In the last step, according to the obtained data, by using the fuzzy matrix decision and we are ranking the contractors according to the fuzzy TOPSIS method.

The form of the research process is presented in Chapter 3.

### 1.5 Defining the Concepts and Vocabulary of the Project

Fuzzy Logic: As a system of concepts, principles, and methods for a type of reasoning based on an approximate basis, it can be defined. More specifically, fuzzy logic is the generalized state of multi-value logic that emerged at the beginning of the last century. In general, fuzzy logic is the practical and functional range of the theory of fuzzy sets. This logic is used by using the concepts, principles and values used in fuzzy sets to formulate various forms of reasonably comprehensible reasoning (Adel Azar, 2008).

The theory of fuzzy sets: Fuzzy theory provides a precise mathematical method for modeling ambiguous conditions and priorities, and makes it easy to describe the phrase "the x-criterion can weigh about 0.8" (DeBoer and Colleagues. 2001).

The criterion is the characteristics, qualities and performance parameters that are used to select decision options. These indicators can be quantitative or qualitative (Ghodsipour, 2006).

Employer: A person who is a party to the treaty signatory and has assigned the contractor to the Sub-contractor on the basis of the contract documents. Representatives and legal substitutes of the employer are in the territory of the employer (Management and Planning Organization, 1999).

Contractor: Providing remuneration for the provision of services to an organization other than the members of the organization itself (Alwani & Ashrafzadeh, 2004).

Contractor: The legal person is the other party to the treaty, and has undertaken the implementation of the treaty subject to the treaty documents. Contractors' legal representatives and substitutes are contractors (Management and Planning Organization, 1999).

## 1.6 Problems and Possible Research Bottlenecks

1) Multiplicity, lack of categorization and categorization and qualities of criteria and indicators

2) Lack of transparency in some information and statistics for contractors

3) Time limitation for conducting research

## 1.7 Related Contractor Selected Criteria

The mandate suggest criteria such as project cost, duration, experience, qualitative performance, teamwork, facilities, financial strength, and the ability to carry out the project for the selection of the contractor (July and Task, 2007).

Based on the regulations of the management organization and the examination of the objectives of different employers, the criteria of experience, financial sustainability, company background, quality, current work, resources, company management, and technology can be used as the basic criteria for determining the competence of contractors (Rajaya and Hazrati, 2007).

The Ismailis and Rabieh also used indicators of profitability, flexibility, technological capabilities, quality and delivery times to select contractors (Ismailis and Rabieh, 2007). In Marquez's view, criteria such as suggested price, financial ability, industry background, management organization, technical records, safety plans and fault records in previous projects were suitable for choosing contractors (Marzouk, 2005). Holt and others have identified the classification of time, quality, and cost criteria from the perspective of private employers, government employers, and contractor counselors in order to select contractors (H0lt, 1995), and in the other categories of Holt and others. The five organizational, financial, Management, experience and performance has been written. (Holt, 1994).

In this study, criteria such as proposed price, legal activity, insurance status, contractor claims, failures in previous contracts, competitors, quality assurance, number of technical staff, experience, type and size of previous projects, environmental protection and health and safety at work selection criteria are considered as benchmarks (Banaitiene, 2006). In another category, the criteria for experience in work, technology, management, experience and knowledge of the

team, quality, familiarity with the region and the workplace, fame, creativity, and innovation are also considered as selection criteria (Darvish and colleagues. 2008).

Kumaraswamy and P. Varta formulate a comprehensive model based on three major groups of criteria (Responsiveness: Agility – Realism - Evolution, Accountability: Adaptation – Performance – Quality – Safety – Environment - Participation and Competency: Resources-Specialization-Constraints- Management - organization) have suggested (Kumaraswamy and P.Varta, 2004).

A comprehensive review of the papers presented in this area suggests that most researchers believe that the cost criterion (bid-bid) lonely is not enough to select a contractor, and other criteria should also be considered in this decision-making process. Unfortunately, in most projects, since the budget of the project is financed by government funds, the desire to choose the price is always lower, which leads to a poor quality of the project.

### 1.8 Summary of Chapter

In this chapter, we have tried to define and explain the problem, as well as a brief overview on the literature. After designing the questions and goals of the research, the importance and necessity of the research have been discussed. The research method is one of the topics that have been considered in this chapter. Chapter One with Definition of Specific Vocabulary for Reader's Introduction to Concepts and Expressions of Concerns and Concerns Ended.

# 2. THE LITERATURE AND RESEARCH BACKGROUND

## 2.1 Project Definition

A project can be defined as a set of activities that are performed to achieve a particular purpose. Projects include activities that must be carried out on specific dates, with specified costs and qualities determined. Projects may be tasks that are required at specific intervals. For example, closing plant accounts at the end of the fiscal year, major refurbishment of a refinery every two years etc. Projects may also include tasks that will only be carried out once by the organization, such as construction, development projects, organization development, research projects etc. (Haj Shir Mohammadi 2008). According to what was said, such things as: forming a seminar, compiling or publishing a book, setting up a factory, producing a new product, running a spatial plan, making a trip plan, and doing thousands of other things done by humans by itself, is a project.

### 2.1.1 Organization of a project

In order to achieve the goal or purpose of a project, an organization must be formed to carry out the necessary activities. The organization must have sufficient resources and facilities to implement the project, resources and facilities are entered into the organization as data (inputs). Policies, procedures, and implementation programs are also part of the inputs to the organization. Management and control matters are the proper functioning of the resources and facilities for the implementation of activities in order to achieve the objectives of the project. This purpose or the ultimate goal is the organization’s (outputs) and includes the factors that the organization is designed to achieve and perform the necessary activities by applying the inputs. Reflexive information system, by establishing a communication channel between (outputs) and management continuously extracts information from the outputs and reflects on project executives. The communication channel between managerial and control affairs, with the organization's data, is shown in Figure 2-1 in the form of the Chinese line. (Haj Shir Mohammadi 2008).

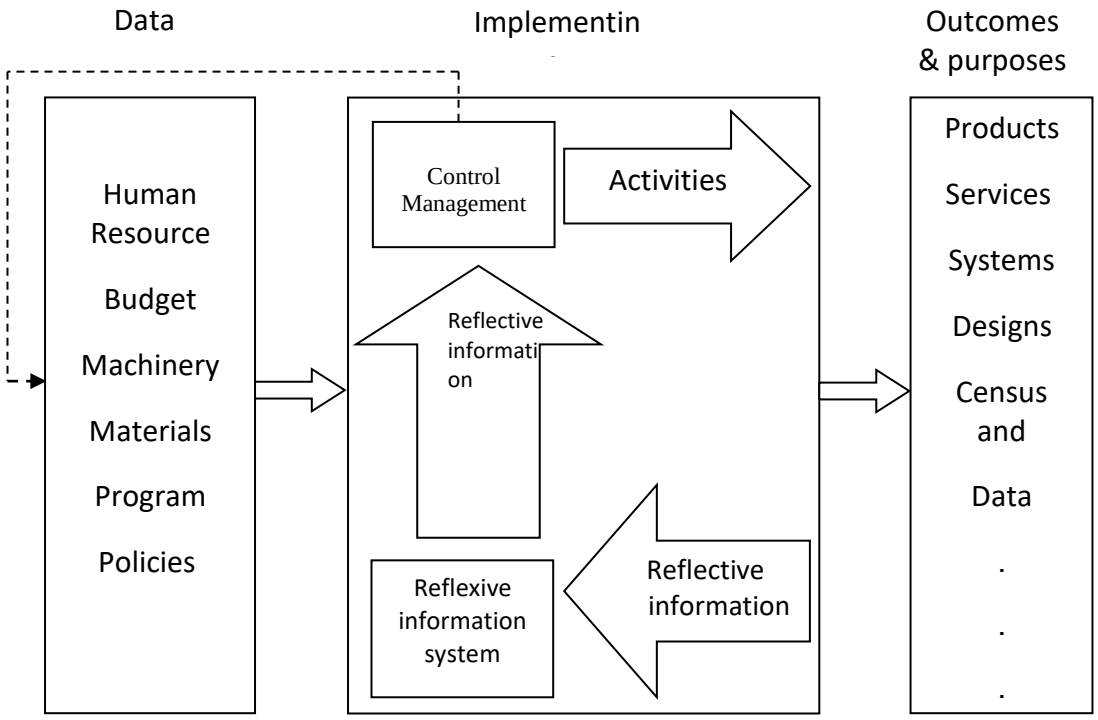


**Figure 2.1:** Organization of a Project 1

### 2.1.2 Time period of the project

Generally, in each project, there are four distinct phases can be defined. These four steps are:

Steps 1 - Theoretical stage

Step 2 - Designing and Planning

Step 3 - Implementation

Step 4 - Final Step (complement)

Each of the four phases of the project is described belowb (Haj Shir Mohammadi, 2008):

### 2.1.3 Theoretical stage

The starting point of a project, with any nature and feature, is a theory or thought, or a desire created by a person or group of individuals or an institution and organization. These comments should, in any event, be explored and studied carefully before being planned for implementation, in terms of feasibility and economics. If the results of such studies indicate that the implementation of the project, taking into account all the local conditions, such as economic, cultural and

political, etc., is feasible and economically feasible, then a variety of possible options for project implementation will be designed and defined, and each of these options will be evaluated. (Obviously, the initial design activities in this phase are to illustrate the overall framework of the options and do not include details) (Haj Shir Mohammadi, 2008).

### 2.1.4 Designing and Planning Stage

At this stage, the affairs of the project in terms of organization are similar to the first stage, but designing and planning are more accurately implemented and more detailed. At this stage, the information between different activities goes round and back and using this exchanged information, the necessary details are tried to be considered and be reflected on the maps and reports. During the implementation of this step, it is necessary to receive the worker's consent in certain periods. One of the important points at this stage is that the designer should be able to design the necessary support system for the system in conjunction with the core design of the system.

One of the important points at this stage is that the designer should be able to design the necessary support system for the system in conjunction with the core design of the system. For example, if the project involves the design and construction of an industrial and manufacturing center, it is necessary, that with the design of the factory and the manufacturing machinery, to provide the necessary facilities for the design, maintenance and repair of the plant. For example, the plans of repair workshops and the necessary equipment in this workshop should also be designed. Obviously, this does not have to be dedicated to a factory, and for each system, the availability of support at the very first moments of the start of the operation of the system will be necessary) (Haj Shir Mohammadi, 2008).

### 2.1.5 Implementation stage

At the end of the second phase of the project, almost all of the activities that are required to be implemented are identified and scheduling methods and schedules are defined for the implementation of the activities. In the third phase, the goal is to make the progress of the project’s implementation in accordance with the plans, principles and qualities that are defined in the second phase. It is certain that in this phase, the executive organization will be much larger than the organizations that

were active in the previous phases of the project. Expenditures spent on the implementation of activities are far more than the costs of the previous steps of the project. In this phase, the controller factor plays a fundamental role, and it is necessary to control the progress of the work, and the cost and other resources, by taking appropriate information and statistics on the progress of the work, and comparing the various characteristics of the work performed with what is planned. Providing materials, equipping, hiring a workforce specializing in technical, financial, personnel, etc. are the primary required tasks at this stage. In a number of cases, the work that the contractor enters into may be in a volume greater than or different from the tasks that the contractor can handle with the permanent cadre.

In this case, the contractor will conclude second-hand contracts with other contractors to carry out a group of activities with the use of the specialties or equipment they are in possession of them. To conclude second-hand contracts, the consent of the employer must be obtained (Haj Shir Mohammadi, 2008).

### 2.1.6 Final stage (complement)

The final stage of the project can be called a project on its own. At this stage, it is necessary that the work be planned in a way that it is easily acceptable by the monitoring and delivery system to the worker. Obviously, such conditions depend entirely on how the activities are carried out during the implementation phase, but in most cases it has been observed that in the final stage and delivery of the project, the complexity of the issues between the contractor, the supervisor and the owner of the work has reached its limit and consequently, the temporarily delivery task and the reoperation of the system became suspended. Such conditions will cause the using capital not to be used for a while, and on the other hand, the contractor will not be able to use its resources and facilities in other projects due to the involvement and dependence on the project. At the final stage of the project, providing accurate reports and notes on how the work is carried out will cause the contractor to have accurate information sources to participate in new tenders and to implement new projects. It can be briefly said that the accuracy in the implementation of tasks in the fourth stage, and the correct planning for the fast delivery of the project, in addition of being economically beneficial to the owner and the contractor, in terms of

obtaining credit for the contracting company and providing Suitable backgrounds for receiving new projects also play a significant role (Haj Shir Mohammadi, 2008).

## 2.2 Construction Projects

Construction projects are the organized effort to construct a building or structure. In the fields of civil engineering and architecture, construction projects involve the process that consists of tangibly assembling an infrastructure or building.

Construction Projects has three main elements as follow:

1. Scope: Each project must have a unique goal and have requirement written in documents which are necessary to the operation.
2. Schedule: Each Project must have a time period in the other word, each project must have a definite time of beginning and definite time of ending.
3. Budget: Each project must have limited funding resource which will cover the requirements of the project in the other word every project needs a budget initially define its funding.

The construction project has many steps like project initiation, planning and funding, environmental, design, permitting, real property acquisition, bid and award, construction, commissioning and operation (Federal Transit Administration, 2012).

## 2.3 General Contractors

The general contractor is a legal person with the capability and authority in engineering, resource provision, procurement, implementation, and management, in order to carry out all activities related to the design and implementation of the project.

The general contractor can assign the implementation of different parts of the project to the consultant engineers or other qualified contractors after the approval of the employer by division of the project into the projects or stages of implementation, but in any case, the contractor undertakes the responsibility, management, control and coordination of the whole project.

### 2.3.1 Overview of goals and tasks of general contracts

Independently taking responsibilities of implementing a project which start from the survey of elementary studies, scheduling, planning till the complement of a project is the contractor job. It doesn't matter the project is small, medium or a huge project, the important is that contractor could do its responsibility. As the companies specialization we should focus on these points.

- Preliminary identification and presenting major plan in special part.
- Technical and economic justification
- Basic engineering
- Consulting services
- Supply of equipment
- The right of exploit and transfer of technical knowledge
- Create, installation and sitting up services
- Operation service
- On time project implementation (Samimi Dehkordi, 2005).

## 2.4 Importance of Contractor Selection

There are many companies and organizations that may delegate part of their activities to other companies on a contractual basis. In most countries, executive projects are carried out by contractors. Failure to select an appropriate contractor can lead to a decrease in the quality of the project, an increase in time and even an abnormal increase in the cost of the project, and in some cases leads to the project's suspension and unfinished. The choice of the contractor in the traditional way (the lowest bidder price) and the failure in considering other factors may cause the contractors to be persuaded to carry out the project with the lowest price and not paying attention to the identification of other factors (Rajaee and Hazrati, 2007).

Considering that municipal projects usually have significant budgets, the selection of unsuitable contractors for these projects can cause a lot of damage.

## 2.5 Process of Contractors Selection

When outsourcing is performed, the outsourcing organization should have a deep understanding of what a contractor wants to do. After that, the project team should examine the contractors. A step-by-step approach is needed to investigate contractors and select an appropriate contractor.

Greaver and Minard outlined the contractor selection process as follows (Greaver, 1999):

1. Identification of potential contractors: The first goal of the project team is to identify the best number of contractors with the appropriate capabilities and competencies and are interested in providing services. This requires to be in contact with the industry and inquiry from aware people.

The next goal is to reduce this list through preliminary studies. If the team sends more than ten to fifteen RFPs, it may not have done enough research.

1. Identifying of the necessary capabilities: One of the goals pursued in the list of abilities and competencies is an attempt to give more emphasis to the evaluation and selection process of the contractors.
2. Determining of Evaluation Criteria: All competencies and capabilities are not easily measurable. These capabilities should be converted into measurable criteria. And these criteria are not equally important. The team should also determine the weight of these criteria.
3. Deciding about one or more contractors
4. Preparing and setting up an RFP (Request for proposal): What should be considered in RFP setup is that the RFP (Request for proposal) should be written and clear and have reasonable time to respond to it and contain enough information. The RFP includes cases in which the organization expects each contractor to include in its proposal such as: reasons for outsourcing, territory of service, contractor's competencies, standards and performance criteria, pricing model.
5. Comparison and Evaluation of Proposals: Proposals are evaluated based on the information requested in the RFP (Request for proposal).
6. Competency appraisal: At this stage, the proposals are assessed and evaluated with the criteria for assessing the suitability of the contractor.

7. Ensuring of job accuracy and Seriousness: This includes viewing existing operations, interviewing key people, reviewing documentation, discussing with competitors and industry advisors.
8. Contractor selection
9. And at the end, there are negotiation and conclusion of the contract.

## 2.6 Contractor Selection Criteria

Choosing criteria in the process of choosing a contractor is an important step, so that organizations must pay particular attention to this in order to succeed in their projects. For example, an organization that provides services to five large contractors may find a particular activity, but is size in this example an important factor? If that activity is important to the organization, financial stability and high investment power are required for the contracting company; otherwise, the contractor's services and responsiveness are sufficient, and a small, high-quality contracting in a nearby location can be the right choice; It may seem like a simple research task, but information is often not readily available or complete. Indeed, the outsourcing market is very large and varied, and everything from outsourcing simple activities up to now has covered all the support activities of large companies. Organizations have been challenged in choosing a contractor whose capabilities are tailored to their needs. Therefore, selecting criteria in the contractor selection process is an important step.

## 2.7 Contractor Selection Models

In most studies, the importance and difficulties associated with the scoring of various specifications and criteria related to the selection of contractors are specified. According to (David and colleagues (2006), (Gallien and Wein (2005), (Dobler and Burt (1996), (Patil (2006), (Beil and Wein (2003), and (Arsalan Partner (2006) considering several features in bidding is important, but it's hard to implement these priorities in evaluating the bidding process and choosing a contractor (Padeh and Mahapatra, 2009).

One of the most commonly used methods for choosing contractors is the use of competitive bidding, the method in which the bidder accepts the lowest price, has a

deep root in the US. The main idea behind this approach was the bidding system with the lowest bidder that protects the public section from extremism, corruption, and other inappropriate behaviors that might have occurred (Thomas and Skitemor, 2001).

In Afghanistan, the National Procurement Law is based on the same biding model, which is currently used in all governmental contracts and volunteering construction bids.

In France, this method is used after the bidder has been removed with the lowest bidder list. In the countries of Italy, Portugal, Peru and Korea, after the elimination of the bidder with the highest bidder and the lowest bidder, among the remaining bidders, the contractor whose offer price is closer to the average offered price is accepted. The same method is used in Denmark, with the difference that first two bidders with the highest bidder and two bidders with the lowest price suggestion are removed and then the remained contractor that whose offer price is closer to the average of the suggested prices is accepted. (Topcu, 2004). Paul and Guthy Yerz studied the project contract at auctions. They have used a common probability model that can be used to compare the expected price (Paul and Gothy Yorzes, 2005). Many researchers such as JS Russell, Skitemour, Wang, Kim Molner, Jason, Tachko, and others have used common methods for identifying, evaluating, and evaluating pricing. Halt and Advar have also introduced qualitative analyzes, in which identification methods, such as, the time of evaluation, and the selection of contractors participated are discussed (Banaitiene, 2006).

Cheng and Lee in a model, after identifying the indicators and checking them based on the paired matrix, compared all the indices and sub-indicators simultaneously and then performed the ranking of the contractors (Cheng and Li, 2004).

Deng (1999) and Padhi and Mohapatra (2009) used Fuzzy AHP and Fuzzy AHP-SMART and Al-Harbi (2001) and Topcu (2004) techniques and AHP technique to award contractors. These techniques can also evaluate the scores that were assessed by the group. Contractors are mentally evaluated by decision making using the hourly scale which then converts these points into numbers, in this there is the possibility of comparing two to two in terms of specifications and also to contractors (Hour, 1980). However, this technique cannot be safely used as a tool for evaluating

the superiority of contractors. The fuzzy that is used in AHP fuzzy scale has overcome this problem by placing the range on this scale that are determined by experts. Anyway, AHP, Fuzzy AHP, Fuzzy AHP-SMART have the problem of no rating existence. Such a problem occurs when the relevant categories of contractors are changed whenever one or more contractors are removed or added (Wang, 2008).

Hatush and Skitmore (1998) and Lambropoulos (2007) used the multi-index utility theory technique to scorecard contractors. In essence, they combined the main advantages of simple scoring methods with optimization models. In addition, in situations where satisfaction is doubtful, the utility functions of this property have the advantage that expected utility can be used as a guide for rational decision making. All decisions include choosing one among several options. For instance, each option is evaluated for determining the degree of utility in relation to a number of scoring criteria. What measures the values of the criteria with the degree of utility is the utility function. In this technique, the contractor's score is determined by the comparison of the optimal value of each characteristic (determined by the government) with the actual values of the contractor's performance. In this technique, the contractor's score is determined by the comparison of the optimal value of each characteristic (determined by the government) with the actual values of the contractor's performance. However, it cannot handle and manage the Fuzzy model data and cannot function properly for group decision problems (Sawalhi et al., 2007).

Lee and colleagues used a multi-criteria analysis technique to award contractors. A simple scoring technique that evaluates contractors on a descriptive scale can be a reliable measure of decision making. But at the same time, there is no uniformity in the decision making about the characteristics, and in addition, Lia and colleagues did not consider the specifications that have a numerical nature (Lai KK Liu., 2004).

Kumarasawami used a performance-based scoring technique and aggregate individual privileges for the final score for each contactor. This technique is easy to use, but it depends on the decisions of the experts. Additionally, this technique cannot match specifications by measuring non-similar scales. This technique is also unable to determine the weight of the specifications (Kumarasawami, 1996).

Huber and Misser used the single-objective method (bidding price) and the integrated planning model for contractor selection. However, they did not consider other

important non-financial features such as quality, runtime, physical resources, and prior contractor performance (Huber and Maser, 2006).

Wang and colleagues chose the selection method based on the unit price to select features to convert into a single view. However, it is difficult to determine the various characteristics of the price (Wang, 2006).

**Table 2.1:** Models Used To Select a Contactor

| Approximate Model | Selecting of used specifications | Country | Writer |
|---|---|---|---|
| Fuzzy-AHP | Cost declaration, technical capability, services and official resources of government | Australia | Deng (1999) |
| Integer programming | bid price | Austria | Missbauer and Hauber(2006) |
| Multi attribute analysis | Contractor's organizational chart, economic and competition score, bidding price announcement, amount of materials used | China | Lai et al. (2004) |
| Multi-attribute utility Theory | Declare cost, quality of work, and runtime | Greece | Lambropoulos (2007) |
| Performance-based Scoring | Financial status, proposed technology, and experience of managing similar types of projects | HK | Kumaraswamy (1996) |
| Fuzzy AHP-SMART | The price of tender announcement, financial status, available physical resources, the amount of work performed, offered services during the work period, cooperation and coordination, runtime, the value of each previous work, the amount of pollution control | India | Padhi and Mohapatra(2009) |
| Unit price based | Using of all the price specifications | Taiwan | Wang et al. (2006) |
| AHP | Cost declaration, work quality and runtime | Turkish | Topcu (2004) |
| AHP | Experience in managing similar types of projects, financial sustainability, quality of implementation, human resources, equipment resources, and work density | United Arab Emirates | Al-Harbi (2001) |
| Cluster analysis | Cost declaration, work quality and runtime | England | Holt (1998) |
| Multi-attribute utility Theory | Tender price announcement, financial accuracy, technical ability, ability to manage, secure execution and credit | England | Hatush and Skitmore (1998) |

Gary Halt in 1988 in an article entitled “Which method to choose a contractor?” collects the studies conducted in this field so far. In his article, he analyzes the methods used in selecting contractors. Because of the importance of these methods, the results of the Halt studies are described here. These methods in a general category are: BASPOCK Approach (BA), Multi- Attribute Analysis (MAA) Multi-Attribute Utility Theory (MAUT) Multiple Regression (MR) Cluster Analysis (CA) Fuzzy Set Theory (FST) and Multivariate Separation Analysis (MDA) are briefly outlined in order to clarify the subject matter and characteristics of each one, and the differences are presented in the form of a table.

Besspock Approaches (BA)

- Multi-Attribute Analysis (MAA)
- Multi-Attribute Utility Theory (MAUT)

Multiple regressions (MR)

- Cluster Analysis (CA)
- Fuzzy set theory (FST)
- Multivariate Separating Analysis (MAD)

**Table 2.2:** Specification of Contractor Selection Methodologies

| **Future outlook on the issue** | **Output nature** | **The nature of the input data** | **Degree of intellectuality** | **Known application** | **Methodology** | |
|---|---|---|---|---|---|---|
| Limited because of being quantitative | Dual / Descriptive | Descriptive, dual, linguistic, subjective | Intellectual Input and output | Extensive use among industry practitioners | Bespoke methods | 1 |
| Limited because of being quantitative | Numerical scores and accordingly, rankings among options | Arbitrary but often Subjective | credible inputs on the subjective evaluation of indicators | Simple scoring models that are used in industry and the scientific environment | Multi-index analysis | 2 |
| good, if the curves showing the desirability are inferred: it needs research | Numerical scores and accordingly, rankings among options | Raw data is often qualitative, giving us the benefit of distance data | The input transforms qualitative data to quantitative | Evidence based on academic application | Multi-index utility theory | 3 |
| good, prospect for research | Numeric, plus value | Predictive distant | The acquisition of distant data tends to be subjective | Evidence of academic application | Multi-index regression | 4 |
| Excellent, prospect for future research | Group membership and group profile | Multivariate | None, if raw multi-variable data is used | Range | Cluster analysis | 5 |
| Good, but it's probably very complicated for easy acceptance in the industry | Group membership | Descriptive / qualitative converted to a distance | A domain for the development of special charts | Evidence of academic application | The theory of fuzzy sets | 6 |
| Previously used, but a broader outlook is undertaken. It requires research. | Group membership / group profile | Multivariate | quantitative | Previous application | Multivariate Separating Analysis | 7 |

**Source:** Holt, 1996

## 2.7 Preliminary Evaluation Models for Contractors

An initial assessment of contractors is a preliminary step in the process of contractor selection, in which contractors are evaluated based on a set of criteria and indicators. In fact, an initial assessment is a critical step, which results the classification and refinement of contractor companies. Based on the preliminary assessment, a suitable contractor can be selected according to criteria such as "workload" and "bid price". Also, in order to provide a one-stop model for contractor selection, we can use the models and criteria of preliminary evaluation of contractors. Preliminary evaluation models of contractors in many cases have similarities with contractor selection models. In other words, the study of the characteristics, capabilities and characteristics of contractors in the financial, technical, functional, organizational and etc. and classification of them are located in the domain and scope of the initial assessment models of contractors and on the other hand, the relevance of the conducted research carried out in this field to the issue of contractor selection as well as the extent of these studies, requires the evaluation of the preliminary evaluation models of contractors to provide a practical and reliable model for contractor selection in terms of scientific and research. Therefore, in this section, the initial evaluation models of contractors are described briefly, and the advantages and disadvantages of each one are explained and then examined in the procedures section and the contractor selection models.

An initial assessment of contractors is an important step in the project's [successful] implementation. An initial assessment is the result of contractor's screening process. The selection of an appropriate contractor gives the employer the confidence that the selected contractor can accomplish the objectives of the project. The preliminary assessment issues distinct from many multi-index issues, when the decision maker may need to provide uncertain, incomplete or non-accurate estimates due to lack of information, time lag, or weaknesses in expertise. In order to search for the most up-to-date model, a summary and critical overview of the models that have the highest rate of publication for the preliminary evaluation of the contractors have been presented. Some of these models are linear, while others are not. Some gadgets have both quantitative and qualitative data.

The initial assessment process for contractors involves setting up a standard relationship to measure and evaluate the potential of participants in the bidding process. Several experts have formulated a preliminary assessment model for contractors. One of the approaches to qualitative evaluation is statistical models. Other models that allow multiple categories, such as Appraisal and Appraisal (PERT), are also being explored for preliminary evaluation of contractors. The combination of statistical models and multiple categorization provides advances in relation to linear species. Multi-index utility theory, fuzzy sets, case-based arguments, and knowledge-based expert system models have been adopted by many researchers to support the employer in terms of non-linearity, uncertainty and inaccuracy. Lam and colleagues suggested the use of artificial neural networks as a nonlinear model. Furthermore, Lam and colleagues proposed fuzzy neural network models (FNNs) for preliminary evaluation of contractors. Another approach provided by Mehdi and partners and Tapco is using AHP (Process Analytical Hierarchy Process) (AHP) methods to select contractors. Pong Peng and Listeron have used a combination of the utility function and social welfare function to evaluate the ability of contractors during the review of proposals. Recently, Wang and colleagues have used a multivariate diagnostic method to improve and develop a model for ranking contractors for specific project criteria. Russell and Skiniosky presented dimensional weight aggregation model (DWA). Dimensional weighing aggregation model makes it possible to determine the decision-makers characteristics of each decision criterion and relative weight of its significance. The decision maker can then classify the contractors according to the decision criteria.

Russell and Skinsky developed a computer program called "Descriptor-1" to help decision makers to easily find the initial evaluation data. This program is based on the aggregated weighting for each contractor, which is obtained by ranking inputs for each decision criterion. Russell and colleagues described "Descriptor-2" as an attempt to overcome the "descriptor-1" defects. Descriptor-2 is a knowledge-based system in which the decision to make a preliminary assessment through the modeling of rules the user's decision is taken and not the calculated scores.

Holt and colleagues introduced a quantitative method for selecting a contractor, which uses multi-factor analysis (MAA) and utility theory (UT). Hatush and Skitmore recommended the application of a PERT evaluation methodology to

measure the criteria for the initial assessment of contractors against the employer's goals in terms of time, cost, and quality. The PERT approach is used to create a linear model for estimating contractor data.

Several studies have been used in the field of preliminary assessment of contractors and contractor selection, the Analytical Hierarchy Process (AHP). Nydick and Hill define AHP as "a methodology for the action-oriented ranking of alternating courses based on decision-maker judgments about the importance of criteria and the values they obtain in one option." Monaev has considered the AHP for contractor selection methods. This model combines the initial evaluation criteria of contractors with the proposed price as one of the criteria for the decision in order to achieve the best concession proposal. Nanwein has constructed a model for the preliminary evaluation of contractors by using the same fuzzy sets. This model meets the uncertainty involved in the preliminary evaluation system. NG introduced a Case-Based Argument Model (CBR) for introductory evaluation. Case-based argument is an artificial intelligence technology that solves new issues by adapting solutions that are used to solve past issues. Taha and Khosroshahi, Lam and colleagues suggested the application of neural network models for preliminary evaluation of contractors. Lam and colleagues also suggested the use of fuzzy models of the neural network for the same purpose. A model that offers the best results should be able to adapt to the specific characteristics of the preliminary assessment problem. Important details of the preliminary assessment are:

- Preliminary evaluation is a multi-criteria issue. The hypothesized model should perform the analysis of the criteria on a symmetric basis. Preliminary assessment includes the risk of crowded and unknown data provided by different contractors.
- A preliminary assessment of the risks is taken from different opinions of the decision-makers.
- An initial assessment includes mental judgments of decision makers.
- Preliminary evaluation includes nonlinear relationships between the contractor's indices and their corresponding preliminary assessment decisions.
- The model should be able to match the results with a sequence of correlated changes among different contractors.

- The ability to process qualitative data should also be as good as quantitative data (Sawalhi et al., 2007).

A comprehensive overview of the advantages and disadvantages of these models is presented in Table 2.3.

**Table 2.3:** Preliminary Assessment Models for Contractors

| Disadvantages of the model | Model Benefits | Adopted by | Model type | Row |
|---|---|---|---|---|
| Depends on the judgments of the decision-makers<br>A low score in one part can be offset by a higher score in another part<br>Does not consider the risks associated with the contradiction of the contractor's information.<br>It does not take into account the inherent risks of different opinions of decision makers<br>The ability to match the criteria is not different from the unmatched units of measurement | Simple application<br>No special knowledge is needed to understand. | Russell and Skibenovsky | Dimensional Weight Composition (DWA) | 1 |
| The constraints in the model are implicit in the uncertainty inherent in innovative knowledge | It gives the rules of decision making a chance to use for better expectations | Russell and his Partners | Knowledge-based system (KBS) | 2 |
| Input variables that are used by users are a very subjective term<br>The model cannot link systematic reviews based on judgments.<br>Does not consider the non-linearity between the criteria of the decision and the characteristics of the contractors<br>The uncertainty of contractor information is not considered. | MAA is a simple scoring model. It is used by decision makers as simply as possible. | Hunt and colleagues | Multi-Attribute Analysis (MAA) | 3 |
| Problems of the core by formulating the spirituality functions for the preliminary evaluation criteria and the number of parameters and complexity of the framework<br>Application must be more mathematical to understand and implement this analysis. | It can deal with quantitative and qualitative data<br>Works with group members<br>It deals with uncertain data. | Nguyen | Introductory evaluation with fuzzy sets | 4 |
| The nature of the mind and the judgments affect the levels of purpose<br>This method does not have the ability to deal with the inherent non-linear communication between contractor indices and their corresponding initial assessment decisions. | Associate multiple categories and check the status quo in contractor data. | Hatosh and Skylator | PERT model for preliminary evaluation | 5 |
| The mental nature of empowering the decision maker in relation to weight will affect the final decision.<br>The scale used is not clear<br>There is a possibility of a reverse ranking<br>The comparison between the two criteria is due to two different scales. | Makes group decision possible | Monaev, Elly Briss Mehdi and Topko | Analytical Hierarchy Process AHP | 6 |
| It is difficult to find the preferences of tangible contractors through the utility function<br>In order to deduce the utility function, it is necessary to prescribe the exact values of the probability<br>The decision-making process requires a lot of time, and if there are a lot of criteria, it's a ?<br>Lacks the ability to handle multiple decision | Mental judgments on meaningful weights and ratios | Hatosh and the skater | Multi-index utility | 7 |

| | | | | |
|---|---|---|---|---|
| makers simultaneously. | | | | |
| The model requires entering a large number of items at the time of initial setup, which may be difficult in practice.<br>In systems where there is no similar and approximate solution, the system will provide an inverse solution.<br>This system is not an adaptive system to has the ability to learn and make new solutions. | A simple application solution can be provided when awareness of the system is weak for the preliminary assessment.<br>The solutions obtained from the above can be modified and adapted to conform to the current position through the conformance functions embedded in the system. | NG | Case-based argument | 8 |
| For the Neural Network model, it is difficult to provide an explanation of why a qualified contractor was qualified or not.<br>The nervous system has often been criticized for demonstrating a low degree of perceptual ability.<br>The neural network model suffers from difficulties in acquiring training couples for private employer projects.<br>Neural networks require a large amount of past data to train. | Self-adapted data-driven methods, in which there are few precedents for assumptions about the models of the underlying study.<br>There is no need to know about statistical distribution of data.<br>Apart from the internal structure of the neural networks, the divergence of data is implicitly computed.<br>It is suitable for analyzing nonlinear relationships among output variables.<br>The results of neural networks can be generalized.It has the ability to perform both calculations and inferences based on a complex combination of quantitative and qualitative data.<br>Uncertainties and inaccuracies are reduced to a minimum. | Taha Khosroshahi Lam and prtners | Artificial Neural Networks | 9 |

**Source:** Sawalahi, 2007

## 2.8 Multi-Criteria Decision Making Techniques

The optimization models from the era of industrial movement in the world, especially since the Second World War, have attracted the attention of mathematicians and industry executives. The main emphasis on classical optimization models is to have a criterion (or a target function), so that the model can be linear, nonlinear, or mixed altogether. But the attention of researchers in recent decades has been focused on multidimensional models (MCDMs) for measuring complex decision making. In this decision-making process, instead of using an optimality measure, several measurement criteria may be used.

These decision-making models are divided into multi-objective models (MODMs) and multiplicity models (MADMs). Multi-objective models are used to design, while multi-index models are used to select the best option (Asgharpour, 2002).

### 2.8.1 Evaluation of MADM models

There are two main categories of different methods for processing information from a MADM problem: a group of methods is based on a well-known model to the non-explicit model, and the other is derived from another model known as the compensatory model.

A-Non-compulsory model: includes methods in which exchange is not allowed among the indicators, for example, the weakness of a given index is not compensated by the existing advantage of another indicator. In these methods, each indicator is considered alone and the comparisons are based on the index to index.

B-Compensatory model: Includes methods that allow the exchange of indices in them. It means, a change (possibly small) in an index can be offset by a change in the opposite index (or indexes) (Azar and Rajabzadeh, 2002). The model consists of three subgroups.

### 2.8.2 Fuzzy Logic

The Modern fuzzy logic which sometimes called diffused logic was developed by Lotfi Zadeh in the mid-1960s against the classic method of two value method to solve the problems which are imprecise or formulated in very basic methods, which are used diffuse categories (Bart Kosko 1991).

The classic method has Greek rote in classic method there was two value for everything like (black or white , 0-1, right or wrong) of course there are many cases which are solved in this method but, we can't say it match for all the cases, in fuzzy logic there are several value it can contain all truth numbers. We are going to explain shortly about fuzzy method in here.

### 2.8.3 The fuzzy Set Concept

The membership function describes the different between classic methods and fuzzy, membership function in fuzzy set of Ã is an infinite set of X describe with membership function of$\mu_{\tilde{A}}(x)$. Which shows for each $x$ of X a number$[0,1]$, the

$\mu_{\tilde{A}}(x)$ function is shows the degree of truth value of $x$ in set of Ã (Kaufmann Gupta 1991).

In function of $\mu_{\tilde{A}}(x)$ If the $(x)$ close to 1 it shows the strong inclusiveness to Ã and it is close to zero it shows the weak inclusiveness to Ã in the case if $\mu_{\tilde{A}}(x) = 0$ the $x$ is not a member of Ã (Adel Azar 2008).

In the below graph Shows the Fuzzy set in the R.

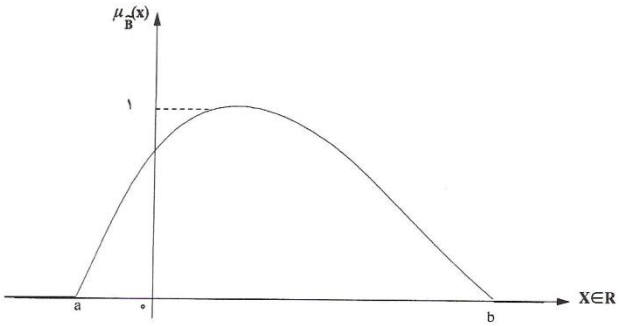


**Figure 2.2:** A Fuzzy Set

**Source:** Adel Azar, 2008

The fuzzy sets shows with different symbols as follow.

$$\tilde{A} = \left\{\frac{\mu_{\tilde{A}}(x_1)}{x_1}, \frac{\mu_{\tilde{A}}(x_2)}{x_2}, \dots, \frac{\mu_{\tilde{A}}(x_n)}{x_n}\right\}$$

$$\tilde{A} = \{(x, \mu_{\tilde{A}}(x)); x \in X\}$$

$$\tilde{A} = \sum_{i=1}^{n} \frac{\mu_{\tilde{A}}(x_i)}{x_i}$$

- Fuzzy set Complement

The Fuzzy set complement shows with $A^c$ symbol and describes as follow.

$$A^c = \{(x, \mu_{A^c}(x)) | \mu_{A^c}(x) = 1 - \mu_A(x)\} x \in X$$

Support, Height and Pass

The X function set elements which are more than zero are supports of Ã and shows with SuppÃ.

$$SuppA = \{x \in X | \mu_{\tilde{A}}(x) > 0\}$$

In Ã set $Sup(\mu_{\tilde{A}}(x))$ is the Height of set Ã as it is equal to 1 we call it normal and if it is opposite of 1 it is not Normal

$hgt\ A = 1$ So Normal

$hgt\ A \neq 1$ Not Normal

It is clear that we could make Normal each fuzzy set by dividing to the Support as follow.

$$\mu_{\text{norm}\tilde{A}}(x) = \frac{\mu_{\tilde{A}}(x)}{Sup\left(\mu_{\tilde{A}}(x)\right)}$$

Also if for an element like x in set Ã, $\mu_{\tilde{A}}(x) = \frac{1}{2}$ so x is the pass point of the set (Momini 2006).

Fuzzy Sub-Sets

In each $x \in X$ if we have $\mu_{\tilde{A}}(x) \leq \mu_B(x)$ in this case Ã is sub set of B and also we can say A and B are equal if we have $x \in X$، $\mu_{\tilde{A}}(x) = \mu_B(x)$

Intersection

If the degree of membership of that in fuzzy set Ã was equal to α where $0 < \alpha \leq 1$ then α is the intersection of A and shows as follow.

$$A_\alpha = \left\{x \in X \middle| \mu_{\tilde{A}}(x) \geq \alpha\right\}$$

Sometimes says about concept of strong intersection which shows with.

$$A_\alpha = \left\{x \in X \middle| \mu_{\tilde{A}}(x) > \alpha\right\}$$

Note that if $\alpha = 0$ $SuppA = A_\alpha = 0$ it means that the support of a set is the set intersection (Klir and Yuan 1995).

Fuzzy Number

From truth number set R we choose a fuzzy set of N and we called a truth fuzzy number if it has the following 3 charecteristic.

1. It should be convex (N)
2. It should be $x_0 \in X$ $\mu_N(x_0) = 1$
3. The graph line should be continually $\mu_N(x)$

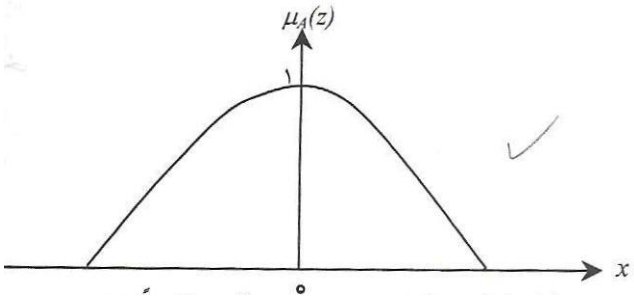


**Figure 2.3:** The Graph Shows the Fuzzy Number

**Source:** Momini

As we know the membership function it has many fuzzy numbers one of these number is Triangle Fuzzy Number which shows (a,b,c) graph showed below.

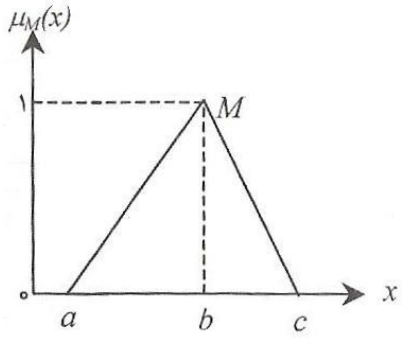


**Figure 2.4:** The Graph is Triangle Fuzzy Number 1

$$\mu_{\tilde{N}}(x) = \begin{cases} 0 & x < n_1 \\ \dfrac{x - n_1}{n_2 - n_1} & n_1 \le x \le n_2 \\ \dfrac{n_3 - x}{n_3 - n_2} & n_2 \le x \le n_3 \\ 0 & x > n_3 \end{cases}$$

A. The distance between fuzzy triangle number is as follow if a= (a, b, c) and b= ( a', b', c') be two fuzzy triangle number the distance between these two number given by this equation using vertex method.

$$d(a,b) = \sqrt{\frac{1}{1}(a - a')^2 + (b - b')^2 + (c - c')^2}$$

B. Linguistic Variables

In fuzzy set method, conversion scales are applied to change the linguistic terms into fuzzy numbers. In here we will apply a scale of 1 to 9 for each of

the criteria and the alternatives. The linguistic variables and fuzzy ratings for the alternatives and the criteria are as shown in Table.

**Table 2.4:** Fuzzy Rating Linguistic Variables

| **Fuzzy Number** | **Alternative Assessment** | **QA Weight** |
|---|---|---|
| (1, 1, 3) | Very poor (VP) | Very Low |
| (1, 3, 5) | Poor (P) | Low |
| (3, 5, 7) | Fair (F) | Medium |
| (5, 7, 9) | Good (G) | High |
| (7, 9, 9) | Very Good (VG) | Very High |

2.8.4 TOPSIS Method Calculation steps

Step-1 Calculate the Normalized Matrix by using

$$X_{ij} = \frac{X_{ij}}{\sqrt{\sum_{i=1}^{n} X_{ij}^2}}$$

Step-2 Calculate Weighted normalized matrix by using

$$V_{ij} = \bar{X}_{ij} \times W_j$$

Step-3 Calculate the Ideal best and ideal worst

Step-4 Calculate the Euclidean distance from the ideal best

$$\boldsymbol{S_i^+} = \left[\sum_{\mathbf{j=1}}^{\boldsymbol{m}} \left(V_{ij} - V_j^+\right)^{\mathbf{2}}\right]^{\mathbf{0.5}}$$

Step-5 Calculate the Euclidean distance from the ideal worst

$$\boldsymbol{S_i^-} = \left[\sum_{\mathbf{j=1}}^{\boldsymbol{m}} \left(V_{ij} - V_j^-\right)^{\mathbf{2}}\right]^{\mathbf{0.5}}$$

Step-6 Calculate Performance Score

$$P_i = \frac{S_i^-}{S_i^+ + S_i^-}$$

## 2.9 Summary of the Chapter

As outlined in the introduction section, organizations have been challenged in choosing a contractor whose capabilities are tailored to their needs. Therefore, the contractor's selection is one of the most important parts of the process of outsourcing activities. If in this work, the choice of tastes instead of using scientific methods will be a lot of losses to the organization. At the beginning of the chapter, we tried to provide definitions of the project and general contractors, then a review of the criteria for choosing the contractor. Many researchers have worked on choosing a contractor; some of them owning a new model and some of them research based on previous research models. In evaluating contractors, decision-makers face uncertainty; hence some of this chapter was devoted to the introduction and description of fuzzy logic. Subsequently, multi-criteria decision-making methods were introduced.

# 3. RESEARCH METHODOLOGY

The Method and design of conducting research should pass through a theoretical, logical or argumenta path. The achievement of the main purpose of the research is possible when a search for cognition is done with a correct methodology. Methodology (regardless of its philosophical dimensions) is referred to an interconnected set of rules, principles, and practices common to a discipline of knowledge (Khaki, 2004). In other words, the purpose of choosing the method of doing research is to determine which research method is necessary to examine a particular topic. The purpose of the research method selection is to provide the researcher with a clear indication of the method that will make him more accurate, easier, faster, and cheaper in obtaining answers to questions or research questions. (Naderi and Naraghi, 1375).

## 3.1 Research Method

### 3.1.1 Research Type Based on the Purpose

This research is considered to be an applied research in terms of research purpose. Firstly, this research has examined and analyzed theories tested in other societies in order to identify and solve problems in their statistical society; and secondly, to identify and investigate the factors affecting the behavior of managers and decision makers and Causes of occurrence are less relevant. Applied research focuses more on the most effective action and lessens the causes.

### 3.1.2 Type of research based on the method

Considering that in this research the objective of identifying effective factors on the ranking of contractors and the importance of each of them, therefore, can be classified into descriptive research. Descriptive research includes a set of methods whose purpose is to describe the circumstances or phenomena under study. Since it is used to collect the information necessary for completing this research, the questionnaire and interviewing tool have been used. It can be said that this research

is a type of survey research. In general, this research is descriptive in terms of information analysis methods and in terms of survey data collection methods.

### 3.2 Research Area

Generally, in each research, it is necessary to provide information about the environment in which the research was conducted and how long it was conducted. So, in this section, we describe the temporal, spatial and temporal frameworks.

#### 3.2.1 Time domain

This research lasted from the beginning of the preparatory studies to the data analysis phase for approximately 5 months (01/2019 to 01/2020).

#### 3.2.2 Subject area

This research has selected the criteria for evaluation and ranking of municipality construction contractors using the fuzzy TOPSIS approach.

#### 3.2.3 Spatial Territory

This research has been carried out in Herat municipality and its related areas.

### 3.3 Statistical Community

According to the model used in the research and also the 3-step process of collecting information in this research, two types of statistical society are defined:

### 3.4 Research Objectives

The objectives of this research are divided into two categories:

- Main goals

Considering that in recent years the municipality has paid particular attention to the development and construction of the city of Herat, it has become clear that a general assessment of contractors with the aim of creating a hospital for continuous improvement and promotion is of interest. Therefore, providing a method and model for choosing the most suitable contractor using multi-criteria decision-making

methods in such a relatively competitive environment is one of the objectives of the research.

- Sub-goals

A) Identification and categorization of comprehensive criteria and indicators for assessing municipal contractors

B) Determining the weight and importance of selected criteria and criteria for choosing contractors for municipal construction projects.

### 3.5 Research Questions

In this research, the following questions are answered:

The main question: What is the ranking of contractors for municipality construction projects according to the criteria and indicators using fuzzy method?

Sub Suggestions

(A) What are the criteria and indicators that provide a comprehensive and complete assessment of the suitability of contractors for municipal construction projects?

(B) What is the importance and weight of each of the criteria and indices chosen for selecting the contractor of the municipal projects in the investigative unit?

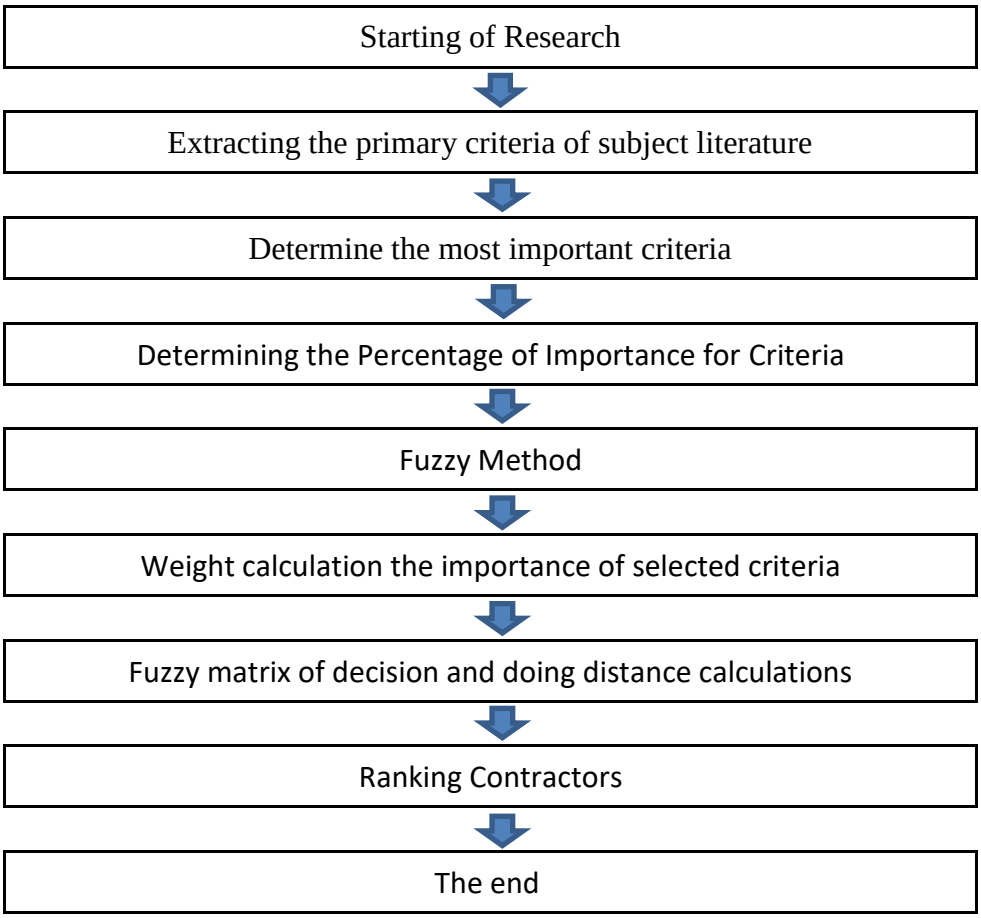


**Figure 3.1:** All Stages of the Study Are Presented In 1

### 3.6 Methods and Tools Used Resources

The required data in this study were collected using four resources of library resources, Internet usage, Procurement law and interview.

#### 3.6.1 Use of scientific library resources

In this research, materials from the second chapter of the research literature chapter were used for the internal and external books and magazines.

#### 3.6.2 Using databases and scientific journals of the World Wide Web

Most of the information about the background of the research was obtained using databases scientific journals of the Internet. Also, for compilation and classification of a set of criteria and indicators for the selection of contractors, the articles in the databases and scientific journals were also used.

### 3.7 Research Processes

All stages of the study are presented in Figure 3-1.

### 3.8 Methods and Tools for Data Collection and Analysis of Information

To collect and analyze the data and information needed in this research, various methods and tools have been used, which are further elaborated on the different requirements of the research model.

#### 3.8.1 Extracting Primary Criteria

In this research, in order to develop a comprehensive list of criteria for selection of contractors, a comprehensive overview of the literature on the subject and background of the research of specialized articles was prepared and collected. Specialized articles collected in the fields are related to contractor selection, categorization of criteria for contractor selection, comparison of contractor selection models, subcontractor's methods and modalities of evaluation, presentation of decision making model in the selection of contractor, criteria and indices of preliminary assessment of contractors.

One of the determining factors for choosing these articles as a reference for identifying criteria for choosing contractor for municipality projects is the rate of adoption of the documents in these articles in the subject literature. In terms of time, these articles include a collection of the most prominent and most authoritative researches in the last two decades. In order to carry out a preliminary screening to identify the criteria for selecting the contractor of municipal projects, the table of frequencies of the criteria and indicators mentioned among the articles was made up.

In order to provide a systematic and practical model for selection of municipal construction projects based on the numerous tables and opinions of professors and experts, seven main criteria and thirty-one indicators or sub-criteria were identified using the literature of the subject. In the translation and transcription of Persian phrases, the titles of identified criteria have been attempted to select the most tangible and most expressive English phrases, and even use the interlocutors between the directors and relevant experts as well as the vocabulary used in related English texts. The criteria and indicators identified are:

1. Contractor Cost and Financial power Criteria: The most important and first Criteria that all contractor shouldn't take it easy, it related to the contractor's Experience and technical specialization, credit rating, current ratio, profitability ratio, adequacy of guarantees and bank treaties, financial turnover records

2. Contractor Quality Criteria: It related to Scale of completed projects, experience of similar projects, duration of activity in industry and business, geographic experience at the project site

3. Contracts time period: In most Contracts time is one of the important factors of the project sometimes more important than the cost: it is related to Management of the project, experience of the contractor and professionalism of company.

4. Criteria of capacity of carrying out new projects: current workload, future workload

5. Organizational and management Criteria: Competency and competence of top managers, system and program of control and quality assurance, size of organization, plan and policy of safety and health, ability and ability of project management, tendency and tendency to court, jurisdiction and Capability of Executive Managers, Detailed Staff Training Program

6. Experience related to the project criteria: Failure to complete the project or previous contracts, actual quality obtained in previous projects, safety performance and safety in previous projects, communication with subcontractors, tendency to claim damages and contractual disputes, the amount of completed projects with time delays, the volume and type of work referred to subcontractors, the relationship with the previous employer, the overrun of the project costs from the planned amount.

7. Occupational Safety Criteria: These criteria in one of the important criteria in a project, it shows the contractors implication to the life of humans.

### 3.9 Determining the Percentage of Importance of the Criteria

When we research and analyze the contractors of Herat municipality we should refer to Procurement law of Afghanistan which shows that the most important Criteria is Cost of Contract and percentage will reduces step by step ( Cost of Contract, Quality, Time, Experience,…..etc.).

### 3.10 Summary of the Chapter

In this chapter, we describe the methodology, research method, data collection method and assumptions to achieve the goals and answer the research questions. The model used in this study consists of fuzzy assumption testing techniques and fuzzy TOPSIS distance. Also identified effective criteria were the ranking of municipal contractors. In the next chapter, the results of the implementation of the research model will be expressed.

# 4. ANALYSIS

## 4.1 Final Accepted Criteria

In order to provide a systematic and practical model for the selection ideal municipal construction project, 13 criteria were identified and 7 of them have been selected by using an interview which has been interviewed with 25 specialist and 20 of them has returned. The Final 7 criteria which have been selected are as follow.

1. Proposed price: This criterion, after the "experience" criterion, has the highest frequency in the literature review, and has traditionally been used as a unique measurement criterion for contractor selection.

2. Experience: In the literature on the subject, the criterion of experience gains the highest frequency among the identified criteria / Alternatives, and about half of the articles are also about criterion of fame. Here, fame is used very closely to the image. The organization's image is a conceptual assessment; however, the contractor's membership in business or professional associations is a well-known approach to improving organizational image. Membership in these forums is an essential element of the evaluation of contractors (Halt, 1996). Reputation is considered as an effective copy of company stability, reliability and business in related Companies (Holt, 1996).

3. Financial: This indicator measures the financial soundness of the contracting entity (contractor) and its ability to carry out technical responsibilities and long-term financial commitment, and measures the current obligations to the project (Singh and Tiong, 2006).

4. Technical and Specialist Capacity: The important and positive features of a contractor for the implementation of projects, is the availability of related equipment and machinery in the field of activities that results the project implementation. Equipment and machinery have direct influence on the technical capabilities of the contractor in executing industrial projects, and from other perspectives they can be considered as important factors in the field of contract capital assets, which in terms

of financial ratios Contractor acquisitions will be effective. Equipment and machinery imply the availability of machinery for the correct operation and the speed of work, and the availability of small tools and test instruments (Hatsush and Skitmore, 1998). Technical abilities have a close relationship with equipment and machinery, and the factor that has a great influence on the technical capabilities of the contractor, the use of technical and experienced experts, and we can say the equipment, machinery, and experienced technicians have complementary experienced and mutually supportive effects on each other.

5. The actual quality obtained in previous projects: In the preliminary assessment of contractors, they should evaluate their performance records from the point of view of the quality of the similar projects (Kumar, M., P. Varta 2004). The basis for the quality of the obtained good quality is the result of a comprehensive quality control program and a quality control policy (Fung & Choi, 2000). The actual quality gained in previous projects can be assessed through an inquiry from two previous employers (Holt, 1996). This Alternative examines the degree of satisfaction of previous employers with the quality of previous work (Holt colleagues., 1994).

6. The experience of implementing similar projects: This indicator indicates how many contractors have the number of similar projects related to this project during the course of their activities. One of the most important criteria for selecting a qualified contractor is to evaluate the past experience of contractors in similar projects that they have completed. The dimension of this assessment includes the background, type and size of the completed projects (Holt Colleagues., 1995).

7. Health and safety performance in previous projects: This indicator is generally assessed through previous studies on safety and health records and safety and health precautions in previous projects (Hathush and Skitmore,, 1999). A study on the safety of construction workshops in Honduras showed a significant lack of awareness of the importance of safety at all levels of the construction industry. Questions related to Emergency Modification (EMR) and Occupational Exposure Scheme and Occupational Safety and Health Administration (OSHA) can, however, provide information on contractor safety performance (Hathush and Skitmore, 1997a,1997).

### 4.2 Final Contractor Selection Criteria Method

The fuzzy hypothesis test was used to determine the effective factors for selection of final criteria of selecting contractor of the municipal. An interview containing 7 criteria was developed in the previous section and designed by 20 experts and specialists of procurement. The work experience was in the contractors' evaluation section and 20 interviews were returned, using a five-point scale. Respondents were asked to rate the significance of each of the proposed criteria at (very low, low, medium, high and very high); for each criterion, the hypotheses C0 to C4 were modeled as follows: By defining and using expert opinions, the degree of verification of each assumption is determined.

$H_0$: In Contractor ranking has Highest importance Point

$H_1$: In Contractor ranking has High importance Point

$H_2$: In Contractor ranking has Medium importance Point

$H_3$: In Contractor ranking has Low importance Point

$H_4$: In Contractor ranking has Lowest importance Point

After that as shown in Table below the important and most effective have selected.

**Table 4.1:** Important Criteria Selected

| No | Criteria | Percentage |
|---|---|---|
| 1 | Proposed Cost | Very High Importance |
| 2 | Experience | High Importance |
| 3 | Financial capacity | Importance |
| 4 | Technical Capacity | Average Importance |
| 5 | Real Quality obtained Last Projects | Low Importance |
| 6 | Similar project Experience | Very low Importance |
| 7 | Safety Performance in previous projects | Very Low Importance |

### 4.3 Evaluating Contractors by Using Fuzzy-TOPSIS Technique.

In this step the Contractors will rank with criteria above and the data we have gotten before from 3 organizations.

The companies which will rank are as follow:

Ashianeh Sazan, Plannet, Aseman Sharqe, Emar-e-Berter, Afghan Sef, Bakhter, Kawishgram and Paida, Diar Sazan, Sodais Saber, Safi, Behsazan-e-Sharq, Hosay-e-Sharq, Benahgran Afghan and Criteria have written in the table above. We would write A1 to A13 behalf of Company names as unspecified codes.

And Behalf of Criteria we will write symbols from C1 to C7.

**Table 4.2:** Table C1, C3, C7 are Financial Criteria

| No | Criteria | Symbol |
|---|---|---|
| 1 | Proposed Cost | C1 |
| 2 | Experience | C2 |
| 3 | Financial capacity | C3 |
| 4 | Technical Capacity | C4 |
| 5 | Real Quality obtained Last Projects | C5 |
| 6 | Similar project Experience | C6 |
| 7 | Safety Performance in previous projects | C7 |

In above Table C1, C3, C7 are financial Criteria and the others are Technical Criteria.

**Table 4.3:** The Combine Fuzzy Matrix Table

| Weight | | Combine Decision Matrix | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Candidate Companies | | Criterias | | | | | | | | | | | | | | | | | | | | | | |
| No | Name | C1 | | | C2 | | | C3 | | | C4 | | | C5 | | | C6 | | | C7 | | | | |
| 1 | A1 | 5 | 7 | 9 | 7 | 9 | 9 | 5 | 7 | 9 | 3 | 5 | 7 | 3 | 5 | 7 | 5 | 7 | 9 | 3 | 5 | 7 | | |
| 2 | A2 | 7 | 9 | 9 | 5 | 7 | 9 | 3 | 5 | 7 | 7 | 9 | 9 | 3 | 5 | 7 | 3 | 5 | 7 | 1 | 3 | 5 | | |
| 3 | A3 | 5 | 7 | 9 | 3 | 5 | 7 | 7 | 9 | 9 | 3 | 5 | 7 | 7 | 9 | 9 | 1 | 3 | 5 | 5 | 7 | 9 | | |
| 4 | A4 | 5 | 7 | 9 | 5 | 7 | 9 | 7 | 9 | 9 | 5 | 7 | 9 | 3 | 5 | 7 | 3 | 5 | 7 | 1 | 1 | 3 | | |
| 5 | A5 | 3 | 5 | 7 | 3 | 5 | 7 | 5 | 7 | 9 | 3 | 5 | 7 | 5 | 7 | 9 | 5 | 7 | 9 | 1 | 3 | 5 | | |
| 6 | A6 | 1 | 3 | 5 | 1 | 3 | 5 | 5 | 7 | 9 | 1 | 3 | 5 | 1 | 3 | 5 | 3 | 5 | 7 | 3 | 5 | 7 | | |
| 7 | A7 | 3 | 5 | 7 | 5 | 7 | 9 | 1 | 1 | 3 | 3 | 5 | 7 | 3 | 5 | 7 | 5 | 7 | 9 | 5 | 7 | 9 | | |
| 8 | A8 | 5 | 7 | 9 | 7 | 9 | 9 | 1 | 3 | 5 | 7 | 9 | 9 | 5 | 7 | 9 | 3 | 5 | 7 | 7 | 9 | 9 | | |
| 9 | A9 | 7 | 9 | 9 | 5 | 7 | 9 | 3 | 5 | 7 | 5 | 7 | 9 | 3 | 5 | 7 | 1 | 3 | 5 | 1 | 3 | 5 | | |
| 10 | A10 | 7 | 9 | 9 | 5 | 7 | 9 | 5 | 7 | 9 | 1 | 3 | 5 | 1 | 3 | 5 | 5 | 7 | 9 | 3 | 5 | 7 | | |
| 11 | A11 | 5 | 7 | 9 | 5 | 7 | 9 | 5 | 7 | 9 | 1 | 3 | 5 | 1 | 3 | 5 | 3 | 5 | 7 | 5 | 7 | 9 | | |
| 12 | A12 | 5 | 7 | 9 | 1 | 3 | 5 | 7 | 9 | 9 | 1 | 3 | 5 | 1 | 3 | 5 | 3 | 5 | 7 | 5 | 7 | 9 | | |
| 13 | A13 | 5 | 7 | 9 | 3 | 5 | 7 | 1 | 1 | 3 | 7 | 9 | 9 | 1 | 3 | 5 | 1 | 3 | 5 | 3 | 5 | 7 | | |

As data we collected before from the decision makers' opinion in shown as a quantitative table below based on fuzzy numbers and weighted the Criteria by percent of importance.

**Table 4.4:** The Normalized Combine Matrix

| **Weight** | | **Combine Decision Matrix** | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Candidate Companies** | | **Criterias** | | | | | | | | | | | | | | | | | | | | | |
| | | **7** | **9** | **9** | **5** | **7** | **9** | **3** | **5** | **7** | **1** | **3** | **5** | **1** | **1** | **3** | **1** | **1** | **1** | **1** | **1** | **1** |
| **No** | **Name** | **C1** | | | **C2** | | | **C3** | | | **C4** | | | **C5** | | | **C6** | | | **C7** | | |
| 1 | A1 | 5 | 7 | 9 | 7 | 9 | 9 | 5 | 7 | 9 | 3 | 5 | 7 | 3 | 5 | 7 | 5 | 7 | 9 | 3 | 5 | 7 |
| 2 | A2 | 7 | 9 | 9 | 5 | 7 | 9 | 3 | 5 | 7 | 7 | 9 | 9 | 3 | 5 | 7 | 3 | 5 | 7 | 1 | 3 | 5 |
| 3 | A3 | 5 | 7 | 9 | 3 | 5 | 7 | 7 | 9 | 9 | 3 | 5 | 7 | 7 | 9 | 9 | 1 | 3 | 5 | 5 | 7 | 9 |
| 4 | A4 | 5 | 7 | 9 | 5 | 7 | 9 | 7 | 9 | 9 | 5 | 7 | 9 | 3 | 5 | 7 | 3 | 5 | 7 | 1 | 1 | 3 |
| 5 | A5 | 3 | 5 | 7 | 3 | 5 | 7 | 5 | 7 | 9 | 3 | 5 | 7 | 5 | 7 | 9 | 5 | 7 | 9 | 1 | 3 | 5 |
| 6 | A6 | 1 | 3 | 5 | 1 | 3 | 5 | 5 | 7 | 9 | 1 | 3 | 5 | 1 | 3 | 5 | 3 | 5 | 7 | 3 | 5 | 7 |
| 7 | A7 | 3 | 5 | 7 | 5 | 7 | 9 | 1 | 1 | 3 | 3 | 5 | 7 | 3 | 5 | 7 | 5 | 7 | 9 | 5 | 7 | 9 |
| 8 | A8 | 5 | 7 | 9 | 7 | 9 | 9 | 1 | 3 | 5 | 7 | 9 | 9 | 5 | 7 | 9 | 3 | 5 | 7 | 7 | 9 | 9 |
| 9 | A9 | 7 | 9 | 9 | 5 | 7 | 9 | 3 | 5 | 7 | 5 | 7 | 9 | 3 | 5 | 7 | 1 | 3 | 5 | 1 | 3 | 5 |
| 10 | A10 | 7 | 9 | 9 | 5 | 7 | 9 | 5 | 7 | 9 | 1 | 3 | 5 | 1 | 3 | 5 | 5 | 7 | 9 | 3 | 5 | 7 |
| 11 | A11 | 5 | 7 | 9 | 5 | 7 | 9 | 5 | 7 | 9 | 1 | 3 | 5 | 1 | 3 | 5 | 3 | 5 | 7 | 5 | 7 | 9 |
| 12 | A12 | 5 | 7 | 9 | 1 | 3 | 5 | 7 | 9 | 9 | 1 | 3 | 5 | 1 | 3 | 5 | 3 | 5 | 7 | 5 | 7 | 9 |
| 13 | A13 | 5 | 7 | 9 | 3 | 5 | 7 | 1 | 1 | 3 | 7 | 9 | 9 | 1 | 3 | 5 | 1 | 3 | 5 | 3 | 5 | 7 |

In next step the table will show the normalized fuzzy decision matrix by using the below formula.

$$\bar{v}_{ij}^{L} = w_i \bar{n}_{ij}^{L} j = 1, 2, \dots, mi = 1, 2, \dots, n$$

$$\bar{v}_{ij}^{U} = w_i \bar{n}_{ij}^{U} j = 1, 2, \dots, mi = 1, 2, \dots, n$$

$$\sum_{i=1}^{n} w_i = 1$$

**Table 4.5:** The Weighted Normalized Decision Matrix

| Normalized fuzzy decision matrix | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Candidate Companies | | Criterias | | | | | | | | | | | | | | | | | | | | | |
| | | 7 | 9 | 9 | 5 | 7 | 9 | 3 | 5 | 7 | 1 | 3 | 5 | 1 | 1 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | |
| No | Name | C1 | | | C2 | | | C3 | | | C4 | | | C5 | | | C6 | | | C7 | | | |
| 1 | A1 | 0.56 | 0.78 | 1.00 | 0.78 | 1.00 | 1.00 | 0.56 | 0.78 | 1.00 | 0.33 | 0.56 | 0.78 | 0.33 | 0.56 | 0.78 | 0.56 | 0.78 | 1.00 | 0.33 | 0.56 | 0.78 | |
| 2 | A2 | 0.78 | 1.00 | 1.00 | 0.56 | 0.78 | 1.00 | 0.33 | 0.56 | 0.78 | 0.78 | 1.00 | 1.00 | 0.33 | 0.56 | 0.78 | 0.33 | 0.56 | 0.78 | 0.11 | 0.33 | 0.56 | |
| 3 | A3 | 0.56 | 0.78 | 1.00 | 0.33 | 0.56 | 0.78 | 0.78 | 1.00 | 1.00 | 0.33 | 0.56 | 0.78 | 0.78 | 1.00 | 1.00 | 0.11 | 0.33 | 0.56 | 0.56 | 0.78 | 1.00 | |
| 4 | A4 | 0.56 | 0.78 | 1.00 | 0.56 | 0.78 | 1.00 | 0.78 | 1.00 | 1.00 | 0.56 | 0.78 | 1.00 | 0.33 | 0.56 | 0.78 | 0.33 | 0.56 | 0.78 | 0.11 | 0.11 | 0.33 | |
| 5 | A5 | 0.33 | 0.56 | 0.78 | 0.33 | 0.56 | 0.78 | 0.56 | 0.78 | 1.00 | 0.33 | 0.56 | 0.78 | 0.56 | 0.78 | 1.00 | 0.56 | 0.78 | 1.00 | 0.11 | 0.33 | 0.56 | |
| 6 | A6 | 0.11 | 0.33 | 0.56 | 0.11 | 0.33 | 0.56 | 0.56 | 0.78 | 1.00 | 0.11 | 0.33 | 0.56 | 0.11 | 0.33 | 0.56 | 0.33 | 0.56 | 0.78 | 0.33 | 0.56 | 0.78 | |
| 7 | A7 | 0.33 | 0.56 | 0.78 | 0.56 | 0.78 | 1.00 | 0.11 | 0.11 | 0.33 | 0.33 | 0.56 | 0.78 | 0.33 | 0.56 | 0.78 | 0.56 | 0.78 | 1.00 | 0.56 | 0.78 | 1.00 | |
| 8 | A8 | 0.56 | 0.78 | 1.00 | 0.78 | 1.00 | 1.00 | 0.11 | 0.33 | 0.56 | 0.78 | 1.00 | 1.00 | 0.56 | 0.78 | 1.00 | 0.33 | 0.56 | 0.78 | 0.78 | 1.00 | 1.00 | |
| 9 | A9 | 0.78 | 1.00 | 1.00 | 0.56 | 0.78 | 1.00 | 0.33 | 0.56 | 0.78 | 0.56 | 0.78 | 1.00 | 0.43 | 0.71 | 1.00 | 0.11 | 0.33 | 0.56 | 0.11 | 0.33 | 0.56 | |
| 10 | A10 | 0.78 | 1.00 | 1.00 | 0.56 | 0.78 | 1.00 | 0.56 | 0.78 | 1.00 | 0.11 | 0.33 | 0.56 | 0.20 | 0.60 | 1.00 | 0.56 | 0.78 | 1.00 | 0.33 | 0.56 | 0.78 | |
| 11 | A11 | 0.56 | 0.78 | 1.00 | 0.56 | 0.78 | 1.00 | 0.56 | 0.78 | 1.00 | 0.11 | 0.33 | 0.56 | 0.20 | 0.60 | 1.00 | 0.43 | 0.71 | 1.00 | 0.56 | 0.78 | 1.00 | |
| 12 | A12 | 0.56 | 0.78 | 1.00 | 0.11 | 0.33 | 0.56 | 0.78 | 1.00 | 1.00 | 0.11 | 0.33 | 0.56 | 0.20 | 0.60 | 1.00 | 0.43 | 0.71 | 1.00 | 0.56 | 0.78 | 1.00 | |
| 13 | A13 | 0.56 | 0.78 | 1.00 | 0.33 | 0.56 | 0.78 | 0.14 | 0.14 | 0.43 | 0.78 | 1.00 | 1.00 | 0.20 | 0.60 | 1.00 | 0.20 | 0.60 | 1.00 | 0.43 | 0.71 | 1.00 | |

**Table 4.6:** The Weighted Normalized Decision Matrix

| Weighted Normalized Decision matrix | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Candidate Companies | | Criterias | | | | | | | | | | | | | | | | | | | | | |
| | | 7 | 9 | 9 | 5 | 7 | 9 | 3 | 5 | 7 | 1 | 3 | 5 | 1 | 1 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | |
| No | Name | C1 | | | C2 | | | C3 | | | C4 | | | C5 | | | C6 | | | C7 | | | |
| 1 | A1 | 3.89 | 7.00 | 9.00 | 3.89 | 7.00 | 9.00 | 1.67 | 3.89 | 7.00 | 0.33 | 1.67 | 3.89 | 0.33 | 0.56 | 2.33 | 0.56 | 0.78 | 1.00 | 0.33 | 0.56 | 0.78 | |
| 2 | A2 | 5.44 | 9.00 | 9.00 | 2.78 | 5.44 | 9.00 | 1.00 | 2.78 | 5.44 | 0.78 | 3.00 | 5.00 | 0.33 | 0.56 | 2.33 | 0.33 | 0.56 | 0.78 | 0.11 | 0.33 | 0.56 | |
| 3 | A3 | 3.89 | 7.00 | 9.00 | 1.67 | 3.89 | 7.00 | 2.33 | 5.00 | 7.00 | 0.33 | 1.67 | 3.89 | 0.78 | 1.00 | 3.00 | 0.11 | 0.33 | 0.56 | 0.56 | 0.78 | 1.00 | |
| 4 | A4 | 3.89 | 7.00 | 9.00 | 2.78 | 5.44 | 9.00 | 2.33 | 5.00 | 7.00 | 0.56 | 2.33 | 5.00 | 0.33 | 0.56 | 2.33 | 0.33 | 0.56 | 0.78 | 0.11 | 0.11 | 0.33 | |
| 5 | A5 | 2.33 | 5.00 | 7.00 | 1.67 | 3.89 | 7.00 | 1.67 | 3.89 | 7.00 | 0.33 | 1.67 | 3.89 | 0.56 | 0.78 | 3.00 | 0.56 | 0.78 | 1.00 | 0.11 | 0.33 | 0.56 | |
| 6 | A6 | 0.78 | 3.00 | 5.00 | 0.56 | 2.33 | 5.00 | 1.67 | 3.89 | 7.00 | 0.11 | 1.00 | 2.78 | 0.11 | 0.33 | 1.67 | 0.33 | 0.56 | 0.78 | 0.33 | 0.56 | 0.78 | |
| 7 | A7 | 2.33 | 5.00 | 7.00 | 2.78 | 5.44 | 9.00 | 0.33 | 0.56 | 2.33 | 0.33 | 1.67 | 3.89 | 0.33 | 0.56 | 2.33 | 0.56 | 0.78 | 1.00 | 0.56 | 0.78 | 1.00 | |
| 8 | A8 | 3.89 | 7.00 | 9.00 | 3.89 | 7.00 | 9.00 | 0.33 | 1.67 | 3.89 | 0.78 | 3.00 | 5.00 | 0.56 | 0.78 | 3.00 | 0.33 | 0.56 | 0.78 | 0.78 | 1.00 | 1.00 | |
| 9 | A9 | 5.44 | 9.00 | 9.00 | 2.78 | 5.44 | 9.00 | 1.00 | 2.78 | 5.44 | 0.56 | 2.33 | 5.00 | 0.43 | 0.71 | 3.00 | 0.11 | 0.33 | 0.56 | 0.11 | 0.33 | 0.56 | |
| 10 | A10 | 5.44 | 9.00 | 9.00 | 2.78 | 5.44 | 9.00 | 1.67 | 3.89 | 7.00 | 0.11 | 1.00 | 2.78 | 0.20 | 0.60 | 3.00 | 0.56 | 0.78 | 1.00 | 0.33 | 0.56 | 0.78 | |
| 11 | A11 | 3.89 | 7.00 | 9.00 | 2.78 | 5.44 | 9.00 | 1.67 | 3.89 | 7.00 | 0.11 | 1.00 | 2.78 | 0.20 | 0.60 | 3.00 | 0.43 | 0.71 | 1.00 | 0.56 | 0.78 | 1.00 | |
| 12 | A12 | 3.89 | 7.00 | 9.00 | 0.56 | 2.33 | 5.00 | 2.33 | 5.00 | 7.00 | 0.11 | 1.00 | 2.78 | 0.20 | 0.60 | 3.00 | 0.43 | 0.71 | 1.00 | 0.56 | 0.78 | 1.00 | |
| 13 | A13 | 3.89 | 7.00 | 9.00 | 1.67 | 3.89 | 7.00 | 0.43 | 0.71 | 3.00 | 0.78 | 3.00 | 5.00 | 0.20 | 0.60 | 3.00 | 0.20 | 0.60 | 1.00 | 0.43 | 0.71 | 1.00 | |
| | A* | 5.444 | 9 | 9 | 3.889 | 7 | 9 | 2.333 | 5 | 7 | 0.778 | 3 | 5 | 0.778 | 1 | 3 | 0.556 | 0.78 | 1 | 0.778 | 1 | 1 | |
| | A- | 0.78 | 3.00 | 5.00 | 0.56 | 2.33 | 5.00 | 0.33 | 0.56 | 2.33 | 0.11 | 1.00 | 2.78 | 0.11 | 0.33 | 1.67 | 0.11 | 0.33 | 0.56 | 0.11 | 0.11 | 0.33 | |

**Table 4.7:** The Positive Distance of FPIS Matrix

| Distance From FPIS | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Candidate Companies | | Criterias | | | | | | | |
| No | Name | C1 | C2 | C3 | C4 | C5 | C6 | C7 | di* |
| 1 | A1 | 1.463 | 0.000 | 0.748 | 1.034 | 0.529 | 0.000 | 0.385 | 4.159 |
| 2 | A2 | 0.000 | 1.104 | 1.745 | 0.000 | 0.529 | 0.222 | 0.602 | 4.202 |
| 3 | A3 | 1.463 | 2.491 | 0.000 | 1.034 | 0.000 | 0.444 | 0.181 | 5.614 |
| 4 | A4 | 1.463 | 1.104 | 0.000 | 0.406 | 0.529 | 0.222 | 0.748 | 4.472 |
| 5 | A5 | 3.145 | 2.491 | 0.748 | 1.034 | 0.181 | 0.000 | 0.602 | 8.202 |
| 6 | A6 | 4.959 | 4.037 | 0.748 | 1.768 | 0.943 | 0.222 | 0.385 | 13.062 |
| 7 | A7 | 3.145 | 1.104 | 3.896 | 1.034 | 0.529 | 0.000 | 0.181 | 9.890 |
| 8 | A8 | 1.463 | 0.000 | 2.875 | 0.000 | 0.181 | 0.222 | 0.000 | 4.741 |
| 9 | A9 | 0.000 | 1.104 | 1.745 | 0.406 | 0.260 | 0.444 | 0.602 | 4.561 |
| 10 | A10 | 0.000 | 1.104 | 0.748 | 1.768 | 0.406 | 0.000 | 0.385 | 4.411 |
| 11 | A11 | 1.463 | 1.104 | 0.748 | 1.768 | 0.406 | 0.082 | 0.181 | 5.752 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 12 | A12 | 1.463 | 4.037 | 0.000 | 1.768 | 0.406 | 0.082 | 0.181 | 7.937 |
| 13 | A13 | 1.463 | 2.491 | 3.559 | 0.000 | 0.406 | 0.230 | 0.260 | 8.409 |

**Table 4.8:** The Negative Distance of FNIS

| Candidate Companies | | Distance from FNIS Criterias | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **No** | **Name** | **C1** | **C2** | **C3** | **C4** | **C5** | **C6** | **C7** | **di-** |
| 1 | A1 | 3.73 | 4.04 | 3.40 | 0.76 | 0.43 | 0.44 | 0.38 | 13.18 |
| 2 | A2 | 4.96 | 3.19 | 2.24 | 1.77 | 0.43 | 0.22 | 0.18 | 12.99 |
| 3 | A3 | 3.73 | 1.60 | 3.90 | 0.76 | 0.94 | 0.00 | 0.60 | 11.52 |
| 4 | A4 | 3.73 | 3.19 | 3.90 | 1.52 | 0.43 | 0.22 | 0.00 | 12.98 |
| 5 | A5 | 1.86 | 1.60 | 3.40 | 0.76 | 0.85 | 0.44 | 0.18 | 9.10 |
| 6 | A6 | 0.00 | 0.00 | 3.40 | 0.00 | 0.00 | 0.22 | 0.38 | 4.01 |
| 7 | A7 | 1.86 | 3.19 | 0.00 | 0.76 | 0.43 | 0.44 | 0.60 | 7.29 |
| 8 | A8 | 3.73 | 4.04 | 1.10 | 1.77 | 0.85 | 0.22 | 0.75 | 12.46 |
| 9 | A9 | 4.96 | 3.19 | 2.24 | 1.52 | 0.82 | 0.00 | 0.18 | 12.92 |
| 10 | A10 | 4.96 | 3.19 | 3.40 | 0.00 | 0.79 | 0.44 | 0.38 | 13.17 |
| 11 | A11 | 3.73 | 3.19 | 3.40 | 0.00 | 0.79 | 0.38 | 0.60 | 12.09 |
| 12 | A12 | 3.73 | 0.00 | 3.90 | 0.00 | 0.79 | 0.38 | 0.60 | 9.40 |
| 13 | A13 | 3.73 | 1.60 | 0.40 | 1.77 | 0.79 | 0.30 | 0.55 | 9.13 |

And the Last step the CCi and Rank Table as follow

**Table 4.9:** The CCi and Rank Table as Follow

| $CC_i$ | **Rank** | Contractors |
|---|---|---|
| 0.76009 | **1** | A1 |
| 0.755625 | **2** | A2 |
| 0.672414 | **8** | A3 |
| 0.743825 | **4** | A4 |
| 0.525844 | **10** | A5 |
| 0.234722 | **13** | A6 |
| 0.424311 | **12** | A7 |
| 0.724335 | **6** | A8 |
| 0.739009 | **5** | A9 |
| 0.749096 | **3** | A10 |
| 0.677682 | **7** | A11 |
| 0.542078 | **9** | A12 |
| 0.520662 | **11** | A13 |

# 5. CONCLUSION AND RECOMMENDATIONS

The fifth chapter is devoted to summarizing, concluding and finally presenting suggestions In a brief overview of the past four chapters, it can be said that the first chapter presents general research on the topic, articulates the aims and questions of the research, explains and describes the keywords and problems and bottlenecks of the research; the second chapter reviews the background and research literature; the third chapter deals with research methodology; the fourth chapter analyzes the data collected with the help of Excel software and fuzzy TOPSIS.

This chapter presents the results of the study based on the findings and analyzes, and concludes with suggestions for improving the status quo based on the research findings as well as topics for future research.

## 5.1 Research Findings

The objectives of this study are:

### 5.1.1 Identification and Determination of Contractor Selection Criteria

The evaluation and selection of project contractors should be based on a comprehensive set of criteria and indicators that cover all functional aspects of the contractor's capabilities, competencies and abilities. In other words, the comprehensiveness of contractor evaluation criteria and indicators means that the relevant criteria and indicators must be capable of predicting the likely performance of the contractor in relation to the project. In this study, according to the research literature and the opinions of relevant experts, seven main criteria were discovered to evaluate the Municipality contractors in the municipality. These criteria are:

- Proposed Cost
- Experience
- Financial capacity
- Technical Capacity
- Real Quality obtained Last Projects

- Similar project Experience
- Safety Performance in previous projects

### 5.1.2 Ranking of Contracting Companies

Surveys show that initial assessments by municipality project contractors and the degree assigned to each, have not yielded accurate and reliable results and since in the evaluation phase of the proposals the final selection is merely based on the lowest bid, in fact many of the decisive differences between the neglected decision options and the differences between the competencies and competences of the bidders will not affect the final ranking and selection. In other words, the choice is not based on a comprehensive assessment of decision options.

In the model proposed in this study, all the issues and problems are considered and the proposed price is considered as one of the decision criteria in the model. Therefore, prioritization and final selection are based on a comprehensive evaluation of decision options. Accordingly, the best choice is not necessarily the bidder that offers the lowest price. The results of such prioritization and selection in the long run will cause in increased profitability and higher competitiveness for the organization.

**Table 5.1:** The Final Ranking Is As Follows

| $CC_i$ | **Rank** | Contractors |
|---|---|---|
| 0.76009 | **1** | A1 |
| 0.755625 | **2** | A2 |
| 0.672414 | **8** | A3 |
| 0.743825 | **4** | A4 |
| 0.525844 | **10** | A5 |
| 0.234722 | **13** | A6 |
| 0.424311 | **12** | A7 |
| 0.724335 | **6** | A8 |
| 0.739009 | **5** | A9 |
| 0.749096 | **3** | A10 |
| 0.677682 | **7** | A11 |
| 0.542078 | **9** | A12 |
| 0.520662 | **11** | A13 |

As it can be seen, the ranking and comprehensive evaluation of decision options based on selected criteria and indicators and using the model gives different priorities rather than the decision options when the options are only ranked on the basis of the bid price.

## 5.2 Research Suggestions

In this section, first, suggestions are made based on the results of the research and then suggestions are made for future research.

### 5.2.1 Practical suggestions

1) Considering the extensive research done in this research to identify important criteria and indicators for contractor selection and also to use a scientifically based decision making model, it is suggested that for future tenders in the municipality, the selection of contractor for construction projects be done with use the proposed model in this research. Applying this model will lead to results such as reducing contract failures as well as improving quality problems and ultimately reducing costs.

2) The model used in this study can be used in other parts of the municipality to select a contractor either. However, it should be noted that depending on the unit being evaluated, the criteria and indicators must be evaluated.

### 5.2.2 Recommendations for future research

1) Since criteria identification is the basis of applied studies and research and no endpoints can be recognized for the identified criteria, expanding the range of identified criteria for better selection adds to the richness of the work.

2) When evaluating and selecting contractors, it should always be borne in mind that real-world decision making is based on interdependent criteria, so using statistical techniques to determine the dependency of criteria to achieve more accurate results and more realistic is a must.

3) In order to select and categorize a set of criteria for selecting contractors, one can use decision making methods such as fuzzy set theory and multi-attribute utility theory and so on.

4) As a broad research field, it is recommended to develop and design software for municipal project contractor selection. This is done through the collaboration of a team of management students and software engineering students. For example, the software can perform various functions such as: determining decision options, choosing the type of decision model, sensitivity analysis, determining decision makers' view of risk, selecting key decision indicators, deleting one or more options,

Graphics Images of Different Options for Decision Indicators, weight and importance of indices and criteria, and so on.

## REFERENCES


**Al Harbi, K.M.A.S** (2001) "Application of the AHP in project management" international journal project management 19(1): 19-27.

**Al-Harbi KM.** (2001) "application of the AHP in project management." Int J proj manage 19(1):19-27

**Alsugair, Abdulah M.** (1999) "framework for evaluating bids of construction contractors." journal of management in engineering 15(2): 72-78

**Amiri, M., Zandieh, M., Soltani, R., Vahdani, B.** (2009) "A hybrid multi-criteria decision-making model for firms competence evolution." Expert systems with applications 36: 12314-12322.

**Andruskevicius A** (2005) "Evaluation of contractors by using COPRAS-the multiple criteria method" technological and economic development of economy 11(3): 158-169.

**Arsalan G Tuncan M Birgonal MT Dikmen I** (2006) "E-bidding proposal preparation system for construction projects build environ 41(10):1406-1413

**Banaitiene, N. and Banaitis A.** (2006) "Analysis of criteria for contractors qualification evaluation" technological and economic development of economy XII(4): 276-282.

**Biel Dr Wein LM** (2003) "An invers optimization based auction mechanism to support a multi attribute" RFQ process mange sci 49(11):1529-1545

**Cheng, E.W.L and Li, H** (2004) "contractor selection using the analytic network process" constraction management and economic 22(10): 1021-1032.

**Chen-Tung Chen-Ching-Tomg Lin-Sue-Fn Hang,** "A Fuzzy approach for supplier evaluation and selection in supply chain management" International journal of production economics 289-301.

**Daivid E Azoulay-Schwartz R Kraous S** (2006) "bidding in sealed –bid and English multi –attribute auctions" deci supp syst 42(2):527 -556

**DeBoer, L-Labro, E-Molarechi** (2001), "A review of methods supporting supplier selection" European journal of purchasing & supply management 30: 75-89.

**Deng H.** (1999) “Multicriteria analysis with fuzzy pairwise comparison.” Int approx reason 21:215-231

**Dobler DW Burt DN** (1996) purchasing and supply management 6 th edn Mc grow Hill,New York.

**Egemen M. and Mohamed, A.N.** (2005) “different approaches of clients and consultants to contractors qualification and selection” journal of civil engineering and management XI(4): 267-276.

**Egemen Mehmedali and Mohamad Abdulrezak N,** (2006) “client’s needs want and expectations from contractors and approach to the concept of repetitive work in thr northern Cyprus construction” market,building and environment 41:602-614

**Fong, Patrik Sik-Wah and Choi, Sonia Kit-Yung** (2000) “final contractor selection using the analytical hierarchy process construction” management and economic 18:547-557

**Gallien J. and Wein LM** (2005) ”Design and analyse of a smart market for industrial procurement” mange Sci 51(1):76-91

**Hassanzadeh Amin, S and Razmi, J.** (2007), “an integrated fuzzy model for supplier management: A case study of ISP selection and evaluation” expert system with applications.

**Hatush Zedan and Skitmore Martin** (1997a) “criteria for contractor selection construction” management and economic 15:19-38

**Hatush Zedan and Skitmore Martin** (1998) “contractor selection using multi criteria utility theory An additive Model” bulding and environment 33(2-3): 105-115.

**Hatush Zedan and Skitmore Martin** (1998) “contractor selection using multiceritera utility theory:An additive model” building and environment 33 (2-3):105-115

Holt, G.D, Olomolaiye, P.O, and Harris, F.C (1994) "Evaluating Prequalification criteria in contractor selection"building and environment 29(4): 437-448.

**Holt, G.D.** (1996) “Applying Cluster Analysis to construction contractor classification” England, building and environment 31 (6): 557-568.

**Holt, G.D.,Olomolaiye ,P.O,AND Harris ,F.C** (1995) "Applying multi attribute analysis to contractor selection decisions "Europen journal of purchasing and supply management 1(3): 139-148.

**ISO 9001:2000**

**Jahanshahloo, G. R., Hosseinzadeh Lotfi, F., & Izadikhah, M.** (2006) "An algorithmicmethod to extend TOPSIS for decision-making problems with interval data."Applied Mathematics and Computation 175:1375–1384.

**Juan, Y.K, Perng, Y.P Castro Lacouture, D. and Kuo-Sheng Lu, K.** (2009) "Housing refurbishment contractors selection based on a hybrid fuzzy – QFD approach" Automation in construaction and international research journal (18): 139-144.

**Kashiwagi Dean and Byfiled Richard E** (2002) "selection the best contractor to get performance:on time on budget meeting qulity expectations" journal facilities management 1(2):103-116.

**Kumar, M., P. Varta, et al.** (2004). "A fuzzy goal programming approach for vendor selection problem in a supply chain." journal of computers & industry management46: 69-85.

**Kumaraswamy Mohan M** (1996) "contractor evaluation and selection: A hong kong perspective" building and environment 31(3):273-282.

**Kumarawamy MM** (1996) "contractor evaluation and selection: a Hong Kong perspective" Build Environ 31(3):273-282.

**Lai KK Liu Sl Wang SY** (2004) "a method used for evaluation bid in Chinese construction industry" Int.J proj manage 22:193-201.

**Lam K.C, Hu T. Ng S.T Skitmore M and Cheong S O** (2001)"A fuzzy neural network approach for contractor prequalification construction" management & economic 19 (2): 175-188.

**Lambropoulos S.** (2007) "the use of time and cost utility for a construction contract award under European union" legisleation buildenviron 42(1):452-463.

**Lee, A.H.I** (2009) "A fuzzy supplier selection and risk model with the consideration of benefits opportunities, costs" expert systems with application 36: 2879-2893.

**Marzouk, M.** (2005) "A superiority and inferiority ranking model for contractor selection" constraction innovation 8: 250-268.

**Masella, C. and Rangone A.** (2000) “A contingent approach to design of vendor selection system for different types of co-operative customer/supplier relationship” industrial journal of operation & production management 20(1): 70-84.

**Missbauer H. Hauber W** (2006) “bid calculation for construction projects regulation and incentive effects of unit price contracts” Eur J oper Res.171:1005-1019.

**Ng, S.T and Skitmore, R.M.** (1999) “client and consultant perspective of prequalification criteria” building and environment 34: 607-621.

**Ng, Thomas S Skitmore, Martin, Smith Nigel J** (1999) “Decision maker’s perception in the formulation of prequalification criteria” engineering construction and architectural management 6(2): 155-165.

**Ordoobadi, S. M.** (2009). "Development of supplier selection model using fuzzy logic." An international journal of supply chain management14: 314-327.

**Palaneeswaran Ekambaram Kumaraswamy, Mohan** (2001) “recent advances and proposed improvement in contractor prequalification methodologies” building and environment 36: 73-87.

**Patil Bs** (2006) civil engineering contract and estimate.university press.new delhi.

**Paul A. and Gutierrez G** (2005)”simple probability models for projects contracting” European journal of operational research 165(2): 329-338.

**Paul, A., and Gutierrez, G.** (2005) ”simple probability models for project contracting” europen journal of operational research 165(2): 329-338.

**Satty TL** (1980) the analytic hierarchy process McGrow Hill.new York.

**Sawalhi, Nabil EI Eaton, Daivid Rustom Rifat** (2008) “forecasting contractor performance using a nuaral network and genetic algorithm in a pre-qulification model.” construction innovation 8(4): 280-298.

**Sawalhi, Nabil EI, Eaton, Daivid, Rustom, Rifat** (2007) “contractor pre-qualification model: state-of-the-art international” journal of project management 25: 465-474.

**Selim, Z., S. C. Mehmet Sevkli, et al.** (2008). "Hybrid analytical hierarchy process model for supplier selection." journal of industrial management & data systems108: 122-142.

**Sevkli, M., Lenny Koh, S.C., Zaim, S., Demirbag, M. & Tatoglu, E.** (2008) "Hybrid analytical hierarchy process model for supplier selection" industrial management & data systems.108 (1): 122-142.

**Shamsi, H., Shahanagi K. and Makuie A** (2005) "choosing appropriate project delivery system by using ANP based on the risk sriteria",4th international project management conference.

**Shyur H, Shih H** (2006) "Ahybrid MCDM model for strategic vendor selection" Math comp model 44: 749-761.

**Singh D. and Tiong Robert L.K** (2005) "A fuzzy decision framework for contractor selection" journal of construction engineering of management 131: 62-70.

**Singh, D. and Tiong Robert L.K** (2006) "contractor selection criteria investigation of opinion of Singapore construction practitioners" journal of consruction engineering and management 132: 998-1008.

**Teach JE Walleniuse J. Koppiuse Or** (2005) "emerging multiple issue e-auctions" eur J oper Res 159: 1-16

**Thomas Ng, R Martin Skitmore** (2001),"constractor selection criteria A cost-Benefit analysis" IEEE transactions engineering 48(1).

**Topcu, Y. I,** (2004) "A decision model proposal for construction contractor selection in Turkey" Bulding and Environment 39: 496-481.

**Wang W. Wang H. Lai Y Li. Jc** (2006) "unit price based model for evaluating competitive bids" Int J proj Manage 24: 156-166.

**Wang X. Triantaphyllu E** (2008) ranking irregularities when evaluating alternative by using some ELECTRE methods .Omega 36(1):45-63

**Wong, C. H., Nicholas, J. and Holt. G. D.** (2003) "Using Multivariate Techniques for developing models" Engineering, Construction and Architectural Management10 (2): 99-116.

**Wong, Chee H Holt Gary D Harries Phil** (2001) "Multi-criteria selection or lowest price? Investigation of UK construction client's tender evaluation preference" engineering, construction and architectural management 4: 257-271.

**Translation of Persian Sources;**


**Attai, Mohammad** "Fuzzy Multi-criteria Decision ", Shahroud University of Technology Publications, First Edition, 2010.

**Azar Adel and Hojjat Faraji,** 2008 "Fuzzy Management Science", Mehraban Publications, Second Edition, 2008.

**Ghodsipour, Seyyed Hossein,** "Multi-Purpose Planning", Amir Kabir University of Technology Publications, Second Edition, 2006.

**Hafez Nia, MR** (2008), Introduction to Research in Humanities, 11th Edition, Tehran: Post Publication.

**Haj Shirmohammadi, Ali,** 2008 Project Management and Control of Isfahan University of Technology Industrial Jihad Publishing Center, 11th Edition

**Jadidi, Babak,** (1994), "Contractor Selection of High Pressure Positions Using Hierarchical Neural Analytical Process" Tehran, M.Sc., Sharif University of Technology.

**Jahankhani, Ali and Parsaian, Ali,** 2006 Financial Management (Volume One) 11th Edition Publications

**July, Fariborz & Task, Asghar** (2007), "Theory and Methodology of Contractor Selection of a Research Project Using Multi-criteria Decision Making Methods", Tehran, 4th International Project Management Conference.

**Kasko, Bart** "Fuzzy Thinking", Ali Ghafari, Adel Maghsoodpour, Alireza Pour Mottaz, Jamshid Kasimi, Khaje Nasir al-Din Toosi University Press, 1998.

**Khoshnavpour, Nader** (2009), "Selection of suitable contractor for drilling projects according to risk factors and using multi-attribute bidding technique (in South Pars Oil and Gas Company)" Tehran, M.Sc., University of Tehran.

**Mir Ahmadzadeh, Nazanin** 2006 Classification of Contractors of Design-Procurement Projects Using Taxonomy Technique with Emphasis on Structural Consultants MSc, Industrial Management, University of Tehran

**Momeni Mansour,** "New Topics in Operations Research", University of Tehran Management School Press, First Edition, 2006.

**Rajaei, Hossein and Hazrati, Ayoub** (2007), "Presenting TOPSIS Fuzzy and SAW Fuzzy Multi-Criteria Decision Making Models for Prequalification and Selection and Comparing Their Results", Tehran, 4th International Project Management Conference.

Regulation on Classification and Qualification of Contractors; Management and Planning Organization; Approved, 1999.

**Samimi Dehkordi, Siamak** 2005, Introducing Engineering Contractor Capabilities - Construction of Amir Kabir University Industrial Jihad Publications, Second Edition.

# RESUME

Baktash Raouf's CV

Cumhuriyet mah, Huriyet Cad, No.23, innovia 1, 5A blok, D.27, Esenyurt, Istanbul

**Fields of Expertise**: Over 7 years of work experience on Supervision, Project management, Administration, Mentoring, Development cooperation.

## EMPLYMENT RECORD

**Director at 1st Vision Tourist Services Company** — **Istanbul –Turkey 2019 - Continuing**

- Preparing the site work plan.
- Managing and Providing Tourist Tours and Services
- Managing Rental Car Department
- Marketing planning
- Managing real state Department
- Preparing reports

**Organization for Cooperation and Development of the Country (OCDC) Field of Executive Director** — **Istanbul - Turkey 2015 - 2019**

**Homalia Construction and Road Construction Company Field of Deputy Director** — **Istanbul - Turkey 2012 -**

**Ministry of Rural Rehabilitation & Development (MRRD/NRAP) Field of Road Designer** — **Kabul - Afghanistan 2014 - 2015**

**National Assembly Mishran_o_ Jorge (Parliament of Afghanistan) Field of Technical Advisor** — **Kabul - Afghanistan 2013 - 2014**

## EDUCATION

**HERAT UNIVERSITY**
**Bachelor of Science (B.Sc.) Civil Engineering Faculty.**

- QCM Construction Quality Management training Certificate
- Auto CAD Civil 3D ,ETABS ,SAFE, SAB Certificates
- Member of discipline & Credit committee.

**Seminars and Workshops Attended**

Time management **2007**
**2008** Financial management
Methodology Program sponsored by **USAID** containing the following:

1. Business
2. Industry
3. Tariff

**2009** Inspiration Trustworthy Leadership
**2007** Computer Software
**2009** ELTAA Annual Conference

**TRANINGING/COURCES**

Computer programs (Windows, Word, Excel, PowerPoint, English and Farsi Typing, and Antivirus) in (Afghan institute of learning and Saudi Institute of Computer Science).

## ADDITIONAL INFORMATION (Skills/Knowledge/Interest)

**LANGUAGES: Dari – (Native) / English-fluent (spoken & written) / Pashtu-good (spoken & written)**

**Urdu- good (spoken & Reading) / German- A2.1 (spoken & Written)**

**COMPUTER:**

MS Windows / MS Word / MS Excel / Power point /Internet / Diploma in English and Dari Typing /Auto CAD /E-Taps /SAFE / Primavera / Auto CAD Civil 3D /Total station & knowledge in the use of: Photocopy Machines / digital scanner & photographical equipment

**OTHER SKILLS:** Leadership & Management, Analytical, communication, photographical equipment, coordination, community development & capacity building program, adaptation in multicultural environment, ability to work under the pressure, manage work related stress & meet multiple short deadlines as well as the ability to prioritize assignment, ability of facilitating meeting (workshops) at any levels, Proactive, self-starter, results-oriented, possessing gender lens & committed to cooperate gender mainstreaming for integral human development, Able to translate(Interpretation & Translation ).

**Interests Include**: Study, Enjoy the nature, play and watch football, play chase, listen to calm music and like watching American movies.