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# Evaluation and Prioritization of Construction Risks in Caspian Sea Coastlines Using the Fuzzy Dematel Approach

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## Abstract

This research was conducted to evaluate and prioritize construction risks in the Caspian Sea coastlines using the fuzzy Dematel approach. The current research was applied in terms of its purpose and descriptive survey in terms of execution. Our statistical community includes experts, supervising engineers, and contractors in the construction field in Tonekabon city. Sampling in this research was done in a non-probabilistic and purposeful way. The criterion for selecting samples in this research was to have at least 5 years of work experience, familiarity with the specialized topics of risks affecting the quality of projects, and the availability of experts, based on which 10 experts were selected. The obtained data were analyzed using the fuzzy DNP method. Each of the risks of pollution, flood, the resistance of the project team with subcontractors to change, changes in the scope of the project, incorrect management style, high humidity, the financial ability of the owner and funding problems, and lack of financial resources of the employer have a positive d + r-value, that is, these risks are effective and can cause other risks in the construction of coastlines. On the other hand, each of the risks of strong coastal winds, insufficient studies and local information about the conditions of the land and the workplace, giving low priority to risk management issues, insufficient commitment to risk management in the construction industry, lack of expert staff, workers' strikes, carelessness of workers, water intrusion In foundation, land collapse, incorrect cost timing are effective due to having a negative D-R value, which means that these risks arise due to non-observance of other risks. The results of the ranking of each risk showed that the risk of geological factors with a weight of 0.184 is in the first place, the risk of management factors is in the second place with a weight of 0.182, the risk of financial factors is in the third place with a weight of 0.180, the risk of technical factors is 0.167 in the fourth place, the risk of human factors with a weight of 0.165 in the fifth place and the risk of environmental factors with a weight of 0.11 in the sixth place.

**Keywords:** Risk management, Uncertainty, Fuzzy dump, Construction, Coastlines.

## 1 | Introduction

Projects can be classified into different dimensions and sizes and have different goals; despite this, one common but intangible feature is present in all projects: project risk. Projects of any size and component have a degree of risk and uncertainty [1]. As the project risk increases, managing and controlling the project becomes difficult. Many failures that occur in projects can be considered due to risk and lack of stability in

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the environment and within the project structure. However, due to the intangible nature of risk, a comprehensive and complete definition of it has not yet been provided; in addition, a comprehensive quantitative relationship that can measure the risk of a project and include all dimensions of risk has not yet been provided [2].

One of the environments in which construction is associated with many risks is coastlines. In coastal lines, there are problems such as the possibility of reinforcement corrosion due to seawater infiltration and alkalinity, the collapse of the foundation wall due to non-observance of the standard distance from the sea, environmental issues, non-use of standard concrete for coastal lines and many other problems. It needs to be controlled by risk management [3].

Risk management is a process of identifying, analyzing, and responding to risk factors that may occur during a project. If risk management is not done correctly, it has the ability to prevent possible risks by controlling future events [4]. Correct risk management reduces the probability of its occurrence and the scope of its effects. In addition to identifying risks and determining their quality, risk management systems are also able to predict the effects they have on the project. Acceptance or non-acceptance of risk generally depends on the resilience level of the project manager. If risk management is done regularly to identify possible problems and find their solution, it will easily complete other processes such as organization, budget planning, and cost control [5].

# 2 | Methodology

According to the purpose, the current research is placed in the field of applied research because it deals with finding the context to solve a problem in the real world. Also, in terms of collecting information, it is included in survey research. A survey is a research-based method of selecting a random and representative sample of the people of the research community and their answers to a set of questions using questionnaires, surveys, or other methods to study the current situation, including attitudes and opinions. Behaviors and general extracting information about hypotheses [6].

A statistical community is a set of people or units with at least one common attribute. Our statistical community includes experts, supervising engineers, and contractors in the construction field in Tonekabon city. The sampling method of this research is non-probability sampling. Instead of relying on the chance factor, the sample is selected with the help of human judgment. Therefore, the chance of entering each population unit in the sample is uncertain and unknown. In the purposeful sampling method, instead of obtaining information from those who are readily available, sometimes it may be necessary to obtain information from certain people or groups, that is, certain types of people who are able to provide the information we want because they are the only people who can provide such information or match some of the criteria developed by the researcher [7].

In this research, the following criteria have been considered to select experts for the sample:

I. At least 5 years of work experience in the field of construction in coastal areas.

II. Familiarity with the specialized topics of risks affecting the quality of projects.

III. Expert availability.

IV. According to the above criteria, 10 experts were selected.

The analysis method in this research is multi-indicator decision-making, which, according to the research conditions, is the DANP method. In this method, the ANP supermatrix is formed by using the Dematel matrix of the sub-criteria, and finally, the weight of the criteria and sub-criteria is obtained.

# 3 | Research Findings

Based on the literature review and research background, this section identified and extracted 18 practical risks on construction projects in 6 dimensions. In the localization of these factors, 20 experts were asked in a questionnaire based on the spectrum from 1 to 5, which included the following items: 1) very little importance, 2) little importance, 3) medium importance, 4) high importance, and 5) importance too many) to score each indicator. Then, the average score of each index was calculated; if the average score of an index is less than 3, it is removed. The results showed that experts approve all indicators; the average of all indicators is higher than 3. The results are given in *Table 1*.

**Table 1. Evaluation of research factors.**

| Average Scores | Sub Criterion | Criterion |
|---|---|---|
| 3.25 | Pollution | Environmental |
| 3.2 | Flood | |
| 3.3 | Strong coastal winds | |
| 3.45 | Inadequacy of studies and local information about land and workplace conditions | Technical |
| 3.5 | Resistance of the project team with subcontractors to change | |
| 3.5 | Changes in the scope of the project | |
| 4.15 | Giving low priority to risk management issues | Managerial |
| 4.05 | Incorrect management style | |
| 3.75 | Inadequate commitment to risk management in the construction industry | |
| 3.45 | Lack of expert staff | Human factors |
| 3.2 | Lack of expert staff | |
| 3.35 | Carelessness of workers | |
| 3.45 | Water penetration in the foundation | Geological factors |
| 3.75 | There has been a landslide | |
| 3.7 | High humidity | |
| 4.05 | Incorrect cost timing | Finance |
| 4.1 | Owner's financial ability and funding problems | |
| 4.15 | Lack of financial resources for the employer | |

**Step 1.** Creating a matrix of experts' opinions.

**Step 2.** Normalizing the direct correlation matrix.

**Step 3.** Normalize the average matrix of direct connections and call it the H matrix. In other words, the value of r equals the highest value of the row sum of the upper limit of the integrated matrix of comments. The highest value in this research is equal to 17/125, so all the funds are divided by this number.

**Step 4.** Calculating the complete correlation matrix of criteria (TC).

After calculating the normal matrices, the matrix of fuzzy total relations is obtained according to the relations of the third chapter. In these relations, I is the matrix of unity, and H _l, H_ m, and H_ u are each nxn matrix, whose terms are, respectively, the lower number, the middle number, and the upper number of the triangular fuzzy numbers of the H matrix. Complete communication matrix (TC).

**Table 2. Pattern of causal relations of TC matrix.**

| | Di+Ri | | | Di-Ri | | | Non-Phase Di+Ri | Non-Phase Di-Ri |
|---|---|---|---|---|---|---|---|---|
| | l | m | u | l | m | u | | |
| M1 | 1.0337 | 3.6646 | 22.1973 | -9.7887 | 0.4040 | 11.3750 | 6.7699 | 0.4288 |
| M2 | 1.0100 | 3.6213 | 21.8234 | -9.8444 | 0.3466 | 10.9690 | 6.6808 | 0.3308 |
| M3 | 1.0857 | 3.7602 | 22.5304 | -12.0164 | -0.6323 | 9.4283 | 6.8932 | -0.7634 |
| M4 | 1.1598 | 3.8964 | 23.0954 | -10.8363 | 0.1021 | 11.0992 | 7.0804 | 0.0628 |
| M5 | 1.0479 | 3.6908 | 22.1173 | -9.6481 | 0.5241 | 11.4213 | 6.7787 | 0.5242 |
| M6 | 1.1968 | 3.9643 | 23.1917 | -11.1603 | -0.0650 | 10.8346 | 7.1469 | -0.1156 |
| M7 | 1.0327 | 3.6628 | 22.4450 | -10.4435 | 0.1243 | 10.9688 | 6.8046 | 0.1151 |
| M8 | 0.7808 | 3.2006 | 20.4842 | -10.9269 | -0.5164 | 8.7765 | 6.1452 | -0.6462 |
| M9 | 1.0923 | 3.7722 | 22.7816 | -10.8145 | 0.0171 | 10.8748 | 6.9388 | -0.0134 |
| M10 | 1.2603 | 4.0806 | 23.5707 | -11.6710 | -0.4123 | 10.6393 | 7.2903 | -0.4106 |
| M11 | 1.1050 | 3.7956 | 22.4505 | -10.7936 | -0.0366 | 10.5519 | 6.9093 | -0.0871 |
| M12 | 0.9400 | 3.4927 | 21.6090 | -10.6773 | -0.1503 | 9.9917 | 6.5477 | -0.2163 |
| M13 | 0.9679 | 3.5440 | 21.9332 | -10.4044 | -0.0766 | 10.5609 | 6.6363 | -0.0501 |
| M14 | 1.0977 | 3.7819 | 22.8866 | -10.8804 | 0.0176 | 10.9085 | 6.9614 | -0.0180 |
| M15 | 1.2057 | 3.9800 | 23.1157 | -10.3149 | 0.2098 | 11.5951 | 7.1483 | 0.2702 |
| M16 | 1.2387 | 4.0408 | 23.3853 | -11.4367 | -0.1765 | 10.7099 | 7.2335 | -0.2356 |
| M17 | 1.1989 | 3.9678 | 22.9844 | -10.5408 | 0.2261 | 11.2446 | 7.1202 | 0.1965 |
| M18 | 1.0891 | 3.7664 | 22.5477 | -10.6048 | 0.0944 | 10.8538 | 6.9006 | 0.0578 |

Calculation of the main criteria with the fuzzy AHP method.

**Step 1.** the matrix of aggregation of experts' opinions.

**Table 3. The experts' opinion accumulation matrix for the main criteria.**

| | C1 | | | C2 | | | C3 | | | C4 | | | C5 | | | C6 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| C1 | 1.00 | 1.00 | 1.00 | 0.00 | 0.25 | 0.50 | 0.25 | 0.50 | 0.75 | 0.50 | 0.75 | 1.00 | 0.75 | 1.00 | 1.00 | 0.5 | 0.75 | 1 |
| C2 | 0.55 | 0.80 | 0.95 | 1.00 | 1.00 | 1.00 | 0.75 | 1.00 | 1.00 | 0.75 | 1.00 | 1.00 | 0.50 | 0.75 | 1.00 | 0.6 | 0.85 | 1 |
| C3 | 0.75 | 1.00 | 1.00 | 0.75 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.50 | 0.75 | 1.00 | 0.75 | 1.00 | 1.00 | 0.75 | 1 | 1 |
| C4 | 0.50 | 0.75 | 1.00 | 0.60 | 0.85 | 1.00 | 0.75 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.75 | 1.00 | 1.00 | 0.5 | 0.75 | 1 |
| C5 | 0.75 | 1.00 | 1.00 | 0.55 | 0.80 | 0.90 | 0.75 | 1.00 | 1.00 | 0.75 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.75 | 1 | 1 |
| C6 | 0.60 | 0.85 | 1.00 | 0.6 | 0.85 | 1 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 0.75 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 |

**Step 2.** This step is to calculate the fuzzy composite expansion of factors.

**Table 4. Fuzzy expansion matrix of factors.**

| | I | M | U |
|---|---|---|---|
| C1 | 3.00 | 4.25 | 5.25 |
| C2 | 4.15 | 5.40 | 5.95 |
| C3 | 4.50 | 5.75 | 6.00 |
| C4 | 4.10 | 5.35 | 6.00 |
| C5 | 4.55 | 5.80 | 5.90 |
| C6 | 4.95 | 5.70 | 6.00 |

**Step 3.** Calculating the degree of feasibility matrix of possible binary states.

**Table 5. Degree of binary possibility.**

| | I | M | U |
|---|---|---|---|
| C1 | 0.02 | 0.03 | 0.06 |
| C2 | 0.03 | 0.04 | 0.06 |
| C3 | 0.03 | 0.05 | 0.06 |
| C4 | 0.03 | 0.04 | 0.06 |
| C5 | 0.03 | 0.05 | 0.06 |
| C6 | 0.03 | 0.04 | 0.06 |

**Step 4.** Determining the minimum degree of feasibility of each column and calculating the final weight and rank of each index (column) through normalization.

**Table 6. The final weight of the criteria.**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Min** | 0.647002 | 0.908114 | 0.987716 | 0.899338 | 1 | 0.97573 |
| **Sum** | 5.417901 | | | | | |
| **w** | 0.119419 | 0.167614 | 0.182306 | 0.165994 | 0.184573 | 0.180094 |
| | A | B | C | D | E | F |

# 4 | Conclusion

Risk management is a process of identifying, analyzing, and responding to risk factors that may occur during a project. If risk management is not done correctly, it has the ability to prevent possible risks by controlling future events. Correct risk management reduces the probability of its occurrence and the scope of its effects. In addition to identifying risks and determining their quality, risk management systems are also able to predict the effects they have on the project. Acceptance or non-acceptance of risk generally depends on the resilience level of the project manager. If risk management is done regularly to identify possible problems and find their solution, it will efficiently complete other processes such as organization, budget planning, and cost control. A pioneer project manager in this field can prevent unexpected events during the project's life. Unfortunately, risk management is not considered in many projects near the coastlines, and the builders do not treat them like normal projects. Considering that risk management is mandatory in projects, especially coastline projects, not paying attention to it will directly affect the project's cost, time, and quality, and no research has been done on the mentioned issue. For this purpose, this research was conducted to evaluate and prioritize construction risks in the coastlines of the Caspian Sea using the fuzzy Dematel approach. The current research was applied research in terms of its purpose and implementation; it was a descriptive survey. Our statistical community includes experts, supervising engineers, and contractors in the construction field in Tonekabon city. Sampling in this research was done in a non-probabilistic and purposeful way. The criterion for selecting samples in this research was to have at least 5 years of work experience, familiarity with the specialized topics of risks affecting the quality of projects, and the availability of experts, based on which 10 experts were selected. The obtained data were analyzed using the fuzzy DNP method.

The findings of the research showed that the main risks in construction along the coastlines are:

I. Environmental risk.

II. Technical risk.

III. Management risk.

IV. Human risk.

V. Geological risk.

VI. Financial risks.

The results of the Denep technique showed following:

Each of the risks of pollution, flood, the resistance of the project team with subcontractors to change, changes in the scope of the project, incorrect management style, high humidity, the financial ability of the owner and funding problems, and lack of financial resources of the employer have a positive d+r value, that is, these risks are effective and can cause other risks in the construction of coastlines. On the other hand, each of the risks of strong coastal winds, insufficient studies and local information about the conditions of the land and the workplace, giving low priority to risk management issues, insufficient commitment to risk management in the construction industry, lack of expert staff, workers' strikes, carelessness of workers, water intrusion In foundation, land collapse, incorrect cost timing are effective due to having a negative D-R value, which means that these risks arise due to non-observance of other risks. The results of the fuzzy ANP technique showed:

I. The risk of geological factors with a weight of 0.184 ranks first.

II. The risk of management factors with a weight of 0.182 in the second place.

III. The risk of financial factors with a weight of 0.180 is in the third place.

IV. The risk of technical factors, with a weight of 0.167, ranks fourth.

V. The risk of human factors with a weight of 0.165 ranks fifth.

VI. The risk of environmental factors ranked sixth with a weight of 0.11.

# Authors' Contributions

All research activities and manuscript development were conducted by the author, who also approved the final manuscript.

# Data Availability

All data supporting the reported findings in this research paper are provided within the manuscript.

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No funding was received to conduct this study.

## Conflict of Interest

The author declares that in this paper, there is no conflict of interests.

## Consent for Publication

The author has provided their consent for the publication of this manuscript.

## Ethics Approval and Consent to Participate

No studies involving human participants or animals were performed in this research.

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