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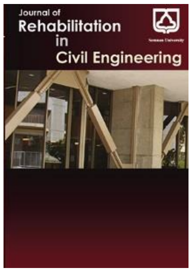

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Risk Prioritization in Water and Wastewater Projects Using a Decision Model Based on the Analytic Hierarchy Process

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ABSTRACT

The risk management standard published by the Project Management Institute (PMI), entitled Project Management Body of Knowledge (PMBOK), was utilized in the present study as the primary method for evaluation of risk management. The general purpose of this article is to prioritize risk in water and wastewater projects through the analytic hierarchy process (AHP). The statistical population considered here covers all the factors involved in water and sewage projects. Sample size determination was done based on the Morgan table, which resulted in selecting 59 high-expertise experts. The Delphi method, a process used to arrive at a group opinion or decision by surveying a panel of experts, was used for risk identification. After entering the raw data into an Expert Choice program, based on the AHP decision model, data analysis was completed. The obtained results indicate that budget deficit is the most critical risk factor of the project, preceding by inflation and international sanctions. Furthermore, risk factors related to expanding the project relationship with other areas, the area's religious location, and the area's environmental hazards, and the project site are the least important ranking items.

1. Introduction

The success or failure to achieve pre-defined objectives in a project depends mainly on its execution system suitability. An important decision in the early steps of a project is to investigate different possible ways to execute projects and select the best one. This requires the identification of risk factors of projects. Risk is, in fact, a measurable uncertainty, but uncertainty is an unmeasurable risk. Risk itself is a multidimensional concept [1]

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defined as the probability of a harmful event in a project affecting the project's objectives [2].

Nevertheless, this concept is not always associated with negative consequences. Despite some opportunities, most risks have negative results, so that individuals only consider negative aspects of risks [3]. As a complementary part of project management [4], risk management is currently responsible for the most difficult activities of project risk assessment and prioritization [5]. It is also considered a key process so that the majority of project managers acknowledge the necessity of risk management for project management [6]. Risk management is defined as the process of risk identification and assessment and the application of some methods to reduce it to an acceptable level [7]. Therefore, the primary objective of project risk management is risk identification, evaluation, and control for the success of projects [8].

Project risk management provides some opportunities, such as the emergence of experienced, skilled, and classic managers, and gets things organized. The risk management standard published by the Project Management Institute (PMI), entitled Project Management Body of Knowledge (PMBOK), was used in this study as the basic method for describing risk management. The underlying reasons for this selection were general familiarity with PMBOK, easy access to it, simplicity of understanding and application, and available supportive resources.

According to the results of Delaram and Ghasemzadeh [9] and Tavakollan and Sohrabi [10] on risk management in construction projects, the factors with the highest impact on the prolongation of the civil projects include the lack of timely supply of sufficient budget, lack of timely resolution of conflicts (traffic, properties, facilities, etc.), unrealistic bidding to win a tender, unfair support from project authorities for [certain] public or private contractors in a tender and during execution, insufficient financial resources of the contractor, poor performance of the contractor in project execution management, poor contractor performance in execution management, prolonged bureaucratic processes in public sectors in dealing with project-related conflicting players, lack of strict laws and regulation in hiring contractors, the lack of a base price list for intracity works, low accuracy in volume estimation, lack of executive and workshop visions in designers, delay in preparation of execution maps, delay in decision making under critical and emergency conditions and weaknesses in design sectors.

Ghanbari and Safae (2017) investigated the concept of ISM, determined its paradigmatic origin, and described its technical execution steps, key aspects, and application in management problems. According to their results, the ISM offers a purposeful order and framework for complex problems and provides decision-makers with a realistic image of their position and involving variables [11].

Sokhakian and Moeni (2011) assessed and ranked risks in water and sewage network projects using a new FMEA approach. They identified 124 risks using different risk identification methods; however, this number of risks was reduced to 63 after consulting with experts in this area. The statistical population included all qualified managers and specialists in the water and sewage development projects. An FMEA-based questionnaire was designed, risk factors affecting project time and cost were introduced, and the impact severity and detection rate were then determined. The figures allocated range from 0 to 10, and the risk priority number (RPN) was calculated by multiplication of these figures, where a higher RPN value indicated a more effective and riskier factor. The new RPN approach used in this study was more precise than the conventional RPN in the risk assessment [12].

Mohammadi and Jafari also investigated the risk analysis, assessment, and management of offshore civil projects using the FMEA method based on the PMBOK. Bibliographic and online resources, opinions of project experts and managers, and documents of relevant companies were used to identify risks and monitor the execution of offshore civil projects. The qualitative and quantitative risk analyses were performed through brainstorming and questionnaire, respectively. Then, the risk failure structure and opinions of experts and project managers were used to prepare a list of risks, which may occur during project execution. Finally, the risk probability, the effect of risk on the project's objectives, and detection risk were determined for all risks. Among the five critical risks selected for offshore civil projects, “price fluctuation of basic materials” was regarded as the most important risk, and some solutions were proposed to reduce it [13]. Liu *et al.* (2018) conducted a study entitled “application of ISM for identification of critical success factors (CSF) of safety management in subway construction.” Their results showed that the higher scores of factors related to the engineering survey and design in the questionnaire, and also their significant indirect impact on other factors. They also found the significant effect of developing a sound plan and investment on the safety management of subway projects [14].

Another study on risk assessment was conducted on an offshore pipeline project by combining the ISM and Bayesian networks (Wei-Shing *et al.*). An integrated ISM and Bayesian network (BN) approach was used in this study for risk management. The ISM was used to determine the relationship of different engineering risk factors, shown through the cause-effect diagram. These factors constitute the BN structure [15]. Li *et al.* (2017) analyzed safety risk factors in subway construction. Due to its characteristics, they used the ISM to investigate both the direct and indirect effects of risk factors and to evaluate the suitability of this method for projects with complex relationships and uncertain structures [16].

The aim of the present study is to prioritize risk in water and wastewater projects through the analytic hierarchy process (AHP). First of all, the factors involved in water and sewage projects were classified. Then, some high-expertise experts were invited, and risk identification was completed by evaluating the results from them. Finally, by data analysis in an Expert Choice program, the ranking of the risk factors based on their importance to the project was done. Expert Choice Solutions combine collaborative team tools and proven mathematical techniques to enables your team obtain the best decision in reaching a goal. The Expert Choice process lets you: structure complexity, measure the importance of competing objectives and alternatives, and synthesize information, expertise, and judgments conduct what-if and sensitivity analyses clearly communicate to share results, and iterate parts of the decision process when necessary allocate resources (if desired). Upon completion of an Expert Choice evaluation, you and your colleagues will have a thorough, rational, and understandable decision that is intuitively appealing and that can be communicated and justified.

2. Research Significance

Since water and wastewater projects are usually exposed to important risks, the success in funding and resource allocation would be dependent upon success in assessment, identification, and prioritization of the main categories of affecting risks. However, to the best of our knowledge, there is no important investigation on risk prioritization of these infrastructural projects. The present study, as the first study investigating the results obtained from the application of the ISM in water and sewage projects, aims to evaluate the most important risk factors affecting the water and wastewater projects and reveal its critical influence on the decision making procedure.

3. Analytic Hierarchy Process

The Analytic Hierarchy Process (AHP) is an analytic method for the evaluation of decisions that utilize both psychology and mathematics. The method was pioneered by Saaty in the 1970s and has been improved many times after that. The method has three stages, including the purpose or problem, alternatives, and the criteria. This method provides a rational framework for making a decision by quantifying its criteria and alternatives. Stakeholders would compare the relative importance of the criteria using pair-wise comparisons. Fig. 1 shows a flowchart for the AHP method.

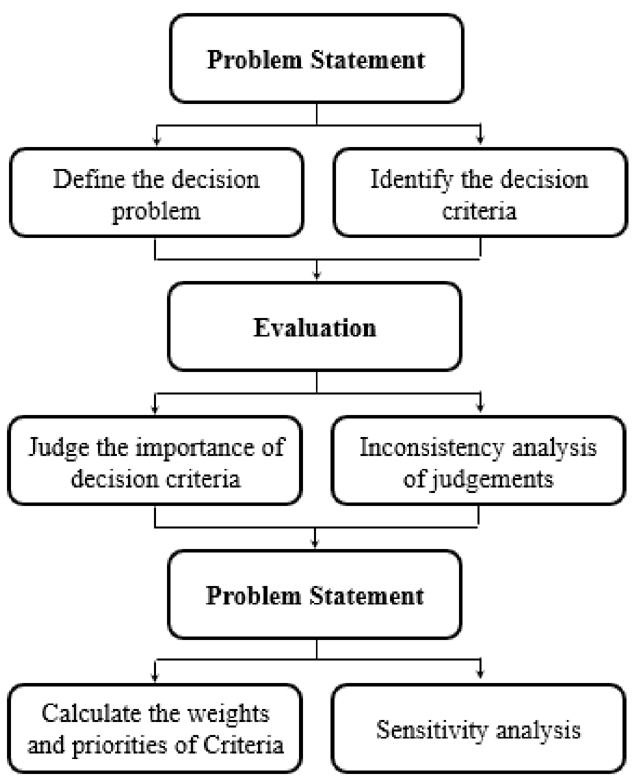

Fig. 1. Steps needed for Analytic Hierarchy Process.

4. Materials and Methods

Generally, collected data are raw numbers and figures which could be used by statistics to make them meaningful in order to achieve the main goals of the research. Data analysis is considered as a part of the process of a scientific research method, by which all research activities are controlled and directed until a result is reached. Descriptive statistics provide the demographic characteristics of the study sample, such as gender, education, age, or any other characteristics that come in the questionnaire through statistical tables and graphs. In this study, experts and expert managers working in the Water and Sewerage Company of North Khorasan Province, whose number is 59 people, were studied. The questionnaire utilized for data collection in terms of AHP is presented in Fig. 2.

<table>
<tr><th colspan="6">Questionnaire</th></tr>
<tr><td colspan="6">The present questionnaire has been designed for risk prioritization in water and wastewater projects using AHP. Based on your technical point of view, please select the priority of factors relative to each other.</td></tr>
<tr><td rowspan="2">Gender</td><td colspan="3">Male</td><td colspan="2">Female</td></tr>
<tr><td colspan="3">○</td><td colspan="2">○</td></tr>
<tr><td rowspan="2">Age</td><td>20-30</td><td>31-40</td><td>41-50</td><td colspan="2">Greater than 50</td></tr>
<tr><td>○</td><td>○</td><td>○</td><td colspan="2">○</td></tr>
<tr><td rowspan="2">Education</td><td>Diploma</td><td>Associate</td><td>B.S.</td><td>M.S.</td><td>Ph.D.</td></tr>
<tr><td>○</td><td>○</td><td>○</td><td>○</td><td>○</td></tr>
<tr><td rowspan="2">Area of activity</td><td>Client</td><td colspan="2">Consultant</td><td colspan="2">Contractor</td></tr>
<tr><td>○</td><td colspan="2">○</td><td colspan="2">○</td></tr>
<tr><td>Definition</td><td>Degree of Importance</td><td colspan="4">Explanation</td></tr>
<tr><td>Component I has the same importance as component J</td><td>1</td><td colspan="4">-</td></tr>
<tr><td>Component I has the relatively same importance compared to component J</td><td>2</td><td colspan="4">The inverse would result in inverse degree (If component J has the relatively same importance compared to component I, the degree would be ½)</td></tr>
<tr><td>Component I has less importance compared to component J</td><td>3</td><td colspan="4">The inverse would result in an inverse degree</td></tr>
<tr><td>Component I has relatively less importance compared to component J</td><td>4</td><td colspan="4">The inverse would result in an inverse degree</td></tr>
<tr><td>Component I has high importance compared to component J</td><td>5</td><td colspan="4">The inverse would result in an inverse degree</td></tr>
<tr><td>Component I has relatively high importance compared to component J</td><td>6</td><td colspan="4">The inverse would result in an inverse degree</td></tr>
<tr><td>Component I has very high importance compared to component J</td><td>7</td><td colspan="4">The inverse would result in an inverse degree</td></tr>
<tr><td>Component I has relatively very high importance compared to component J</td><td>8</td><td colspan="4">The inverse would result in an inverse degree</td></tr>
<tr><td>Component I is very important than component J</td><td>9</td><td colspan="4">The inverse would result in an inverse degree</td></tr>
</table>

Fig. 2. The designed questionnaire for risk prioritization using AHP.

The statistical population of this study is all the factors involved in water and wastewater projects. The risk identification method is a dolphin method. The analytic hierarchy process (AHP) was used to rank the risk factors. The interpretive structural modeling method in four steps are summarized in Figure 3. These four steps would be explained in the following.

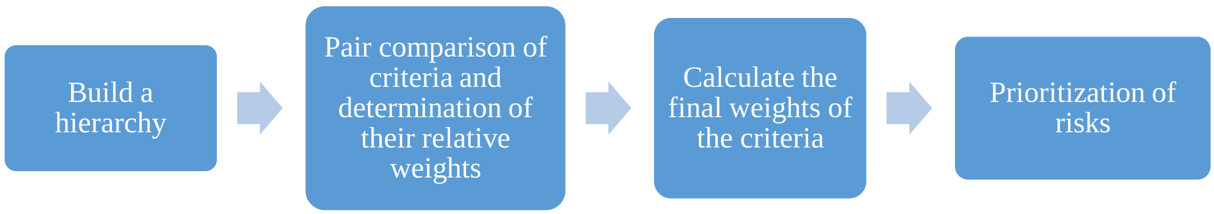

Fig. 3. Stages of the utilized AHP.

Step 1: Build a Hierarchy

The process of identifying elements and the relationship between them, which leads to the creation of a hierarchical structure, is called hierarchical construction. The hierarchy of the structure is due to the fact that the decision elements can be summarized at different levels. Consequently, the first step in the process of hierarchical analysis is to create a hierarchical structure of the subject under study, in which the criteria and the relationship between them are shown. The set goal of this process is to prioritize the risks of water and wastewater projects (see Table 1).

Table 1. Risk criteria in water and wastewater projects.

Component	Criterion
Integrity Management Criteria	Technical and executive coordination between the monitoring and implementation sectors
	Cooperation between consultant and government agency and contractor
	Delays in project preparation, planning, and coordination
	Obtaining licenses and failing to renew them
	Improper communication (task interference)
Cost management criteria	Lack of credit during the project
	Increase transportation costs
	International sanctions
	Inflation
	Fluctuations in material prices
Procurement management criteria	Low productivity and efficiency of the equipment
	Lack of equipment and parts and an increase in their price
	Deficiency in materials
	Failure to pay on time
	Lack of use of specialized personnel
Time management criteria	Delay in financial payments to consultant and contractor
	Delay in reviewing status forms, agendas, and delivery of completed work
	Delay in approval of plans and approval of tests
	The seasonality of some executive operations
	Delay in the supply of materials
Criteria for human resource management	Lack of skilled manpower
	Lack of familiarity of contractors with project management and control
	Insufficient contractor experience and weakness in workshop management by the contractor
	Errors and bugs during the project
Criteria related to range	Existence of errors and ambiguities in the executive plans

management	Problems related to the type of contract
	Distribution and scope of executive work
	Lack of transparency of work dimensions
	Unfavorable weather conditions in the region
Criteria related to stakeholder management	Major disputes with the employer and the contractor
	There are contradictions and problems related to them
	The weakness of the monitoring sector in the investigation of the project under construction of water and sewage
	Non-acceptance of risks defined by the parties to the contract
	Lack of willingness to work with contractors and consultants
Risk management criteria	Bureaucracy in project-related organizations
	Unforeseen events and situations at work
	Geographical, political, and religious location of the region
	Unauthorized traffic control and related problems
	Risk of using new technology
Criteria related to quality management	Lack of proper quality control of works and re-works due to the low quality of work
	Weakness in the executive management of the consultant
	Prioritize financial issues over technical ones
	The inefficiency of contractor evaluation and selection system
	Low-quality materials
Criteria for communication management	Lack of systemic attitude between different parts of the project
	Lack of coordination with relevant organizations and bodies
	The discontinuity of government policies
	Delay of government agencies in the implementation of the contract
Safety management criteria	Poor workshop equipment
	Theft and robbery of equipment
	Failure to comply with regulations and safety tips
	Accidents for the workforce and equipment during work
	Lack of quick and timely decision making in project implementation
Financial management criteria	Lack of accurate estimate of price before getting a job
	Low adjustment indicators compared to increased costs over time
	Delay in the payment of government budgets (payment in the form of fixed-term bonds) during the construction of the water and sewage project
	Lack of funding for initial studies and project implementation
Criteria for litigation management	A disagreement between consultant and contractor
	Cultural conflicts and sabotage of the residents of the region
	The religious position of the region
Environmental criteria	Damage to materials and equipment
	Environmental restrictions and permits
	Risks of environmental conditions and project implementation location
	Expanding communications between the project site and other areas and the consequences of this connection (such as pollution)

Step 2: Pair comparison of criteria and determine their relative weight

In the current research, to compare the criteria, the group pairwise comparison method has been used, and the opinions of experts and managers have been combined through a questionnaire and then by Expert Choice software, and the weight of all criteria has been obtained.

Step 3: Calculating the final weight of the criteria

The final weights of the criteria will be obtained by multiplying the relative weight of the criteria by the relative weight of the relevant component (Table 2).

Step 4: Prioritizing the risks of water and sewage projects

The final weight of the criteria indicates the effectiveness of that criterion on prioritizing the risks of water and sewage projects. This means that any criterion that weighs more than other criteria has a higher priority than other criteria.

Table 2. Calculating the final weights of the criteria.

Components	Relative weights of components	Criteria	Relative weights of criteria	Final weights of criteria
Integrated Management Criteria	0.091	Technical and executive coordination between the monitoring and implementation apparatus	0.347	0.03
		Cooperation between consultant, the government agency, and contractor	0.267	0.023
		Delayed project preparation, planning, and coordination	0.169	0.015
		Licensing and their neglected renewal	0.118	0.01
		Poor communication (interfering tasks)	0.098	0.009
Cost Management Criteria	0.252	Shortage of financial resources during project implementation	0.335	0.084
		Increased transportation costs	0.134	0.034
		International sanctions	0.170	0.043
		Inflation	0.215	0.054
		Fluctuating material prices	0.147	0.037
Procurement Management Criteria	0.097	Low productivity and efficiency of the equipment	0.189	0.023
		Lack of equipment and parts and their increased price	0.228	0.028
		Shortage of materials	0.149	0.018
		Untimely invoice payments	0.268	0.032
		Failure to employ specialized personnel	0.165	0.020
Time Management Criteria	0.110	Delayed payments to consultant and contractor	0.402	0.037
		Delayed review of invoices, agendas, and delivery of completed work	0.216	0.020
		Delayed approval of plans and tests	0.178	0.016
		Certain seasonal executive operations	0.105	0.010
		Delay in material supply	0.100	0.009
Human Resource Management Criteria		Shortage of skilled manpower	0.195	0.018
		Unfamiliar contractors with project management and control	0.374	0.035
		Underskilled contractor and his/her weakness in workshop management	0.289	0.027
		Executive errors during project implementation	0.142	0.013
Scope Management Criteria	0.105	Mistakes and ambiguities in executive plans	0.332	0.011
		Contract type problems	0.306	0.010
		Scattered and extensive executive work	0.154	0.005
		Unspecified dimensions of project implementation	0.129	.0004
		Unfavorable weather conditions in the area	0.078	0.003
Stakeholder Management	0.034	Major disputes with employer and contractor	0.320	0.020
		Conflicts and related problems	0.190	0.012

Criteria		Poor surveillance apparatus in investigating road construction projects	0.274	0.017
		Unaccepted risks defined by the parties to the contract	0.110	0.007
		The unwillingness of contractors and consultants for cooperation	0.106	0.006
Risk Management Criteria	0.058	Bureaucracy in project-related organizations	0.386	0.024
		Unforeseen events and situations during implementation	0.266	0.017
		The geographical, political, and religious situation of the region	0.130	0.008
		Unauthorized traffic control and related problems	0.120	0.008
		Risks during new technology adoption	0.098	0.006
Quality Management Criteria	0.073	Failure to control the quality of work and re-work appropriately due to poor work quality	0.232	0.018
		Poor executive management of the consultant	0.196	0.015
		Financial issues prioritized over technical issues	0.231	0.018
		Inefficient system of contractor evaluation and selection	0.239	0.018
		Low-quality materials	0.102	0.008
Communication Management Criteria	0.055	Lack of a systemic approach between different components of the project	0.265	0.009
		Inconsistency with relevant organizations and bodies	0.249	0.008
		Government policy discontinuity	0.292	0.009
		Delayed contract performance by government agencies	0.194	0.006
Safety Management Criteria		Poor workshop equipment	0.260	0.010
		Stolen equipment	0.109	0.004
		Failure to comply with regulations and safety tips	0.320	0.012
		Workforce and equipment accidents during implementation	0.169	0.006
		Failure to make quick and timely decisions during project implementation	0.142	0.005
Financial Management Criteria	0.028	Failure to estimate the price correctly before taking the job	0.354	0.009
		Low adjustment indices relative to increased costs during implementation time	0.175	0.004
		Delayed payment of government budgets (payment in the form of fixed-term bonds) during the construction of the road project	0.235	0.006
		Shortage of funds allocated for initial studies and project implementation	0.236	0.006
Claim Management Criteria	0.036	The disagreement between consultant and contractor	0.579	0.007
		Cultural conflicts and sabotage of the residents of the region	0.283	0.003
		The religious position of the region	0.138	0.002
Environmental Criteria		Damaged materials and equipment	0.200	0.003
		Environmental restrictions and permits	0.403	0.005
		Risks associated with environmental conditions and project site	0.253	0.003
		Expanded communications at the project site with other areas and its consequences (e.g., pollution)	0.143	0.002

5. Results

The final weights for the considered criteria and prioritization of project risks (Risk Prioritization) were utilized for risk rankings, which are presented in Table 3 and Figure 4. The obtained results indicate that budget deficit is the most critical risk factor of the project, preceding by inflation and international sanctions. Furthermore, risk factors related to expanding the project relationship with other areas, the area's religious location, and the area's environmental hazards, and the project site are the least important ranking items.

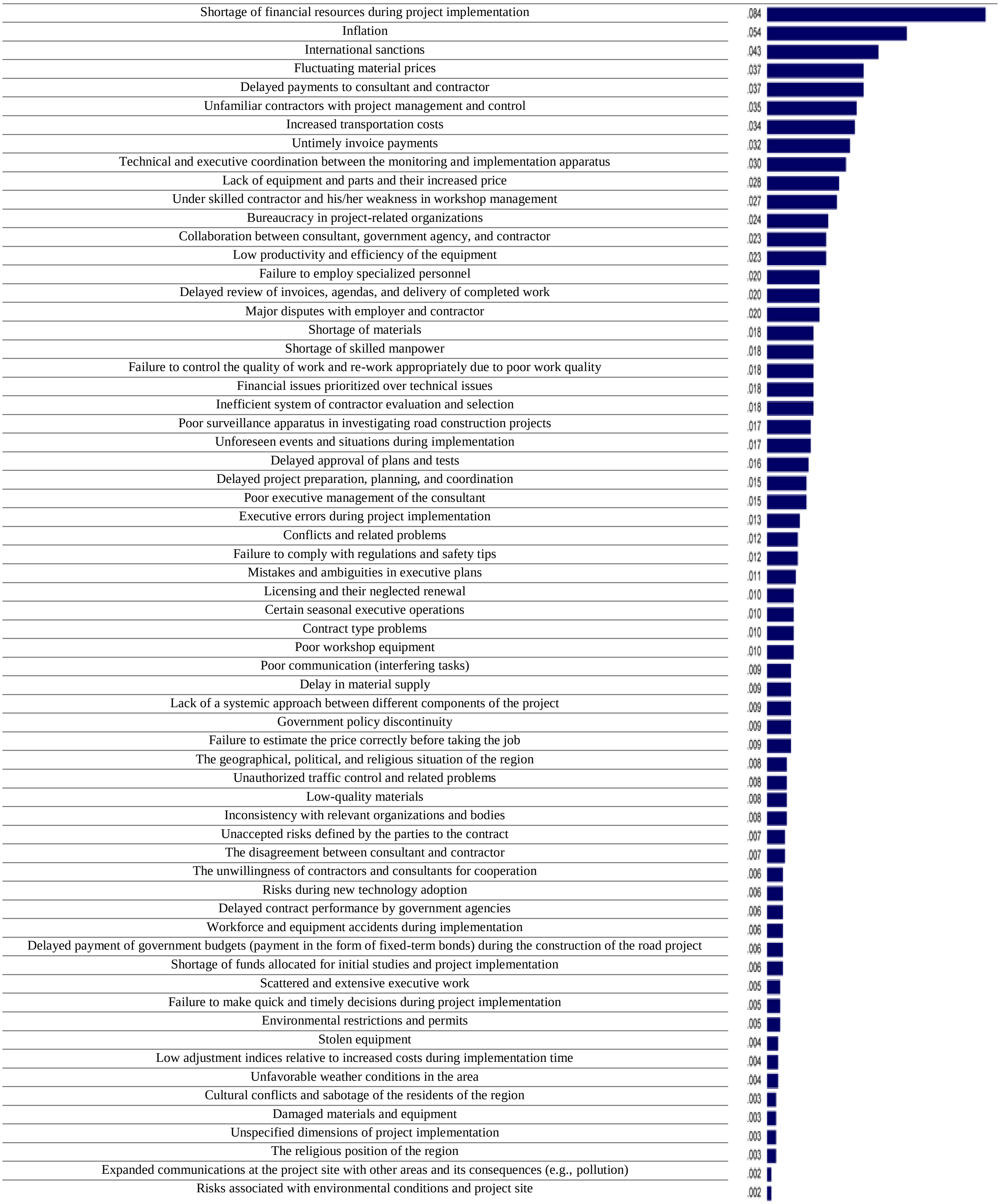

Fig. 4. Prioritization of project risks.

Table 3. Prioritization of project risks.

Component	Criterion	Final weight	Priority
Cost Management Criteria	Shortage of financial resources during project implementation	0.084	1
Cost Management Criteria	Inflation	0.054	2
Cost Management Criteria	International sanctions	0.043	3
Cost Management Criteria	Fluctuating material prices	0.037	4
Time Management Criteria	Delayed payments to consultant and contractor	0.037	5
Human Resource Management Criteria	Unfamiliar contractors with project management and control	0.035	6
Cost Management Criteria	Increased transportation costs	0.034	7
Procurement Management Criteria	Untimely invoice payments	0.032	8
Integrated Management Criteria	Technical and executive coordination between the monitoring and implementation apparatus	0.03	9
Procurement Management Criteria	Lack of equipment and parts and their increased price	0.028	10
Human Resource Management Criteria	Underskilled contractor and his/her weakness in workshop management	0.027	11
Risk Management Criteria	Bureaucracy in project-related organizations	0.024	12
Integrated Management Criteria	Collaboration between consultant, government agency, and contractor	0.023	13
Procurement Management Criteria	Low productivity and efficiency of the equipment	0.023	14
Procurement Management Criteria	Failure to employ specialized personnel	0.02	15
Time Management Criteria	Delayed review of invoices, agendas, and delivery of completed work	0.02	16
Stakeholder Management Criteria	Major disputes with employer and contractor	0.02	17
Procurement Management Criteria	Shortage of materials	0.018	18
Human Resource Management Criteria	Shortage of skilled manpower	0.018	19
Quality Management Criteria	Failure to control the quality of work and re-work appropriately due to poor work quality	0.018	20
Quality Management Criteria	Financial issues prioritized over technical issues	0.018	21
Quality Management Criteria	Inefficient system of contractor evaluation and selection	0.018	22
Stakeholder Management Criteria	Poor surveillance apparatus in investigating road construction projects	0.017	23
Risk Management Criteria	Unforeseen events and situations during implementation	0.017	24
Time management criteria	Delayed approval of plans and tests	0.016	25
Integrated Management Criteria	Delayed project preparation, planning, and coordination	0.015	26
Quality Management Criteria	Poor executive management of the consultant	0.015	27
Human Resource Management criteria	Executive errors during project implementation	0.013	28
Stakeholder Management Criteria	Conflicts and related problems	0.012	29
Safety Management Criteria	Failure to comply with regulations and safety tips	0.012	30
Scope Management Criteria	Mistakes and ambiguities in executive plans	0.011	31
Integrated Management Criteria	Licensing and their neglected renewal	0.01	32
Time Management Criteria	Certain seasonal executive operations	0.01	33
Scope Management Criteria	Contract type problems	0.01	34
Safety Management Criteria	Poor workshop equipment	0.01	35
Integrated Management Criteria	Poor communication (interfering tasks)	0.009	36
Time Management Criteria	Delay in material supply	0.009	37
Communication Management Criteria	Lack of a systemic approach between different components of the project	0.009	38
Communication Management Criteria	Government policy discontinuity	0.009	39
Financial Management Criteria	Failure to estimate the price correctly before taking the job	0.009	40
Risk Management Criteria	The geographical, political, and religious situation of the region	0.008	41
Risk Management Criteria	Unauthorized traffic control and related problems	0.008	42
Quality Management Criteria	Low-quality materials	0.008	43
Communication Management Criteria	Inconsistency with relevant organizations and bodies	0.008	44
Stakeholder Management Criteria	Unaccepted risks defined by the parties to the contract	0.007	45
Claim Management Criteria	The disagreement between consultant and contractor	0.007	46
Stakeholder Management Criteria	The unwillingness of contractors and consultants for cooperation	0.006	47

Risk Management Criteria	Risks during new technology adoption	0.006	48
Communication Management Criteria	Delayed contract performance by government agencies	0.006	49
Safety management criteria	Workforce and equipment accidents during implementation	0.006	50
Financial Management Criteria	Delayed payment of government budgets (payment in the form of fixed-term bonds) during the construction of the road project	0.006	51
Financial Management Criteria	Shortage of funds allocated for initial studies and project implementation	0.006	52
Scope Management Criteria	Scattered and extensive executive work	0.005	53
Safety Management Criteria	Failure to make quick and timely decisions during project implementation	0.005	54
Environmental Criteria	Environmental restrictions and permits	0.005	55
Safety Management Criteria	Stolen equipment	0.004	56
Financial Management Criteria	Low adjustment indices relative to increased costs during implementation time	0.004	57
Scope Management Criteria	Unfavorable weather conditions in the area	0.003	58
Scope Management Criteria	Cultural conflicts and sabotage of the residents of the region	0.003	59
Environmental criteria	Damaged materials and equipment	0.003	60
Scope Management Criteria	Unspecified dimensions of project implementation	0.003	61
Scope Management Criteria	The religious position of the region	0.002	62
Environmental Criteria	Expanded communications at the project site with other areas and its consequences (e.g., pollution)	0.002	63
Environmental Criteria	Risks associated with environmental conditions and project site	0.001	64

6. Conclusion

The general purpose of this study is to *prioritize risk* in water and wastewater projects through the analytic hierarchy process (AHP). In the criteria, the risk of credit deficit with a final weight of 0.084, inflation with a final weight of 0.054, and international sanctions with a final weight of 0.043 have the first to third priority and are of the greatest importance, and risks related to expanding the project's relationship with others areas with a final weight of 0.002 and the religious location of the area with a final weight of 0.002 and the environmental hazards of the area and the project site with a final weight of 0.001 are of the least importance.

According to the literature on the identification of civil project risks, a broad range of relevant studies addressed only one dimension of the risk, such as economic, social, and technical aspects. Among the relevant studies, Mohammadi *et al.* [17], Atashsooz *et al.* [18], and Nikabadi *et al.* [19] did the most comprehensive categorization to identify the supply chain risks of projects. The results reported by Yuan *et al.* [20], Bi *et al.* [21], Naderpour *et al.* [22], Mortazavi *et al.* [23], Monirabbasi *et al.* [24] and Gao *et al.* [25] were used as the main sources to extract the project risk dimensions and indices. An important literature gap on civil project risks is the lack of study proposing a comprehensive model for the water and sewage project risks. Therefore, the results of this study can be used as a risk management model in water and sewage projects. This study aimed at identifying challenges representing a bias element based on the experts' knowledge. Since this study focused mainly on water and sewage projects, further research should be conducted to generalize the results to other areas.

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