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Utilization of AHP and MCDM Integrated methods in Urban Project Management (A Case Study for Eslamshahr-Tehran)

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Abstract

Project management is one of the most important indicators in civil projects that have tried to take into consideration of the different managerial, social, operational, executive and environmental aspects in order to advance the project goals especially in cities. In the meantime, some factors are effectively involved in determining the different conditions and methods of project implementation and management in urban areas that are of significant importance in decision making, promotion or stopping work. Multi-criteria decision-making (MCDM) and hierarchical decision-making (AHP) approaches are used today to meet multiple goals. In this study, using the integrated approach including MCDM and AHP methods where are implemented by Expert Choice and Excel software's, we tried to evaluate the effective factors in urban projects for Eslamshahr city of Tehran. For this purpose, by identifying the effective factors in the city's development projects, extracted from the 10 infrastructure projects of the city, the project design criteria and sub-criteria are determined at the management and implementation levels. Then, these criteria are evaluated according to the importance and sensitivity of the different projects prioritized on the effectiveness of each in Eslamshahr urban projects.

1. Introduction

Urban planning involves the several management factors including environmental constraints, existing land uses, legal restrictions and land ownerships, land use policies, community facilities availability and etc. which are highly controlled the suitability and development actions in urban areas [11]. In implementing of a project, these factors should be considered as decisions set and evaluate against different aspects [10]. In civil construction projects, the project engineers are responsible for aspects assessments of the all site condition of the project. As known, the project management is the initiating practice, planning, executing, controlling, and closing the work to achieve specific goals at specified time. The project management primary challenge is achieve to all project goals by considering the limitations and resources [15]. To this end, required to identifying the criteria's and evaluate the amount of efficiency and sensitivities [13].

Analytic hierarchy process (AHP) and multi-criteria decision making (MCDM) approaches are the most success methodologies where used to evaluate multi-task parametric decisions. The first application of MCDM techniques for decision-making process is related to 1960s and accommodating different opinions with several alleviative [21]. These capabilities have help the manager for combine decision methods like MCDM with AHP, fuzzy logic, geographical information system (GIS), Promethee, etc. [4, 9, 12, 14, 20]. MCDM involves a multi-stage process concluded objectives definition, criteria identification, objectives measurement, alternatives specifications, criteria weights assessments and providing appropriate mathematical matrix for ranking alternatives and criterias which allows to accommodate to considered the require aspects and integration the various methods to achieve the main goal of study [3, 15]. The majority of MCDM applications are used for analytic hierarchy process (AHP) integration for evaluate the multi-task goals in various projects. AHP used the multiple levels of criteria classification system for optimized decisions on project aim by means of criteria sets. Saaty (1980) is first scholar who developed AHP models for investigate the hierarchical decision problem framework based on both subjective (intangible) and/or objective (tangible) criterias [17, 5, 7].

AHP is a reliable tool to facilitate systematic and logical decision making processes, and determine the significance of a set of criteria and sub-criteria. It is widely applied to construction fields such as resources allocation, project design, planning for urban development, maintenance management, policy evaluation, etc. [13, 18, 6, 19]. Saaty and his colleagues proofed the mathematical calculations and decision process of AHP [18]. However, the pairwise comparison and preparing decision matrix are important steps in AHP were be completed by the experts (specialists and technical personals). Flexibility of AHP for large number of criteria or alternatives process is the advantage of the method where used for different aspect of managements. For reduction of human-act efficiency for low expert judgments due lose patience during process or tiredness which may effect on their judgments used the compatibility index (CR) rate to avoid such drawback [6]. If the CR is less than 0.1 or 10% then the presses is compatible and acceptable. Also, the prepared decision matrix will be reliable [2]. Pairwise comparison methodology for considering the importance classification of input data is straightforward and convenient for the users which are help to evaluate multi-task decisions by considering all aspects of estimations. Thus, coupled application of AHP with MCDM is very suitable for complex social and engineering issue in management levels.

In this study, we take advantage of these approaches and attempted to use these terms for identification of criteria and alternatives in urban infrastructure projects. To this end, 10 infrastructure projects of the Eslamshahr city where located in Tehran province, Iran are considered as cases of the study. To this end, the results conducted based on the expert system and 50 questionnaires for related specialists.

2. Material and Methods

2.1. Studied location

Eslamshahr city were only 12 kilometers away from the Tehran city (capital of Iran). According to the 2016 census the city has a population of 548,620 which includes 279,282 men and 269,338 women. The city is located on the Saveh Road, which starts in the south of Tehran, and ends at Saveh City. This city due to its location and its proximity to

Tehran, it is one of the fastest growing cities in the Iran which is faced with different urban infrastructure projects such as squares, passages, streets, mosques, housing masses, apartment complexes, etc. Figure 1 is presents the location of the Eslamshahr city in Tehran province.

2.2. Sustainable urban development for Eslamshahr

Rapid development of Eslamshahr without thoughtful planning as nearest city to Tehran is lead to population density in last years which leads to underutilization and inefficient use of scarce land resources. In order to deal with the physical constraint on city, the numerous urban issues such as traffic congestions, amenities lack, deteriorating urban fabric and substandard living condition, many urban projects have been conducted in new year's. These projects are generally prepared in cooperation with the municipality and under various conditions, which will have future consequences and achievements. So, the construction management experts have been trying to predict and analyze these demographics considering different project conditions. The appropriate decisions in management levels in urban projects which are concerned parties criticize, and covered economic development, environmental quality overlook and social requirements [8]. Therefore, application of the sustainability concept of projects is achieve with identification of effective parameters and suitable multi-task decisions.

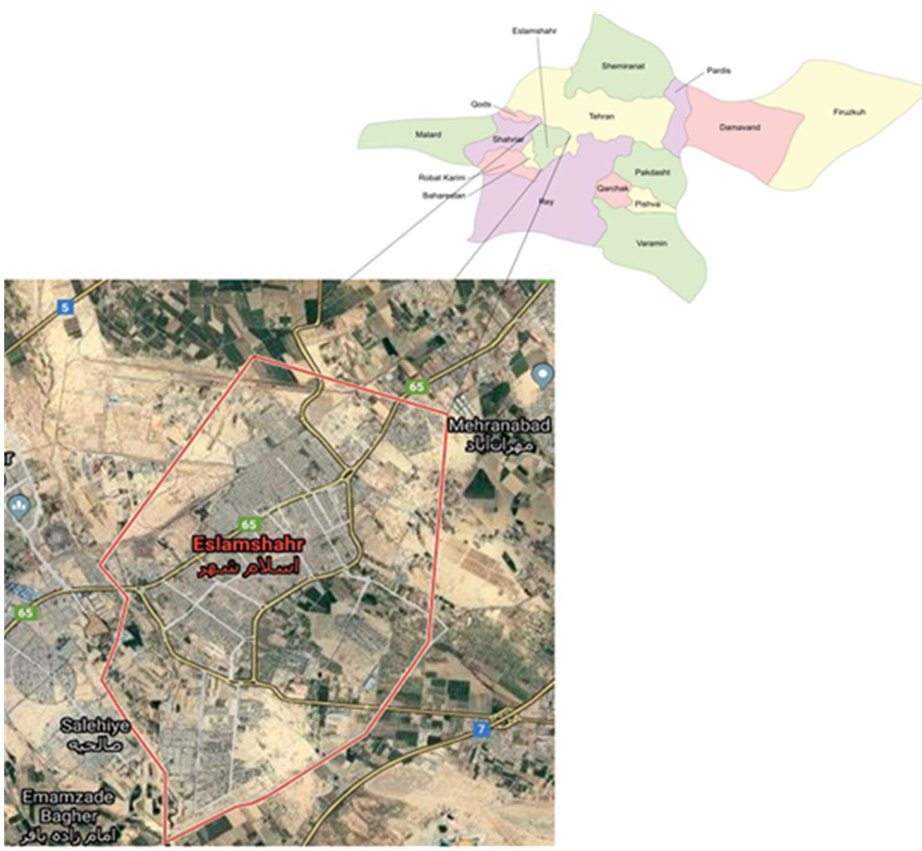

Fig. 1. Location of the Eslamshahr city in Tehran province.

2.3. Proper multi-task decisions for project managements

Establishment of sustainable urban managements in different levels of infrastructure projects can be lead for implementation of proper model and framework for the city in the coming years. To do this, it is required to know the effective factors and interactive relationships between them. The AHP and MCDM methodologies are successful multi-task decisions systems where used for achieve appropriate decisions based on various alternatives and criteria which is considered in this study.

2.4. Research methodology

The main objective of the study is present a framework based on AHP and MCDM integrated methods which is implemented by Expert Choice and Excel software's for providing the coupled approach were can be adopted by any construction companies that is interested in urban area civil projects. The tasks were performed in this study can be summarized as follows:

- Selecting the main urban construction projects in Eslamshahr city,
- Identification of criteria and alternatives related to projects,
- Providing the link between the alternatives, criteria and sub-criteria's,
- Integration of AHP and MCDM for identification of effective management parameters in urban projects,
- Appling the coupled method to solve the project selection based on effective criteria,
- Prioritization of urban projects based on importance and sensitivity for each projects in city.

2.5. Application steps

To the application of the AHP-MCDM methodologies on the studied projects, the 50 specialist are selected as the experts to fill the main questionnaires. The information about the specialist can be summarized in Table 1.

Table 1. The information of the specialists.

Index information	**Level**	**Number by gender**	
		Man	Women
Age	Old (35> years old.)	17	3
	Young (<35 years old.)	25	5
Education	B.Sc.	12	3
	M.Sc.	25	4
	Ph.D.	5	1
Work	Civil Engineering	17	2
	Geo-Engineering	15	2
	Management	10	4
Expertise / Related work	Less than 5 year	24	8
	More than 5 year	18	0

By using the results of these questionnaires, the input parameters for the assessment are prepared. To this end, at the first the main parameters involved in urban projects extracted from different references then by using an expert system and specialists opinions, the efficiency of these parameters investigated for studied cases.

3. Results and discussions

The ten urban project is considered for investigate the main parameters involved in urban projects for Eslamshahr city which is describe in Table 2. These projects are considered for extract the parameters affected on project management level. Table 3 is present the main criteria and alternatives were involved the selected project in the city which is at the first time extracted from the main references and modified for studied cases. For this purpose, 50 questionnaires were conducted from technical experts involved in the urban construction projects of for each of the urban construction projects where mentioned in Table 2. Table 3 is present the results of the field investigations were achieved for all projects. As can be seen in this table, the parameters involved in the evaluation indices are presented as the main sub-categories and alternatives evaluated for each of the methods that can be used to select the evaluated approaches. Also, depending on the coefficients of impact of each project management method and the impact of the reliability criteria on construction management projects, prioritization and decision-making are made.

Table 2. The selected cases from urban projects in Eslamshahr.

No.	Project name	Location
1	Namaz square	35.5622 - 51.2547
2	Islamic Azad University	35.5569 - 51.2500
3	Towhid town	35.5665 - 51.2303
4	Shahrak-e-Anbiya	35.5705 - 51.2367
5	Tehran-Saveh Rd	35.5493 - 51.2264
6	Saiditeh town	35.5368 - 51.2175
7	Commercial Complex Valieasr	35.5211 - 51.2417
8	Shahrak-e-Azadegan	35.5275 - 51.2138
9	Qaem square	35.5373 - 51.2034
10	Algadir square	35.5166 - 51.2308

Table 3. Effective criteria in urban construction management projects.

No.	Effective parameters	Functional alternatives
1	Planning system quality	- The existence of a certain position of urban design in the planning system - Description of standard services and updates - Non-overlapping and parallel work of related organizations at every stage of development projects - The amount of attention paid to overseas designs in construction management - Considering the scale of construction projects
2	Project consultant qualification	- Continuous presence and cooperation of the project consultant from preparation to execution - Professional and experienced staff in urban planning and management - A professional and ethical commitment to scientific principles against possible pressures - Realizing and understanding the managerial, economic and executive bottlenecks of the project - The degree of certainty and independence of the consultant's opinion - Detailed technical studies with valid standards

3	Academic Supports	- Delivery on project documentation - Involvement and collaboration of construction management professors in the process of developing projects - University participation and collaboration in formulating theoretical foundations of plans, service descriptions and executive mechanisms
4	Proposal quality	Introduce up-to-date and efficient scientific methods for use in projects by professionals - Using design patterns tailored to local and native features (identity) - Design, comprehensiveness and flexibility of the design - The project has technical, economic, social and environmental justifications - Full and executable maps available
5	Client qualification and managements	- Considering the quality aspects and considerations of construction management in urban design - Unified, integrated and coherent management - Superb and permanent monitoring - The authority of the approval to review and control the consultant's proposed plan - The employer's ability to establish coordination between the consultant and the contractor - The quality of the contractor's documents handling, including the agenda and the situation - The accuracy of project consultant selection - The accuracy of project contractor selection - Notice when projects are approved for implementation - Level of coordination between municipal departments (utilities, etc.) to create infrastructure - Consider the feasibility of projects when defining them - Knowledge and understanding of the client about the nature of urban design and management projects - Quality of project schedule - The extent of the project manager's discretion in decision making - Have extra-political and non-political views - Hurry, rush and show off - The accuracy of the bidding - Stability at different levels of management over the project duration
6	Legal interaction	- Interaction between private and public ownership to easily secure the lands needed for development - Resolving conflicts (traffic, property and facilities) in a timely manner - The amount of attention paid to corporate rights - The amount of attention paid to real estate - Lack of legal and cumbersome obstacles - Conflict between existing rules Existence of project implementation guarantees - The transparency of the project contract - Lack of bureaucracy in related organizations - The extent to which the project-related rules are updated
7	Project Contractor Qualification	- The executive management capacity of the contractor - Have sufficient skilled and experienced forces - Adherence to the principles of the contract, especially the terms of the treaty - The amount of attention given to the advice of the consultant and the employer - Equipped with project equipment, machinery and materials - The level of readiness of the contractor to deal with climate and environmental conditions - Applying new technologies and methods of implementation - Contractor's financial vigil - Run the project with the least possible changes
8	Economic and financial power	- Ethical Commitment in Economic Issues (Corruption and Rent) - Appropriate financial mechanisms - Sustainability of finances and revenues - The amount of budget flexibility given the economic fluctuations - Lack of financial corruption and rent on the project - Having a specific price list for inner-city tasks

Based on the provided criteria where identified by effective parameters and functional alternatives each projects are evaluate and prepared the coefficients of impact of each criteria on each projects managements. The results of the AHP-MCDM based modeling and multi-criteria decision matrixes are presented in Tables 4 to 13 and Fig. 2.

Table 4. Hierarchical evaluation and prioritization decision matrix for Project No. 1.

Criteria	1	2	3	4	5	6	7	8
1	1	2.00	5.00	1.00	2.00	7.00	6.00	5.00
2	0.50	1	2.00	0.25	2.00	4.00	6.00	1.00
3	0.20	0.50	1	0.25	0.50	5.00	1.00	1.00

4	1.00	4.00	4.00	1	4.00	6.00	4.00	3.00
5	0.5	0.50	2.00	0.25	1	7.00	1.00	0.50
6	0.14	0.25	0.20	0.17	0.14	1	0.50	0.17
7	0.17	0.17	1.00	0.25	1.00	2.00	1	0.20
8	0.20	1.00	1.00	0.33	2.00	6.00	5.00	1
Number of comparison		28	Consistency Ratio (CR)		7.1%	Principal Eigen value		8.697
Eigenvector solution		5	Iteration, delta		3.4E-8			

Table 5. Hierarchical evaluation and prioritization decision matrix for Project No. 2.

Criteria	1	2	3	4	5	6	7	8
1	1	1.00	1.00	0.14	0.50	7.00	0.17	1.00
2	1.00	1	0.50	0.14	0.50	4.00	0.17	0.33
3	1.00	2.00	1	0.25	2.00	5.00	0.20	1.00
4	7.00	7.00	4.00	1	4.00	9.00	1.00	6.00
5	2.00	2.00	0.50	0.25	1	4.00	0.50	0.50
6	0.14	0.25	0.20	0.11	0.25	1	0.14	0.14
7	6.00	6.00	5.00	1.00	2.00	7.00	1	1.00
8	1.00	3.00	1.00	0.17	2.00	7.00	1.00	1
Number of comparison		28	Consistency Ratio (CR)		6.6%	Principal Eigen value		8.3648
Eigenvector solution		5	Iteration, delta		7.5E-8			

Table 6. Hierarchical evaluation and prioritization decision matrix for Project No. 3.

Criteria	1	2	3	4	5	6	7	8
1	1	2.00	5.00	1.00	2.00	7.00	6.00	5.00
2	0.50	1	2.00	0.25	2.00	4.00	6.00	1.00
3	0.20	0.50	1	0.25	0.50	5.00	1.00	1.00
4	1.00	4.00	4.00	1	4.00	6.00	4.00	3.00
5	0.50	0.50	2.00	0.25	1	7.00	1.00	0.50
6	0.14	0.25	0.20	0.17	0.14	1	0.50	0.17
7	0.17	0.17	1.00	0.25	1.00	2.00	1	0.20
8	0.20	1.00	1.00	0.33	2.00	6.00	5.00	1
Number of comparison		28	Consistency Ratio (CR)		7.1%	Principal Eigen value		8.697
Eigenvector solution		5	Iteration, delta		3.4E-8			

Table 7. Hierarchical evaluation and prioritization decision matrix for Project No. 4.

Criteria	1	2	3	4	5	6	7	8
1	1	6.00	2.00	0.50	7.00	4.00	1.00	0.50
2	0.17	1	2.00	0.20	1.00	4.00	0.33	0.33
3	0.50	0.50	1	0.25	0.50	3.00	0.14	0.25
4	2.00	5.00	4.00	1	9.00	8.00	2.00	1.00
5	0.14	1.00	2.00	0.11	1	4.00	0.20	0.33
6	0.25	0.25	0.33	0.12	0.25	1	0.17	0.20
7	1.00	3.00	7.00	0.50	5.00	6.00	1	0.50
8	2.00	3.00	4.00	1.00	3.00	5.00	2.00	1
Number of comparison		28	Consistency Ratio (CR)		7.2%	Principal Eigen value		8.703
Eigenvector solution		6	Iteration, delta		5.4E-8			

Table 8. Hierarchical evaluation and prioritization decision matrix for Project No. 5.

Criteria	1	2	3	4	5	6	7	8
1	1	0.20	0.17	0.50	0.14	1.00	0.20	1.00
2	5.00	1	2.00	0.33	0.17	2.00	1.00	6.00
3	6.00	0.50	1	1.00	0.17	4.00	1.00	6.00

4	2.00	3.00	1.00	1	0.20	5.00	1.00	4.00
5	7.00	6.00	6.00	5.00	1	6.00	5.00	4.00
6	1.00	0.50	0.25	0.20	0.17	1	0.20	1.00
7	5.00	1.00	1.00	1.00	0.20	5.00	1	6.00
8	1.00	0.17	0.17	0.25	0.25	1.00	0.17	1
Number of comparison		28	Consistency Ratio (CR)		9.0%	Principal Eigen value		8.883
Eigenvector solution		6	Iteration, delta		3.6E-8			

Table 9. Hierarchical evaluation and prioritization decision matrix for Project No. 6.

Criteria	1	2	3	4	5	6	7	8
1	1	4.00	5.00	1.00	4.00	1.00	0.50	0.25
2	0.25	1	1.00	1.00	2.00	0.33	0.20	0.17
3	0.20	1.00	1	0.33	1.00	0.14	0.25	0.17
4	1.00	1.00	3.00	1	2.00	0.20	1.00	1.00
5	0.25	0.50	1.00	0.50	1	0.33	0.20	0.17
6	1.00	3.00	7.00	5.00	3.00	1	1.00	2.00
7	2.00	5.00	4.00	1.00	5.00	1.00	1	1.00
8	4.00	6.00	6.00	1.00	6.00	0.50	1.00	1
Number of comparison		28	Consistency Ratio (CR)		7.3%	Principal Eigen value		8.712
Eigenvector solution		7	Iteration, delta		5.2E-9			

Table 10. Hierarchical evaluation and prioritization decision matrix for Project No. 7.

Criteria	1	2	3	4	5	6	7	8
1	1	0.25	1.00	0.17	0.14	3.00	0.20	0.33
2	4.00	1	2.00	0.50	1.00	7.00	0.20	1.00
3	1.00	6.00	1	0.17	0.14	3.00	0.14	1.00
4	6.00	7.00	6.00	1	2.00	4.00	0.25	1.00
5	7.00	0.33	7.00	0.50	1	5.00	0.50	4.00
6	0.33	7.00	0.33	0.25	0.20	1	0.11	0.33
7	5.00	0.33	7.00	4.00	2.00	9.00	1	5.00
8	3.00	1.00	1.00	1.00	0.25	3.00	0.20	1
Number of comparison		28	Consistency Ratio (CR)		7.7%	Principal Eigen value		8.755
Eigenvector solution			Iteration, delta		8.5E-9			

Table 11. Hierarchical evaluation and prioritization decision matrix for Project No. 8.

Criteria	1	2	3	4	5	6	7	8
1	1	0.25	1.00	0.17	0.14	3.00	0.20	0.33
2	4.00	1	2.00	0.50	1.00	7.00	0.20	1.00
3	1.00	0.50	1	0.17	0.14	3.00	0.14	1.00
4	6.00	2.00	6.00	1	2.00	4.00	0.25	1.00
5	7.00	1.00	7.00	0.50	1	5.00	0.50	4.00
6	0.33	0.14	0.33	0.25	0.20	1	0.11	0.33
7	5.00	5.00	7.00	4.00	2.00	9.00	1	5.00
8	3.00	1.00	1.00	1.00	0.25	3.00	0.20	1
Number of comparison		28	Consistency Ratio (CR)		7.7%	Principal Eigen value		8.755
Eigenvector solution		6	Iteration, delta		8.5E-9			

Table 12. Hierarchical evaluation and prioritization decision matrix for Project No. 9.

Criteria	1	2	3	4	5	6	7	8
1	1	0.25	0.33	2.00	1.00	3.00	1.00	0.17
2	4.00	1	5.00	7.00	1.00	5.00	7.00	2.00

3	3.00	0.20	1	6.00	1.00	5.00	1.00	1.00
4	0.50	0.14	0.17	1	0.17	2.00	0.25	0.25
5	1.00	1.00	1.00	6.00	1	7.00	1.00	0.25
6	0.33	0.20	0.20	0.50	0.14	1	0.14	0.11
7	1.00	0.14	1.00	4.00	1.00	7.00	1	0.33
8	6.00	0.50	1.00	4.00	4.00	9.00	3.00	1
Number of comparison		28	Consistency Ratio (CR)		9.8%	Principal Eigen value		8.875
Eigenvector solution		6	Iteration, delta		2.2E-8			

Table 13. Hierarchical evaluation and prioritization decision matrix for Project No. 10.

Criteria	1	2	3	4	5	6	7	8
1	1	2.00	3.00	4.00	6.00	3.00	7.00	9.00
2	0.50	1	1.00	5.00	3.00	3.00	3.00	6.00
3	0.33	1.00	1	5.00	4.00	3.00	6.00	7.00
4	0.25	0.20	0.20	1	2.00	2.00	4.00	4.00
5	0.17	0.33	0.25	0.50	1	2.00	4.00	8.00
6	0.33	0.33	0.33	0.50	0.50	1	2.00	5.00
7	0.14	0.33	0.17	0.25	0.25	0.50	1	2.00
8	0.11	0.17	0.14	0.25	0.12	0.20	0.50	1
Number of comparison		28	Consistency Ratio (CR)		7.2%	Principal Eigen value		8.710
Eigenvector solution		6	Iteration, delta		6.2E-8			

By focuses on the Fig. 2, the variation of the efficiency for each criterias ordered based on the impact coefficients which represent the amount of involving the criteria in projects. For example in project 1, the proposal quality, planning system quality and economic and financial power are higher impacts then others. In the other hand, the project contractor qualification and client qualification and managements are less than others considered.

According to the results of the AHP-MCDM integration method where applied on all main criteria related to project managements from urban projects in Eslamshahr, it is indicated that the criteria identified for project managements with appropriate compliance rates (CR) of less than 10% have been implemented for each projects. This fact reflects the success of the implementation framework. By considering the order of the projects and involved criterias in each of them, the projects can be classified as importance and sensitivity. Table 14 illustrated the prioritize results for studied urban projects in Eslamshahr.

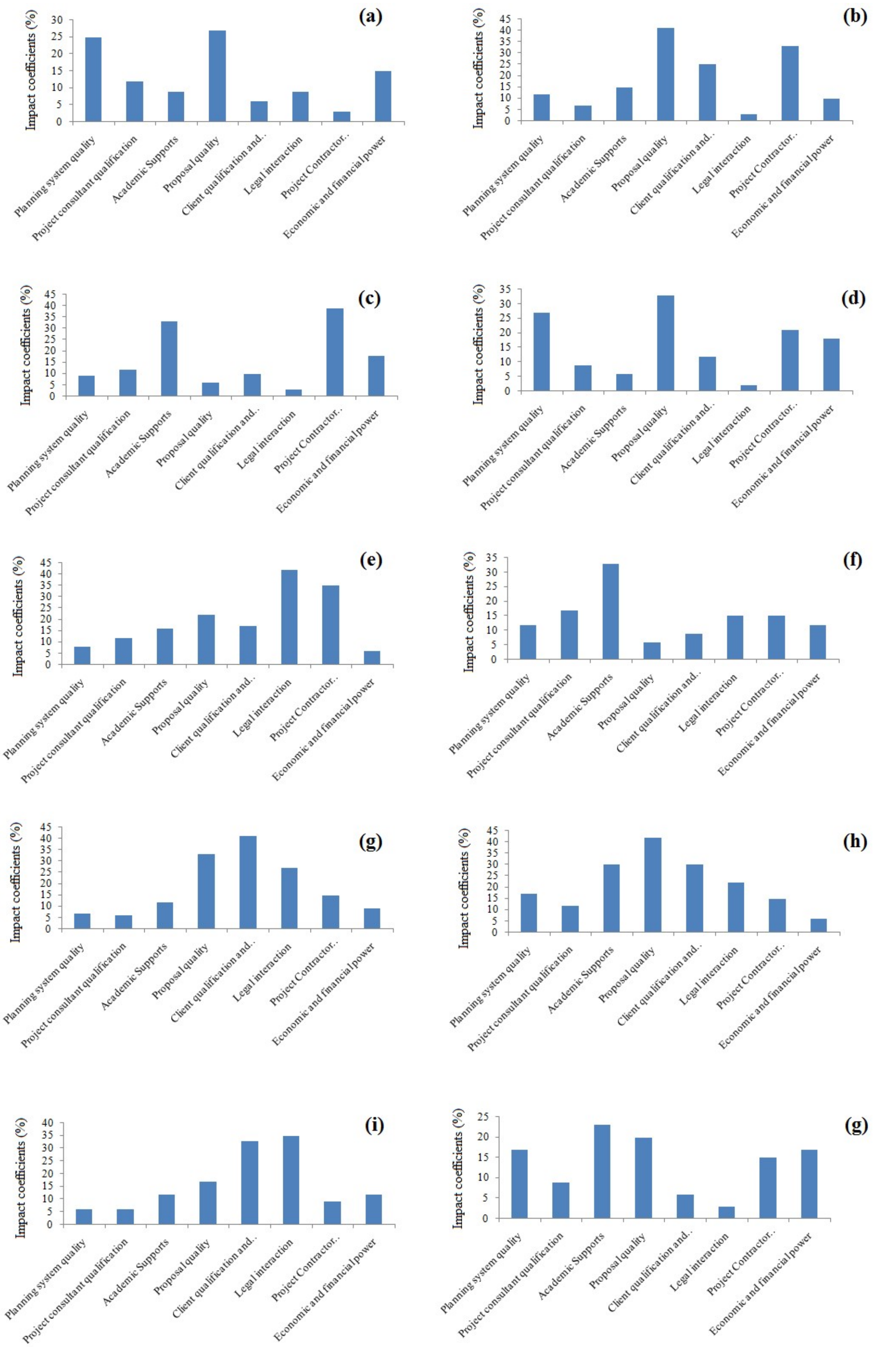

Fig. 2. Results of critical analysis by AHP-MCDM integrated methods for the projects: (a) No. 1, (b) No. 2, (c) No. 3, (d) No. 4, (e) No. 5, (f) No. 6, (g) No. 7, (h) No. 8, (i) No. 9, (g) No. 10.

Table 14. Prioritize results for studied urban projects in Eslamshahr.

No.	Project name	Highest impact	Prioritize
1	Namaz square	0.167	2 (B)
2	Islamic Azad University	0.174	1 (A)
3	Towhid town	0.137	3 (C)
4	Shahrak-e-Anbiya	0.111	4 (D)
5	Tehran-Saveh Rd	0.061	7 (G)
6	Saiditeh town	0.053	8 (H)
7	Commercial Complex Valieasr	0.047	10 (J)
8	Shahrak-e-Azadegan	0.044	9 (I)
9	Qaem square	0.097	6 (F)
10	Algadir square	0.109	5 (E)

4. Conclusions

The presented paper is used the coupled method based on AHP and MCDM approaches for investigate the urban projects managements in Eslamshahr city where located in Tehran province, Iran. The main focuses of the study is conducted on the 10 infrastructural projects implemented in the city. For this purpose, by identifying the effective factors in the city's development projects, extracted from the 10 infrastructure projects of the city, the project design criteria and sub-criteria are determined at the management and implementation levels. Then, these criteria are evaluated according to the importance and sensitivity of the different projects prioritized on the effectiveness of each in Eslamshahr urban projects. According to the results of the AHP-MCDM, criteria identified for project managements with appropriate compliance rates (CR) of less than 10% have been implemented for each project which reflects the success of the implementation framework. Uncertainty can be considered in modelling order to grade projects and make benefit of Fuzzy ahp [16]. Also, other methods including dea [1] can be used.

Disclosure of potential conflicts of interest

There are no conflicts of interest.

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