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An FCM-based dynamic modelling of operability and maintainability barriers in road projects

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Abstract

Building a new road infrastructure in the country leads to economic and industrial growth. A massive amount of money is paid by governments to build them; however, they fail due to many reasons related to Operability and Maintainability (O&M) issues. They are not also completed within the expected budget, time, and quality; so they are not justifiable. As these factors have a strong impact on projects, to reduce the final cost and other mentioned problems, it is necessary to identify the existing O&M barriers, their interrelationships, and their effects on the three mentioned factors. An in-depth literature review is conducted to identify the barriers. The Fuzzy Cognitive Mapping (FCM) technique is used to model O&M barriers using real case data analyses. The findings reveal that managerial factors have more significanct impacts on the project's success compared to other factors such as organizational, human resource, technology, and project management. Therefore, management methods are very important in developing integration in the project. Identifying, classifying, and determining the effects of barriers to entry of O&M contractors on the cost, time, and quality of road infrastructure projects show the signifcance of conducting this research, which is necessary to deal with the existing barriers. All these ultimately increase quality and reduce time and cost in road infrastructure projects.

Keywords: Fuzzy Cognitive Mapping (FCM), Operability and Maintainability (O&M), Operability and Maintainability Barriers, Road Infrastructure

1- Introduction

To achieve economic growth in a society, the economic resources available for people and their efficiency are the major factors [1]. One of the fundamental issues in a country that is addressed in this paper is road infrastructure as an economic resource. All kinds of roads, various structures and facilities, electrical and mechanical systems that belong to the road infrastructure need to be more efficient in terms of safety, traffic problems and so on. Improving the quality of these projects through their lifecycle requires finding remedies as a basic need. Thus, the more improved quality in a project, the more effective maintenance they will have. On the other hand, roads should be in an acceptable condition, and special attention should be paid to their maintenance plans to reduce unwanted and unexpected costs. Therefore, ignoring maintenance activities leads to imposing a huge amount of money and paying attention to the maintenance needs at the early stages of projects that require the designer's consideration, is an effective way in this regard [2]. Hence, considering the operation and maintenance knowledge and experiences at the initial stages of projects as subsequences of these projects' construction costs in a country and neglecting maintenance in the project's lifecycle seems necessary [3].

As mentioned earlier, road infrastructure projects are crucial to the economic growth and development of a country. Completing this type of project in the expected quality and within the time and budget set, is always a major concern for the employers, especially if a government-funded project is implemented [4, 5]. Therefore, the main challenge of such projects is the cost of their implementation. Indeed, ability to estimate the final cost of project and avoiding cost overruns that are reliable, is essential for proper planning of the project and the resources required for it. However, despite its importance, it is not easy to make decisions for various reasons, such as not sharing cost estimates at the early stages of a project [5]. Cost increases can be one of the reasons why a project is not successful. Moreover, when this problem occurs, the cost of project completion will increase too, and the reasonable profit for stakeholders will finally lose. Therefore, these kinds of projects are not economically and technically justifiable [4].

Another major trouble is time overrun, and risks associated with conducting similar projects with competitors and not taking a new project is possible if the project is not completed in the scheduled time [6]. In fact, for project management, balancing among the three traditional project success factors of cost, time, and budgetis one of the crucial and fundamental problems. Thus, the project's success stems from three fundamental factors [7], and through the integration of different project stages, it can be expected that the project to succeed. Finally, the role of the O&M stage is very crucial for this aim [8]. Kahvandi et al. [9],and Musta [10] have investigated these three success factors as a tool for successful projects. In line with these researches, this study has focused on them too. As there is no official statistical report regarding O&M, this study aims to determine how O&M barriers impact each other and how they will affect time, cost, and quality. Previous studies have mostly focused on identifying the barriers [2, 3], finding solutions to reduce the barriers [11], and presenting frameworks to facilitate the O&M [12].

To reduce existing challenges and barriers, it is essential to have an integrated team from the early stages to O&M and to find out the challenges that exist among all stakeholders in a project [13, 14]. Nevertheless, so far, no identified paper has addressed the relationships among the O&M barriers and their impact on three major factors; time, budget, and quality of projects. As mentioned before, although some studies investigated and classified the barriers based on interviews and a review of several case studies, this study intends to utilize another helpful method to analyze the severity of the impact of factors on each other. Identifying the most important barriers to O&M implementation is significant since some of them will solve thorough planning, which leads to enhancing the quality of the infrastructure industry [15]. This study seeks to increase project success under the collaboration of various stakeholders and mitigate problems such as reworks in the O&M phases. Finally, the reduction of O&M costs will arise from it.

he next section is literature review, which begins by laying out the road construction projects, and highlights the O&M definitions and O&M barriers to entering the early stages of projects. The research methodology section then follows the literature review. The fourth section is concerned with results, and it will then go to the conclusion part.

2- Literature Review

Some prior researches have investigated the O&M barriers, and they mentioned that the integration among various phases of a project can decrease the implementation cost and reworks [2, 3]. Despite the significance of the proposed issue, it has still been neglected, and many projects have not been integrated so far. Accordingly, they suffer from lack of sharing information and effective collaboration. Therefore, the cost and time overrun and, finally, poor quality is their direct consequences. Thus, it is required to study the significance of the studied road construction projects, O&M definitions, and barriers to have a successful project.

2-1 Road Construction Projects

Road infrastructure projects ease transporting goods and passengers, regardless of distance, time, or speed, which can significantly influence the flexibility and mobility of workforce. These factors lead to higher levels of employment and welfare in a society. Besides, road infrastructure development is also influenced by other factors such as tourism development, the volume of foreign investment, and regional development. In fact, given its importance, it can be acknowledged that it will affect foreign trade and international cooperation. Therefore, developing a communication network in a region and country is very necessary [1]. Since the significance of road infrastructure is very clear, it is essential to note that these national assets' proper O&M are essential. Because governments need to invest a significant capital to develop and build new highways, they will face rapid demolition without proper planning and operation. Finally, increasing maintenance costs coupled with financial losses and reduced productivity for users and governments will have disastrous consequences [16]. This issue leads to knowing more about the O&M definitions and barriers discussed in the next section.

2-2 Operability and Maintainability Barriers

The convenience of project maintenance reflects the concept of maintainability, as expressed in 1984 by the British Standard Institute. This concept should be incorporated in the design and implementation processes to reduce costs and improve maintenance [17]. Maintainability is defined as "the conditions defined for an item or level that allow it to be repaired, adjusted, or cleaned with reasonable effort and cost." Along with the concept of maintenance, the concept of operability should also be explained. This concept mainly refers to the ease of operation in projects that is commensurate with the project’s end-use and uses [18]. Despite the importance that researchers place on these two concepts, there are many barriers to implementing them.

In the construction industry, whether building or infrastructure projects, one of the main concerns is the operation and maintenance of projects, because the lower the budget allocated to this phase, the higher the associated costs are [19]. Since the amount of money spent at this stage generally accounts for 50 to 80 percent of a project's cost, it is of the utmost importance [20]. The four maintainability criteria currently under consideration by design engineers include [21]; 1) providing sufficient access to components [22], 2) Improving the design and use of simpler shapes and features [21], 3) End-user behavior and consideration [23], 4) Utilizing more durable materials and high strength against drastic temperature changes [24]. However, most of the operation and maintenance phase problems are directly attributable to the performance and decisions made at the design stage; although designers consider that they use the best design approaches [25].

One of the most effective success factors is the presence of the O&M team knowledge at the intial stages of the project [26], especially with the possibility that low-cost changes at the early stages can impact the project [27]. However, despite the significance of this issue, it is not easy for these people to participate at the early stages [28]. On the other hand, this partnership has always faced many barriers studied and explored in various types of construction projects [3, 15, 29]. Lack of consultants and designer’s experience and knowledge, lack of sharing information and minimizing maintenance, lack of motivation for cooperation and unwillingness for active interaction between various stakeholders [3, 13], lack of databases to record the attitudes and experiences of previous projects [8] are some of these barriers.

This study explored all barriers in road infrastructure projects. It identified how the experts can solve the integration problems in a project. The Meta-synthesis method has been used to understand the barriers mentioned in other studies. Organizational, managerial, project management, technological, and human resources are the main categories of barriers identified in the study presented in Table 1. Each group has its components that show the barriers in detail. Many of these factors are related to each other as it is possible to mitigate ones by reducing and solving them. Thus, it is necessary to identify their impact on each other, as it is the paper's primary goal.

As presented in the table, the most important factors are managerial barriers related to the clients' and managers' decisions and beliefs. Many of them may cause other barriers during the project life cycle, and solving them is vital. Structural barriers are then followed by it, and the factors in this group are mostly regarded as strategic factors and organization's discipline. A factor such as "lack of appropriate organizational structure to coordinate between the various stages" under the organizational group can create as many barriers as possible. The organizational structure is not appropriate for cooperation between different parties. The mentioned barriers are just some examples showing a strong relationship between them, which is vital in reducing their impact.

Table 1. Barriers to the presence of O&M contractors at the early stages of the projects

Category	Title	Resources
Managerial	Lack of weekly or monthly meetings among stakeholders	[2, 12]
	Pay more attention to the other organizations' criteria and needs	[2]
	Legal constraints	[30-32]
	Inappropriate contract strategies	[30, 33]
	Lack of motivation for the various project's parties	[2, 8]
	Lack of attention of the authorities for coordination between the various stages of the project	[2]
	Wrong judgment of ultimate goals of O&M and project among stakeholders	[2, 30]
	Prioritization of the budget, time or aesthetics, and the environment by the authorities	[2, 28, 34]
Organizational	Lack of databases to record the attitudes and experiences of previous projects	[2, 35]
	Lack of appropriate organizational structure to coordinate between the various stages	[2, 36]
	The existed boundaries between different stages of the project team	[35, 36]
	Collaborate with inexperienced O&M contractors in the early stage	[37, 38]
	Using of employer's opinions and ideas by design team regardless of standards	[28]
	Limited budget	[2, 28, 32, 34-36]
	Unclear and incorrect decision-making processes	[35]
Human Resource	Unwillingness to cooperate and give feedback to other stages of a project	[28, 32, 39, 40]
	Lack of common language/ culture and working methods between different stages of the project	[36, 41]
	weak knowledge and experience of people working in the O&M stage	[8, 35, 36, 39]
	Lack of O&M contractors’ interest to share information to preserve competition	[36, 42]
	Lack of common understanding of the project's objectives by the employer and the O&M contractor	[2, 43]
Technology	Lack of designer's experience and awareness about the O&M and the problems caused by the design	[2, 28, 34, 44]
	Design changes due to the presence of the O&M contractors at the early stages and increasing the real cost of the project	[2]
	Inaccurate maintenance policy	[32, 34]
Project Management	The lack of a clear definition of the O&M content among the project’s members	[2, 8]
	Lack of knowledge of project manager or consultant on the importance of O&M	[2, 45]
	Poor relationship and communication	[3, 12]
	Site management problems	[12]
	Project time constraints	[8, 33]

Each of the above barriers has had some effects on the projects presented in Table 2. Some studies have mentioned the cost and time overrun in a project due to lack of cooperation and many reworks that arise from designer’s decisions during the early stage of the project [33, 46]. Moreoveraccoding to Ganisen et al., [22], O&M plays a significant role in reducing cost and functionality in a project while ignoring those factors leads to increasing overall cost. On the other hand, O&M usually is not adequately considered in the design phase, which makes the maintenance activities difficult. Because accessing some particular parts of the structure is impossible in many ways [46, 47]. As presented in the table, some other effects may cause a dire situation in a project. These effects are the most critical O&M barrier’s effects on the project. Thus, it is critical to know their impacts on each other and the project.

Table 2. O&M Barriers’ effects

ID	Barriers’ effects	References
E1	Reduction of sharing necessary information and knowledge	[33, 48]
E2	Lack of understanding of the O&M contractor's role in the project life- cycle	[23, 40]
E3	Reduction of cooperation and interaction among various stakeholders	[37, 48]
E4	Increased reworks and changes	[8, 49]
E5	Reduction of flexibility, accessibility, and durability of the project	[22, 25, 44, 47, 50]
E6	Reduction of mutual trust among various stakeholders	[51]
E7	Increasing O&M workloads	[37, 52]
E8	Reduction of designing and planning for O&M, inferior construction and inefficient O&M planning	[49, 53]
E9	Reduction of project performance	[37, 52]
E10	Increased the design and services complexity	[36, 54]

In the methodology section, the paper presents how the FCM method assists the authors to evaluate the impact of these factors on each other. Besides, their influences on three factors of time, budget, and quality are investigated.

3- Research Methodology

This study aims to identify the most critical operability and maintainability implementation barriers in the literature and then discover the underlying interrelationships. This article uses a research structure based on literature review, real case data, and Fuzzy Cognitive Mapping (FCM) as the data analysis procedure to achieve this goal. The main research steps are illustrated in Figure 1.

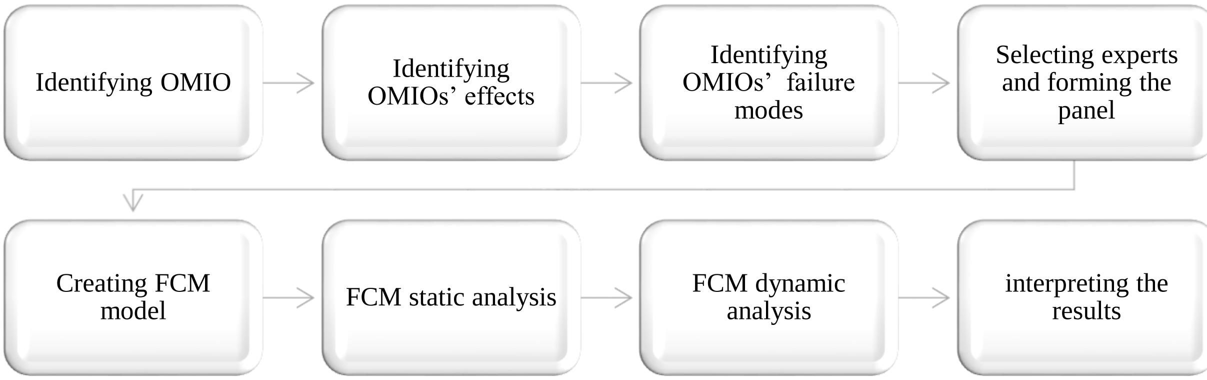

Fig 1. The research steps

3.1 Fuzzy Cognitive Maps (FCM)

FCM is an extension of cognitive maps as a tool to understand and analyze complex systems with several interrelated concepts [55]. FCMs are a combination of Neural Networks and Fuzzy Logic. They are fuzzy weighted digraphs, including several nodes and arcs [56]. FCMs define the relationships using fuzzy terms such as very low, low, medium, high, and very high; while they aim to describe complex systems including interrelated concepts [57]. The nodes or concepts (Ci) and related weighted arcs (Wij) display the modeled problem and causal dependencies between them, respectively [50]. The relationships between two concepts can be 1) positive causality (Wij >0), 2), negative causality (Wij < 0), and 3) no relationship (Wij = 0). The higher values of Wij depict the stronger effects of Ci on Cj.

There are also two types of analysis in FCMs as static and dynamic. Static analysis displays the overall effects of the extracted model, which is the total influence of the input and intermediate concepts on the output ones. To conduct such analysis, at first, a casual path from some concept node Ci to concept node Cj, say Ci --~ Ck1, Ck1--~… Ckn, Ckn--~Cj can be indicated by sequence (i, k, …., kn,j). Then the indirect effect of Ci on Cj is the causality C~I impart to Cj via the path (i, kl….kn,j). The total effect of Ci on Cj is the composite of all indirect effect causalities C~ imparts to Cj [49].

A simple fuzzy causal algebra is created by interpreting the indirect effect of operator I as the minimum operator (or t-norm) and the total effect of operator T as the maximum operator (or s-norm) on the partially ordered set P of causal values. Formally let ~ be a causal concept space, and let e: ~ x ~ P be a fuzzy causal edge function, and assume that there are m-many causal paths from Ci to Cj: (i, k~…. k~, j) for 1 ~< r ~< m. Then let Ir (Ci, Cj) denote the indirect effect of concept Ci on concept Cj via the "r"th causal path, and let T (i, Cj) denote the total effect of Ci on Cj over all m causal paths. Then:

$$I\sim(C_i,C_j)=\min(w(C_p,C_{p+,}): (p,p+1) \sim (i, k\sim.....k,\sim j)) \quad (1)$$

$$T(C_i,C_j)=max(Ir(C_i, C_j)), \text{ where } l< \sim r<\sim m \quad (2)$$

Where p and p+1 are contiguous left to right path indices [58].

On the other hand, the dynamic analysis starts with an extracted model, as mentioned above, and an initial state of the corresponding system, representing weight matrix W and initial vector A0, respectively. A0 depicts the existing state of each concept in the modeled system.

The ultimate goal of dynamic analysis is to estimate the final state of these concepts under cause and effect relationships of the model. Thus, in order to achieve this goal, an iterative process is started and is used at each step for calculating the new value of concepts in Equation 3 [59],

$$A_i^t = f\left(\sum_{\substack{j=1 \\ j\neq i}}^{n} A_j^{t-1} W_{ji} + A_i^{t-1}\right) \tag{3}$$

Where, A_i^t is the value of concept Ci at time t, A_i^{t-1} the value of concept Ci at time t-1, A_j^{t-1} the value of concept Cj at time t-1, and the weight W_{ji} of the interconnection from concept Cj to concept Ci. The function f is a threshold function and to squash the result in the interval [60]. This value indicates that at which level this concept gets activated. The activation level can represent membership in the fuzzy set, describing linguistic measures of relative abundance (e.g., low, average, and high) [49]. Furthermore, the logarithmic sigmoid function is applied here to activate any concept's value, where $\omega > 0$ determines the steepness of the continuous function f as Equation 4:

$$f(x) = \frac{1}{1+ e^{-\omega(x)}} \tag{4}$$

3.2. Selecting experts and forming the panel

FCM graphs can be built from any kind of data that show causal relationships or with the support of a single expert or a panel of experts [61]. The output of this technique is highly relied on the quality of the input data. To improve the reliability and consistency of the final graph, using a panel of experts is recommended [62]. A heterogeneous panel is a group of people with the same knowledge but at different social or professional levels. [63]. Hence, to build our model, we used a panel of experts. The optimal number of participants depends on the features of the research. However, it is recommended that the greater the panel's heterogeneity, the fewer the number of participants.

Regarding the heterogeneity of our panel (project managers, clients, consultants, contractors, and operationa and maintenance contacrtors) and the fact that they have different professional degrees, this study did not aim for a large panel size (see Table 3 for demographics of the experts). In addition, our chosen experts had participated in different construction projects. This team composition guarantees that the selected participants have a profound knowledge of O&M barriers. Moreover, based on the FCM sample size's recommendations on the heterogeneous panel of experts [64, 65], 10 was set as our sample size. The panel size is similar to that of prior FCM studies [66-68].

Table 3. Demographics of the experts in the panel

Id	Role	Field	Characteristics
Expert1	Head of the Project management office	Client	12 years of experience Post-graduate in the field of construction Having direct cooperation in road construction projects
Expert2	Architectural Designer	Consultant	16 years of experience Undergraduate in the field of construction Having direct cooperation in the mass housing projects project
Expert3	Project manager	Contractor	14 years of experience Undergraduate in the field of construction Having direct cooperation in the infrastructure project
Expert4	Technical expert	Maintenance Contractor	10 years of experience Undergraduate in the field of construction Having direct cooperation in the road construction project
Expert5	Executive expert	Maintenance Contractor	20 years of experience Post-graduate in the field of construction Having direct cooperation in the construction project
Expert6	Executive expert	Maintenance Contractor	22 years of experience Undergraduate in the field of construction Having direct cooperation in the road construction project
Expert7	Executive Supervisor	Contractor	35 years of experience Undergraduate in the field of construction Having direct cooperation in the infrastructure project
Expert8	Head of Design Team	Consultant	32 years of experience Post-graduate in the field of construction Having direct cooperation in the road construction projects project
Expert9	Structural designer	Consultant	15 years of experience Post-graduate in the field of construction Having direct cooperation in the road construction project
Expert10	Technical expert	Maintenance Contractor	34 years of experience Undergraduate in the field of construction Having direct cooperation in infrastructure projects

To grasp a full view of O&M barriers, respondents from different planning, design, construction, and O&M phases are required, as these are the main concepts of O&M definition [69]. Throughout the panel making process, we aimed for field expertise (e.g., design, and operation and maintenance contractor) rather than affiliated bodies (e.g., employer and consultant). Accordingly, three experts are included in the design domain (Experts #2, #8, #9), and four experts with operation and maintenance experience (Experts #4, #5, #6, #10). Besides we included two project managers (Experts #1, #3) and one Executive Supervisor (Expert#7) for the sake of having multi-disciplinary experience in the panel (to include views on other areas than design and construction, such as planning, and maintenance). These multi-disciplinary experts are highly experienced in the field, each having at least 10-years of related experience. Above all, experts with both academic and practical knowledge and experience are included in this study, which facilitated explaining the method and weighting procedure.

The project examined in this study is a road project in Iran as a developing country. The Tehran-North road project aims to provide fast and cheap communication between the northern and central regions of Iran and facilitate communication with neighboring northern countries. The original plan was given in 1974. This project is a part of the North-South National Freeway, which is the shortest communication route between the Caspian Sea and the Persian Gulf and will play a major role in the region's transit. The length of the road is 121 km. The project has been delayed due to financial issues and problems between the parties to the contract, and these issues have caused its construction to take longer than the scheduled time. On the other hand, due to the large volume of activities, many domestic and foreign contractors are involved in this project. Therefore, it is necessary to study and resolve the existing obstacles together and take steps towards the project's success. The results of the research will be useful in future studies conducted by project managers and researchers.

3.3 Creating the FCM Model

To create the research model, 28 barriers were used as the model's first layer, 10 barriers' effects, as the second layer; and the three project failure modes (e.g., time, cost, and quality) as the third layer (see Figure 2). To model the interdependencies, at first, experts in the heterogeneous panel were asked to represent the interactions: a) between OMIOs, and b) between OMIOs and the effects, and then c) between the effects and project failure modes.

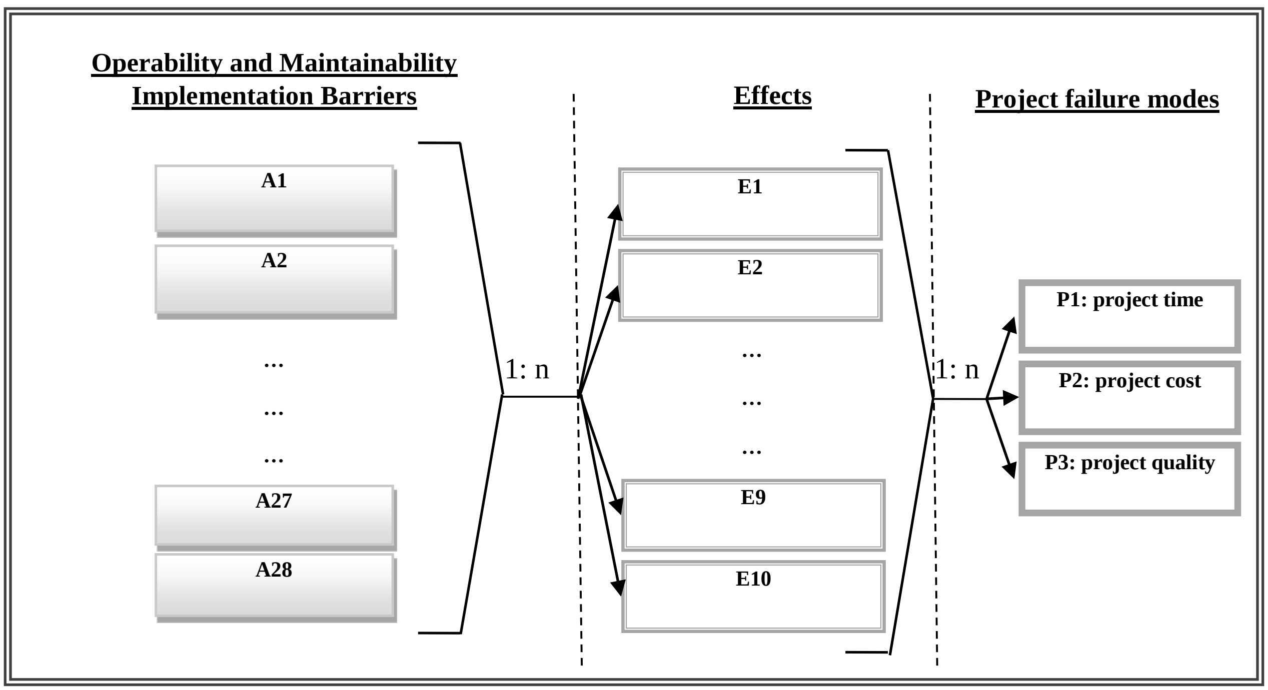

Fig 2. Operability and Maintainability Implementation Barriers, Effects, and Project Failure Modes

Table 4 shows the relationship between numbers and linguistic variables. Note that the relations are positive; meaning that changes at the level of the factor's exposure provoke changes in their effect factors in the same direction. In a similar vein, all direct connections are positive. Therefore, an increase at the level of one barrier makes the project failure more likely.

Table 4. Linguistic values and the mean of fuzzy numbers

Linguistic values	The mean of fuzzy numbers
Very high (VH)	1.00
High (H)	0.70
Medium (M)	0.50
Low (L)	0.30
Very low (VL)	0.10

4. FCM Results

Generally, there are two types of analyses in FCMs. The static analysis depicts each concept's overall effects on output ones; and dynamic analysis acts as an estimator of the final state of the system. Moreover, it allows investigating "what-if" scenarios by performing simulations of a given model from different initial state vectors [70], presented in the following.

4.1. Static Analysis

Based on the augmented adjacency matrix between barriers (Ai), effects (Ei), and project failure modes (Fi) (see Appendix 1, and Table 5), and Equations 1-4, the path effect from constructability barriers to effects (Ai~Ej) and from there to project failure modes (Ei~Fj) can be calculated. The results of the calculations are presented in Table 6.

Table 5. The link from barriers' effects (Ei) to project failure modes (Fi) (initial data)

	Time	**Cost**	**Quality**
E1	0.5	0.7	0.5
E2	0.3	0.5	0.5
E3	0.5	0.3	0.3
E4	0.9	0.9	0.5
E5	0.5	0.5	0.3
E6	0.5	0.5	0.5
E7	0.5	0.9	0.3
E8	0.9	0.5	0.3
E9	0.9	0.9	0.9
E10	0.5	0.5	0.1

Table 6. Indirect effects (based on FCM Max of Mins relations)

	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	Average* (indirect effects)	Average** (Initial effects)	FCM augmentation***
A1	0.1	0	0	0	0	0.1	0.1	0.1	0.1	0.1	0.06	0	0.06
A2	0	0	0	0	0.1	0	0	0	0	0	0.01	0	0.01
A3	0.1	0	0	0	0	0	0.1	0	0.1	0	0.03	0	0.03
A4	0.1	0.1	0.1	0.1	0.1	0	0.1	0	0.1	0.1	0.08	0	0.08
A5	0.1	0.1	0.1	0.1	0.1	0	0	0.1	0	0	0.06	0.03	0.03
A6	0.1	0.3	0.1	0.3	0.1	0	0	0.1	0	0.1	0.11	0.03	0.08

A7	0	0.3	0	0	0.3	0	0	0	0	0	0.06	0.01	0.05
A8	0	0.1	0	0.1	0.3	0	0	0	0	0	0.05	0.04	0.01
A9	0.1	0	0	0.1	0	0	0.1	0	0.1	0	0.04	0	0.04
A10	0.1	0	0.3	0	0	0	0.1	0.1	0.1	0	0.07	0	0.07
A11	0	0	0.3	0	0	0	0	0	0	0	0.03	0.03	0.00
A12	0	0.1	0.1	0.3	0	0.1	0	0.1	0	0.1	0.08	0.06	0.02
A13	0	0.1	0.1	0	0.1	0.3	0.5	0.3	0	0.3	0.17	0.08	0.09
A14	0	0.1	0.1	0	0.1	0	0.1	0.5	0.1	0.1	0.11	0.01	0.10
A15	0	0	0	0	0	0	0	0.1	0.1	0.1	0.03	0	0.03
A16	0	0	0.3	0	0	0.3	0.3	0	0.3	0.3	0.15	0.03	0.12
A17	0	0	0.1	0	0	0.3	0	0.3	0	0	0.07	0.06	0.01
A18	0	0	0	0.1	0	0.1	0	0.5	0.3	0.1	0.11	0.07	0.04
A19	0.3	0	0	0.1	0	0.1	0	0	0	0.1	0.06	0.04	0.02
A20	0.1	0	0	0	0.1	0	0.1	0.1	0	0.1	0.05	0.02	0.03
A21	0.3	0.1	0	0	0.3	0.3	0	0.3	0.3	0.1	0.17	0.03	0.14
A22	0.1	0.1	0.1	0.3	0.1	0.1	0.1	0.1	0.1	0.1	0.12	0.03	0.09
A23	0	0.1	0	0	0.3	0	0.1	0	0	0	0.05	0	0.05
A24	0	0.3	0	0.1	0	0	0	0	0	0	0.04	0.01	0.03
A25	0	0	0.1	0.1	0	0.1	0.1	0	0	0.1	0.05	0.01	0.04
A26	0	0.1	0.1	0.1	0.1	0.1	0.3	0	0	0.3	0.11	0	0.11
A27	0	0	0	0	0	0.1	0	0	0	0	0.01	0.01	0.00
A28	0	0.1	0.1	0	0.1	0.1	0	0.3	0	0	0.07	0.04	0.03

* Average based on indirect effects (based on FCM Max of Mins relations)
** Average based on Initial effects (direct relations, Appendix 1)
*** FCM augmentation= Average (indirect effects) – Average (Initial effects)

4.2. Dynamic Analysis

The purpose of the dynamic analysis is to investigate what-if analyses (scenarios) using different initial vector states. Each scenario analysis begins with setting an initial vector, i.e., initial situation or scenario. Here, five scenarios were applied by activating a set of specific barriers in each run. Indeed, scenarios describe events and situations that are likely to happen in practice. For instance, the first scenario relates to the condition under which only managerial barriers contribute to the model, and other barriers are deactivated. Likewise, scenarios 2-5 are related to organizational, human resource, technology, and project management sources of barriers, respectively. Any other set of barriers can also be activated to aid further interpretations. Finally, scenario 6 is run using the study case data. Table 7 illustrates the initial condition of each scenario with its value in the equilibrium point.

Table 7. Simulation results of the proposed scenarios

	Scenario#1, Managerial	Final State	Scenario#2, Organizational	Final State	Scenario#3, Human resource	Final State	Scenario#4, Technology	Final State	Scenario#5, project management	Final State	Scenario#6, our case	Final State
A1	1	0.000	0	0.307	0	0.283	0	0.275	0	0.276	0.9	0.301
A2	1	0.295	0	0.292	0	0.276	0	0.275	0	0.293	0.5	0.300
A3	1	0.282	0	0.292	0	0.306	0	0.000	0	0.286	1	0.301
A4	1	0.275	0	0.299	0	0.347	0	0.276	0	0.334	0.8	0.349
A5	1	0.275	0	0.293	0	0.309	0	0.293	0	0.300	0.7	0.309
A6	1	0.331	0	0.298	0	0.276	0	0.311	0	0.309	0.6	0.337
A7	1	0.288	0	0.310	0	0.296	0	0.000	0	0.286	0.5	0.307
A8	1	0.351	0	0.329	0	0.358	0	0.307	0	0.329	0.5	0.380
A9	0	0.293	1	0.314	0	0.313	0	0.286	0	0.289	0.8	0.331
A10	0	0.294	1	0.276	0	0.282	0	0.288	0	0.289	0.4	0.300
A11	0	0.309	1	0.329	0	0.298	0	0.276	0	0.311	0.6	0.334
A12	0	0.331	1	0.317	0	0.282	0	0.286	0	0.304	0.5	0.339
A13	0	0.282	1	0.321	0	0.323	0	0.276	0	0.292	0.9	0.328
A14	0	0.275	1	0.307	0	0.304	0	0.000	0	0.286	0.4	0.306
A15	0	0.300	1	0.289	0	0.311	0	0.282	0	0.323	0.6	0.338
A16	0	0.286	0	0.325	1	0.303	0	0.321	0	0.324	0.8	0.330
A17	0	0.301	0	0.308	1	0.310	0	0.276	0	0.275	0.5	0.316
A18	0	0.307	0	0.000	1	0.308	0	0.303	0	0.000	0.6	0.307
A19	0	0.293	0	0.299	1	0.304	0	0.000	0	0.000	0.7	0.302
A20	0	0.303	0	0.294	1	0.000	0	0.275	0	0.299	0.6	0.300
A21	0	0.277	0	0.341	0	0.305	1	0.000	0	0.000	0.7	0.335
A22	0	0.312	0	0.292	0	0.315	1	0.290	0	0.284	0.4	0.336
A23	0	0.288	0	0.302	0	0.281	1	0.275	0	0.282	0.4	0.300
A24	0	0.333	0	0.290	0	0.315	0	0.279	1	0.296	0.6	0.339
A25	0	0.294	0	0.285	0	0.286	0	0.289	1	0.000	0.7	0.301
A26	0	0.286	0	0.276	0	0.301	0	0.289	1	0.277	0.6	0.301
A27	0	0.275	0	0.303	0	0.312	0	0.276	1	0.304	0.8	0.312
A28	0	0.275	0	0.293	0	0.289	0	0.286	1	0.290	0.4	0.295
E1	0	0.300	0	0.284	0	0.286	0	0.289	0	0.000	0	0.300
E2	0	0.315	0	0.276	0	0.000	0	0.305	0	0.301	0	0.311
E3	0	0.282	0	0.299	0	0.290	0	0.276	0	0.298	0	0.303
E4	0	0.298	0	0.276	0	0.276	0	0.292	0	0.292	0	0.303
E5	0	0.305	0	0.283	0	0.275	0	0.306	0	0.281	0	0.311
E6	0	0.286	0	0.310	0	0.296	0	0.290	0	0.295	0	0.315
E7	0	0.282	0	0.307	0	0.309	0	0.305	0	0.305	0	0.316
E8	0	0.293	0	0.359	0	0.286	0	0.290	0	0.286	0	0.347
E9	0	0.294	0	0.303	0	0.296	0	0.000	0	0.000	0	0.303
E10	0	0.282	0	0.295	0	0.295	0	0.301	0	0.296	0	0.309
Time	0	0.365	0	0.485	0	0.555	0	0.403	0	0.467	0	0.706
Cost	0	0.369	0	0.522	0	0.525	0	0.446	0	0.434	0	0.716
Quality	0	0.352	0	0.395	0	0.453	0	0.389	0	0.374	0	0.575

A glance at the above table reveals that in scenario 1 (managerial), there are eight activated nodes (barriers) from A1 to A8, while the others are not activated in the first vector. Those activate challenges have much influence over the next ones. It is interesting to note that the findings show the significance of the managerial barriers to the presence of O&M contractors at the early stages of the projects. The A8 and A24 barriers- got higher effects of 0.351 and 0.333, respectively. It is then followed by A6, A12, and A22, the former ones are 0,331, and the latter one is 0.312. Concerning most affected barriers' impacts in the same scenario, the E2 (0.315) and E5 (0.305) got higher values. All the activated barriers contributed to failure modes as time (0.365), cost (0.369), and quality (0.352).

Not surprisingly, to bring the O&M contractors knowledge in the early phases of the projects prioritizing and clarifying the future O&M activities is more significant to other criteria. Despite the importance of O&M, barriers such as A8 "prioritization of budget, time or aesthetics and the environment by authorities" and A24 "lack of presenting a clear definition of maintenance content among the project's members through project management process" exists in projects that stakeholders are involved with them from the beginning to the end of the project [2, 8, 34]. It is stated that, in many projects, the O&M phases have the lowest level of significance, and thus they ignore its significance in the estimated cost [73]. On the other hand, these phases' funding is not enough due to the lack of total investment for infrastructure projects [74].

Generally, these actions make the O&M an expensive stage for the project lifecycle. As shown in the table, E2, "lack of understanding the O&M contractor's role in the project lifecycle" and E5, "reduction of flexibility, accessibility, and durability of the project" with mentioned numbers influence the managerial barriers most. Indeed, an essential part of the O&M process is stakeholders' cooperation and interaction and understanding the role of O&M contractors through efficient management. However, it is being neglected, and, in many cases, the last goals are not noticed by clients. Thus, its dire consequences will affect the lifecycle and, finally, the time, cost, and quality of the project. As mentioned, in the project lifecycle, O&M are important tasks, but at the early stages, like the design phase, experts do not pay attention to the needs of O&M tasks and how they should be carried out. As a result, accessibility to specific project components in the emergency will be faced with many problems [50].

Inactivated nodes in 'organizational' barriers as <u>scenario 2</u> are from A1 to A8, and from A16 to A28, while the others are activated barriers. By far, the most significant challenges in the initial vector are A21, A8, A11, and A16, with 0.341, 0.329, 0.329, and 0.325, respectively. The higher values in the effects section belonges to E8 (0.359) and E6 (0.310). All the activated barriers contributed to failure modes as time (0.485), cost (0.522), and quality (0.392).

A21 "lack of designer's experience and awareness about the maintenance and the problems caused by design" A8 "prioritization of the budget, time or aesthetics and environment by the authorities", A11 "the existed boundaries between different stages of the project team", and A16 "unwillingness to cooperate and give feedback to other stages of the project" are factors influenced by organizational factors. From the information provided in various resources, most of the problems at the final stages are driven by the decisions made at the initial stages. Based on them, the designers make decisions without noticing all aspects of O&M, and as a result, many problems ensue from their actions [8, 49, 52]. Despite the traditional thoughts, clients, and other parties' cooperation leads to reduce many significant issues as their knowledge and experiences will prevent unpredicted problems in projects [12].

A glance at the table provided in the effects section reveals the items that affect the mentioned topic. They include E8 "reduction of designing and planning for O&M, inferior construction, and inefficient maintenance planning" and E6 "reduction of mutual trust among various stakeholders". To have a successful project, all parties should work together to reduce costs and reworks by sharing their knowledge and experiences. Although this fact is important, we see that many people are reluctant to do this job for many reasons as there is no mutual trust between stakeholders, and they may be afraid of being eliminated by other competitors in the project. Thus, O&M planning and inferior construction will ensue from them [51, 53]

Activated nodes in the 'human Resources' barriers as <u>scenario 3</u>, are from A16 to A20, while the others are inactivated barriers. From the information provided, it is evident that significant challenges in the initial vector are A8, A4, and A13, with 0.358, 0.347, 0.323, respectively. In the lower section of the table, the higher values belonged to E7 (0.309) and E6, 9 (0.296). All the activated barriers contributed to failure modes as time (0.555), cost (0.525), and quality (0.453).

In some studies, human behavior is a critical issue to project success, so paying attention to this item is necessary [75]. In a study conducted by Omonyo [76], it was stated that a fundamental challenge in any project is identifying the right people and choosing them for the project team. On the other hand, for the organization to succeed, recognizing individuals and experts' behaviors is a fundamental need, and managers equipped with this knowledge can complete the project on time and within the determined budget. The project manager also plays a significant role and can gather all people from various stages of the project together. Under this condition, team members will have better communication and responsibility [2, 45]. Overally, better delivery will result in cooperation. A8 "prioritization of the budget, time or aesthetics and environment by the authorities" and A4 "inappropriate contract strategies", A13 "using the employer's opinions and ideas by design team regardless of standards", are the factors influenced by human resources. Human resource factors are most vulnerable to the E7 "increased maintenance workloads", E6 "reduction of mutual trust between various stakeholders", and E9 "reduction of project performance". Transferring data inappropriately among various stages of the project has dire consequences like reworks and changes. So, as a result, operation and maintenance stages will face workloads due to the inappropriate design and then construction phases. Reduction of cooperation among various stakeholders in a project results from the lack of trust between working groups in the management and financial problems [20]. Overally, these factors have a significant influence on time, cost, and quality of the project.

A glance at scenario 4 (technology) shows that there are five activated nodes (barriers) from A21 to A23, while the others are not activated in the first vector. Those activate challenges have much influence over the other ones. It is interesting to note that the findings show the significance of the technical barriers to the presence of O&M contractors at the early stages of the projects. The A16 and A6 barriers got higher effects of 0.321 and 0.311, respectively. It is then followed by A7 and A8, the former ones are 0,307, and the latter one is 0.303. Concerning most affected barriers' effects in the same scenario, the E5 (0.306) and E2 and 7 (0.305) got the higher values. All the activated barriers contributed to failure modes as time (0.403), cost (0.446), and quality (0.389).

Although the significance of sharing O&M knowledge and experiences in order to reduce the total cost of the project and its better performance, people are not willing to do this because of various reasons [53]. Moreover, one of them is traditional contracts and procurement methods, as the responsibility of the bodies is not integrated, and all of them do their jobs separately without any cooperation and interaction. On the other hand, many O&M contractors are afraid of their competitors and reduction of the total profit of the project, so they are reluctant to share their knowledge and experiences with others [12]. As it is apparent from barrier number A16 "Unwillingness to cooperate and give feedback to other stages of the project", people in a project do not show interest in working with other stages, and some of its reasons were mentioned above. The other remained challenges in this category more influenced by technology are, A6 "lack of attention of the authorities for coordination between the various stages of the project", A 7 "wrong judgment of ultimate goals of maintenance and project among stakeholders", and A8 "prioritization of the budget, time or aesthetics and environment by the authorities". In fact, the lack of maintenance data is an issue that affects the function of designers' activity and final performance, and due to the mentioned problem, maintainability criteria are not frequently considered at the early stages; subsequently, their definition and goals are completely different [26].

Technology factors are most affected by the E5 "Reduction of flexibility, accessibility, and durability of the project", E2 "Lack of understanding the O&M contractor's role in the project lifecycle", and E7 "Increased maintenance workloads". Prior research shows that the main problem in the projects is because of the differences between design and measured performance [12], and poor coordination and communication [2]. Furthermore, due to the O&M definitions, they are a design quality that the projects are kept in their good condition and functional state, besides the facilities that are readily available and efficient in the manner of accessibility and flexibility. Any situation on the opposite of the mentioned definition has meant that the goal of O&M cannot be fully implemented, and therefore increasing cost, time, and reworks are its dire consequents [20].

In scenario 5 'Project Management' activated barriers (nods) in the first vector are from A24 to A28. According to the table, the mentioned activated barriers have a strong influence over the other deactivated barriers. A4 (0.334), A8 (0.329), and A16 (0.324), respectively got the higher effects. E7 (0.305), and E2 (0.301) are the most affected challenges' effects in this scenario. All the activated challenges contributed to failure modes as time (0.467), cost (0.434), and quality (0.374).

A4 "inappropriate contract strategies", A8 "prioritization of the budget, time or aesthetics and environment by the authorities", and A16 "unwillingness to cooperate and give feedback to other stages of the project" are the factors influenced by the project management factors. The inappropriate form of contracts will cause less relationship and cooperation between individuals involved in a project, and as a result, they are not willing to share any data and information. While a contract is a way to reach success in a project, and ensures that all parties acquire benefits and returns [21, 54, 77]. Moreover, a strong project manager in a project will reduce many claims and conflicts among stakeholders. It is important to understand the project manager's overall responsibility for the successful planning, execution, and his/her abilities and skills to solve all the problems. However, the results are shown that this role is not considered in many cases [12]. So, the projects will suffer cost and time overruns, and poor quality. A glance at the table provided in the effects section reveals the items which have the most effect on the mentioned topic. They include E7 "increased maintenance workloads" and E2 "lack of understanding the O&M contractor's role in the project lifecycle". Utterly, all these contribute to time and cost overruns and poor quality.

As it is apparent from Table 7, in scenario 6 (our case scenario), there are all activated nodes (barriers), while in the others factors from 1 to 5, there are not activated nodes like the first vector. The A8 and A4 barriers got higher effects of 0.380 and 0.349, respectively. It is then followed by A24, and A12 with the same degree, 0,339. Concerning most affected barriers' effects in the same scenario, the E8 (0.347) and E2 (0.311) got higher values. All the activated barriers contributed to failure modes as time (0.706), cost (0.716, and quality (0.575). It is interesting to note that the findings show that the effects of these items on time, cost, and quality are more prominent in our case scenario than other factors.

In the investigated case in this study, none of the barriers are controlled by the project managers, and this may lead to many issues and overruns. In fact, because of the less attention to the items like inappropriate contract strategies and prioritization of the budget, time, or aesthetics and environment by the authorities, the project has faced critical issues. The applied contract has a potent influence on building trust among all parties, as it helps solving the problems and improves savings [50]. Another issue here is that currently, project stakeholders assume that if they decrease the budget for planning efficient O&M is better for their final goals; however, this action is not true due to the higher cost of changing at the final stages of the project. Indeed, they do not pay attention to the O&M needs at the early stages, and finally, this may cause more duplications and reworks [28, 37]. As a consequence, the total cost will arise from neglecting the O&M. Our case study is most vulnerable to the E8 "Reduction of designing and planning for maintainability, inferior construction, and inefficient maintenance planning", E2 "Lack of understanding the O&M contractor's role in the project life- cycle". Lack of knowledge of O&M benefits will cause increasing costs, duplications, and many other problems that make a project unsuccessful.

5- Conclusion

This research aimed finding the O&M barriers at the early stages of projects, and for this purpose, a in-depth review of literature has been conducted. The results of the study included 28 barriers to integration between the project's stages, which are included in five general categories. The importance of this research is that it is one of the first studies on the use of the FCM method to investigate the existing challenges of O&M. The results of this method can be used to analyze, simulate, and test the effects of barriers, as well as predict their effects on the final success or failure of the project. At first glance, the findings of the FCM analysis show that some of the barriers are reinforced compared to others. For example, the A14 "Limited budget", A16 "Unwillingness to cooperate and give feedback to other stages of the project", A21 "Lack of designer's experience and awareness about the maintenance and the problems caused by design", and A26 "Poor relationship and communication among various stakeholders" are the discussed barriers in the FCM findings.

In order to conduct what-if analysis, six scenarios were followed in this study. Scenario 1 examined the conditions under which management barriers have affected this model. Organizational barriers, human resources, technology, and project management are 2-5 barriers, respectively. Finally, the real data obtained from the reviewed study of the project in scenario 6 was obtained, which was analyzed in the previous sections of the results obtained from it. Enabling the formal analysis of O&M barriers and their role in the project's success or failure is the study's contribution. All parties in the academic and industry will benefit from its findings to reduce the challenges and problems of such projects. The clients in the industry can recognize the barriers in advance. Through this study, they can find out which factor is associated with their projects. Thus, it is easier to take action to mitigate its effects. On the other hand, the project stakeholders can understand how their cooperation positively impacts the project's success. This work contributes to existing knowledge by providing a comprehensive existed barrier in the road projects for entering the O&M contractors to the early stage of the project. This new understanding will help academics to improve the significance of the O&M in projects.

This study suffers from some limitations. At first, this research may not be sufficiently comprehensive to cover all the barriers to the presence of O&M contractors in projects, and there may be barriers that have not been fully explored. The second limitation was relying on experts' judgments to create an FCM model, resulting in high density and lack of sparsity. This problem moves the model toward overfitting in which the FCM never converges or traps in a constant point regardless of its starting state. The researchers tackled this limitation by sharing the judgments with the panel members as a decision criterion to keep the FCM's weight matrix sparse (with several zero weights) and putting lower weights on it. Third, because of the cross-sectional nature of this study (the required data to create the FCM model were verified at one specific point in time), the researchers were unable to fully understand the dynamics of the underlying concepts in the long run. Fourth, the FCM does not provide the level of significance of the interdependencies among the variables. The fifth limitation of this study is that the researchers cannot be so confident to generalize the obtained results to other contexts since the interrelationships are extracted and interpreted for a limited context.

As a potential for future works, the proposed model can be used in other contexts to test its applicability. Researchers may also follow qualitative research methods such as case studies or other quantitative methods to investigate O&M barriers' interrelationships in similar or other settings. It is further suggested for future studies that other dimensions of the project, in addition to cost, time, and quality, such as risk, resource supply, or stakeholder satisfaction, be quantitatively and dynamically assessed. Implementing the same approach with a focus on different project phases will also lead to interesting results. Therefore, another suggestion is to evaluate the existing obstacles with the FCM method in the project life cycle. In addition, experts' suggestions should also be considered to find solutions to resolve these obstacles. Analyzing each of the factors highlighted in this study's results can be useful in resolving these obstacles.

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Appendix 1. The effects among O&M barriers and their effects

Id	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20	A21	A22	A23	A24	A25	A26	A27	A28	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
A1	0	0.1	0	0	0	0	0	0	0.1	0	0	0	0	0.1	0	0	0.1	0	0.1	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A2	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A4	0	0	0	0	0.1	0	0	0	0	0	0	0.1	0	0	0.5	0	0	0	0	0	0	0.1	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0.3	0	0	0	0	0	0.1	0.1	0	0.1	0	0	0	0	0
A6	0	0	0	0	0	0	0	0.1	0.3	0	0	0.3	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0
A7	0	0.1	0	0	0	0.5	0	0.5	0	0.3	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0
A8	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0.1	0	0	0.3	0	0	0	0	0
A9	0	0	0.1	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0.5	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A10	0	0.3	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0	0	0.3	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0
A12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.1	0.3	0	0	0	0	0	0.1
A13	0.1	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0.1	0	0	0	0	0.3	0	0	0	0	0	0	0.5	0	0	0.3
A14	0	0	0	0	0.1	0	0	0	0	0	0	0	0.1	0	0	0	0	0.5	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0.1	0	0	0
A15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A16	0.1	0	0	0.3	0	0	0	0	0.5	0	0.3	0	0.3	0.1	0	0	0	0	0	0	0.3	0	0	0	0	0.1	0	0	0	0	0	0	0	0.3	0	0	0	0
A17	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0.3	0	0
A18	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0.5	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0.5	0.1	0.1
A19	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0.3	0	0.1	0	0.3	0	0	0	0	0	0	0	0	0.1
A20	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0.3	0	0	0	0.1	0	0	0	0.3	0	0	0	0	0.1	0.1	0	0	0	0	0	0	0.1	0	0
A21	0	0	0.1	0	0	0	0.1	0.7	0	0	0	0	0	0	0	0	0.3	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0
A22	0	0	0	0	0	0	0.1	0	0	0	0	0.5	0.1	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0.1	0	0.1	0
A23	0	0	0.3	0	0	0.1	0	0.3	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
A24	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0.1	0	0	0	0	0	0
A25	0	0	0	0	0	0	0	0	0	0	0.1	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0.1	0	0	0	0	0	0
A26	0	0	0	0.1	0	0	0.3	0	0	0	0	0.1	0.3	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0.5	0	0	0	0	0	0	0	0	0	0	0
A27	0	0	0	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0.1	0	0	0	0
A28	0	0	0	0	0.1	0	0	0	0	0.1	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0.3	0	0

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