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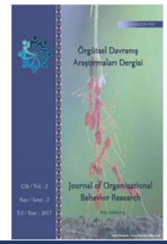

PROJECTS RANKING MODEL USING FAHP TECHNIQUE AND RESOURCE ALLOCATION WITH SYSTEM DYNAMICS (SD) APPROACH

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ABSTRACT

Project ranking is one of the most important issues to fulfil project management objectives. The project ranking plays a vital role for completion of any project. The aim of this paper is to ranking project with 8 main criteria in pmbok 2021(MCDM), mathematically by using a multi-criteria method in order to assist project managers in decision-making. The fuzzy Analytic Hierarchy Process (FAHP) is selected with the use of trapezoidal fuzzy numbers for pairwise comparison scales in prioritizing projects in managing projects. Utilizing the fuzzy FAHP technique can facilitate uncertainty in doing evaluation. In this study, demonstrates how uncertainty in making evaluation of multiple criteria can be solved by using fuzzy method AHP [6, 12]. In other words, prioritizing projects is the basis for their successful execution, and it is a strategy that allows us to align our projects with the strategic objectives of our organization. Weak prioritization leads to project failures and ultimately results in the loss of business goals. Prioritizing projects enables us to not only deliver projects more successfully but also, by combining it with a System Dynamics approach, allocate time, cost, and resources in the best possible way[4, 15,18]. This helps in controlling deviations from the accumulation of irreparable consequences, preventing the accumulation of problems resulting from errors and deviations at the end of the project. It allows us to align project execution with the organization's strategy and objectives. Additionally, we manage resource allocation considering the constraints governing the project environment.

Keywords: *Project Management, Fuzzy Analytic Hierarchy Process (FAHP), System Dynamics(SD), Multi-Criteria Decision Making (MCDM), Continuous System Simulation(CSS), System Thinking.*

INTRODUCTION

Decision-making in prioritizing projects context is resource allocation and complicated project. [3]. Project management is the application of knowledge 8 main project criteria in pmbok 2021 necessary to achieve the project's requirements. It is an approach to handling resources in order to accomplish specific project objective successfully as well as it is a way to implement the strategies of project management [5,9]. A successful project management can then be defined as achieving a continuous stream of project objectives 8 main project criteria in pmbok 2021, at the desired performance and utilizing the assigned resources effectively and efficiently, and having the results accepted by the customer and stakeholders [12].

This paper focuses on Project ranking of project management using a MCDM model, specifically the Fuzzy Analytic Hierarchy Process (FAHP) technique. Fuzzy set theory deals with the vague information by using the fuzzy numbers and changing vague information into useful data [11]. The Fuzzy AHP applies fuzzy aggregation operators and fuzzy arithmetic in order to address the hierarchical structure of the multi-criteria problems [10, 12]. This paper demonstrates the application of Fuzzy AHP for prioritization of project with main criteria (MCDM) in handling project management.

After prioritizing projects, it is essential to allocate resources with a System Dynamics approach. Utilizing project ranking and embracing a Systems Thinking perspective, a project manager's most crucial abilities come into play[14,17]. Through this, we can:

1. Align projects with the organization's strategy.
2. Balance the workload of the projects we are responsible for by delivering them effectively.
3. Allocate resources to projects that create value for the organization.
4. Prevent deviations from the plan and avoid accumulating problems at the end of the project.
5. According to studies from the Project Management Institute (PMI), projects aligned with the organization's strategy have a 57% higher chance of success.
6. A prioritized list of projects signifies effective resource allocation for the organization.
7. In general, project prioritization is a process that helps us understand which projects are more important. Consequently, we allocate our resources for the successful delivery of projects that create value for the organization. Due to resource constraints, it is necessary to rank them using a robust technique based on valid and standard criteria. Then, allocate time, cost, and resources to the projects and plans accordingly. In this study, we utilize the Fuzzy Analytic Hierarchy Process (FAHP) technique.
8. The absence of a systemic perspective in project management leads to increased costs and project duration. Additionally, not calculating delays and not timely addressing problems resulting from delays will ultimately lead the project to failure. Static approaches in modeling (such as discrete event simulation methods) often disregard all system interactions due to the lack of system thinking. In other words, static approaches in modeling fail to consider problems arising from unforeseen side effects of past operations. Therefore, the problem-solving strategies derived from this approach are often piecemeal and not only fail to solve the issues but may also lead to more significant problems in the near future.
9. A project is a complex system that involves several interactive feedback processes. Feedback processes are essential elements in System Dynamics in project management.
10. Unlike the static approach, the System Dynamics approach to project management provides a holistic view of the project by determining the role of each project variable and simulating their effects. It aims to provide suitable strategies in different conditions.

System Dynamics is an object-oriented simulation method that helps understand issues in complex and dynamic systems.

In this study, we will prioritize projects using the Fuzzy Analytic Hierarchy Process (with 8 criteria based on the standard of the Project Management Institute). We will also examine its advantages over other prioritization methods, aiming to answer the main hypothesis regarding the relationship between system thinking and problem-solving during project execution. Finally, using a modeling process with a System Dynamics approach and solving it using Vensim software, we will simulate and analyze the model.

Literature Review

The following methods have been used for prioritizing projects:

Scoring Model

One of the most common methods for project prioritization is scoring. This technique relies on the opinions of experts and stakeholders in the business domain, often within the company's team. Various criteria such as project profitability for the company, risk level, and similar factors are considered. The opinions of team members regarding all projects are then reviewed based on these criteria. Each project will have a numerical value, and project prioritization will be done accordingly.

Project Prioritization Matrix

In this method, various criteria are compared in a matrix, and in the end, the combined impact of all variables on project prioritization is considered.

Payback Period

This method focuses more on the potential for capital return and achieving profit in a short period. In essence, this method prioritizes projects based on how quickly they can be profitable. This technique is mostly used when seeking to recover the investment in the business.

MoSCoW Method

This method is used to achieve results that align with stakeholder requirements. It involves precise classification of stakeholder requirements while facing constraints. It can prioritize the most essential requirements. Extra elements are eliminated, and elements in projects are considered based on their highest impact on project success.

Kano Model

This model in project management primarily focuses on the satisfaction of users and customers. In this model, items affecting user satisfaction are prepared in a questionnaire, and the results obtained will be related to the level of user satisfaction. In this model, all user requirements are prioritized.

Priority Scale Method

In this method, in addition to considering stakeholder requirements, factors such as legal obligations or the necessary capabilities for project execution are taken as the main steps in this method.

Voting Method

In this technique, all members of the organization can participate in a completely fair and pressure-free prioritization process of projects through a vote. It is better to collect votes anonymously so that the results are entirely based on individuals' own ideas. Each person gives projects a rating from 1 to 10, and in the end, the result of this voting can indicate the priorities.

RICE Technique

In this technique, the following criteria are considered as the main criteria for prioritization:

- Reach: Indicates the number of people and events that will be affected by a project.
- Impact: Specifies the contribution of each feature in a product or project.
- Confidence: Represents this metric as a percentage, which is a reduced Impact.
- Effort: Defines the amount of energy and focus required by employees on a project.

The main advantage of this technique is that it is more useful and engaging for employees to make decisions for prioritizing projects. Its major drawback is its time-consuming nature and existing complexities.

Eisenhower Matrix

This technique uses a time management matrix with four areas to achieve long-term success:

- Urgent and Important
- Urgent but Not Important
- Important but Not Urgent
- Neither Urgent nor Important

In this research, we will prioritize projects and allocate resources using the comprehensive 8-criteria approach of the Project Management Institute (PMI) along with the application of Fuzzy Analytic Hierarchy Process (FAHP) technique. We will simulate the actual project environment, addressing plans and projects. Additionally, with a Systems Dynamics (SD) approach, we will dynamically schedule the project, allocate resources, and calculate errors and delays, effectively preventing the accumulation of issues at the end of the project[4, 15].

Recent investigations indicate that over 50% of large-scale projects are unable to meet their objectives in terms of cost and scheduling, ultimately facing failure. In the System Dynamics approach, the project manager makes strategic decisions in the project design phase with a systems thinking perspective. They subsequently guide operational decisions in that direction. Implementing systems thinking in project management not only involves understanding the relationships between different components and work sequences within their domain, but also allows managers and analysts to examine how a consequence or decision affects the overall project performance[16].

In this research, we will employ the Fuzzy Analytic Hierarchy Process technique for project prioritization. Furthermore, using a Systems Dynamics approach, we will dynamically model project scheduling, resource allocation, and analyze errors and delays. Through this, by efficiently allocating resources throughout the project with a System Dynamics and system thinking approach, we will prevent the accumulation of issues at the project's end. Consequently, there will be no sudden need for resource reallocation and time extension. The project manager will thereby achieve the stakeholders' requirements within the specified time, eliminating the possibility of project failure.

MATERIALS AND METHODS

The project evaluation process with FAHP and Delphi

1-constructing the hierarchical structures

2-determining criteria of project evalution

3-determining the evaluation criteria weights

4-evaluating and ranking project

5-resource allocation to project base on step 4 with system dynamic(SD)

In this research, prioritizing projects and allocating resources will be considered as a multi-criteria decision-making problem (MCDM), employing the Fuzzy Analytic Hierarchy Process (FAHP) technique in 9 steps for prioritization. Finally, time, cost, and resources will be allocated to plans and projects (project management) using the System Dynamics (SD) approach.

Multi-Criteria Decision Making (MCDM) approaches have a considerable benefit over conventional decision. This approach can evaluate a variety of alternatives based on several important criteria that need in project management [11, 12]. Additionally, most MCDM methods have the capability to analyze together both qualitative and quantitative assessment criteria. Based on the literature, FAHP method is the most popular technique utilized for dealing with decision-making problems. The main characteristic of this technique is the use of pairwise comparisons that is by comparing the alternatives based on a variety of criteria [6, 12]. The use of pairwise comparisons is a vital role of the prioritization procedure in FAHP, which provides a rational framework for organizing a decision problem. The pairwise judgments in this technique are structured in a pairwise comparisons matrix, and a prioritization procedure is implemented to draw a corresponding priority vector [9, 10]. In this paper, FAHP was used to assess the main criteria in evaluating project management which are 8main criteria based PMBOK2021.

Fuzzy Analytic Hierarchy Process (FAHP) USED to understand mathematical calculations when compared with other MCDM methods, FAHP is more suitable to conduct a hierarchical rating [3, 12].

The primary application of the System Dynamics (SD) method is to identify feedback processes that, along with stock structures, flows, and time delays, determine the dynamic behavior of the system. Stocks and flows are the main components of the System Dynamics method that demonstrate effective interaction between variables in complex systems. The System Dynamics approach (Continuous Event Simulation method) provides a more detailed view of interactions between system components,

and therefore can play an influential role in project managers' decision-making. This approach can also qualitatively represent interactions and has a close relationship with problem-solving structure and causal loop diagrams [6, 7].

Step 1: Construct the fuzzy criteria matrix ($\tilde{C}$) and then decompose it into four crisp matrices:

C_U و C_n و C_m و C_L

Step 2: We convert the four crisp matrices obtained from Step 1 into equivalent fuzzy linear equations using the following relationships. [12]

$\tilde{c}_l = 2\,C_L + C_m$

$\tilde{c}_m = C_L + 2\,C_m$

$\tilde{c}_n = 2\,C_n + C_u$

$\tilde{c}_u = C_m + 2\,C_u$

Step 3: The following equations are used to calculate the eigenvalues λ_u, λ_n, λ_m, and λ_L.

$\tilde{\lambda}_l = 2\,\lambda_L + \lambda_m$

$\tilde{\lambda}_m = \lambda_L + 2\,\lambda_m$

$\tilde{\lambda}_n = 2\,\lambda_n + \lambda_u$

$\tilde{\lambda}_u = \lambda_m + 2\lambda_u$

Step 4: Calculate the eigenvectors W_u, W_n, W_m, and W_L from matrices C_u, C_n, C_m, and C_L, and then normalize them using the following equations: [1]

$$W_L = \frac{W_L\ \lambda_L}{\sum_z^n W_{il}\,\lambda_m}, W = \frac{W_m}{\sum_{i=1}^n W_{im}}, W_n = \frac{W_n}{\sum_{i=1}^n W_{in}}, W_u = \frac{W_u\ \lambda_u}{\sum_{i=1}^n W_{iu}\,\lambda_m}$$

Step 5: Calculate the Consistency Index (CI) and Consistency Ratio (CR) for matrix Cm using the following equations: [6]

$$CI = \frac{\lambda_m - n}{n - 1}, CR = \frac{CI}{RI}$$

CR should be less than or equal to 0.1 in order to claim that the pairwise comparison matrix is consistent (non-contradictory) and the calculated RI is a random consistency index. [6]

The RI used for calculating random consistency depends on the size of the matrix.

The table of RI values calculated by Saaty is recommended for use. [6]

Step 6: Calculate the set of fuzzy priority matrices P_u, P_n, P_m, and P_L, which include the normalized eigenvectors W_u, W_n, W_m, and W_L corresponding to the criteria, in comparison with each criterion.

Step 7: Calculate the overall priority vectors g_u, g_n, g_m, and g_L, which are calculated according to the following equations.

$$\tilde{w}_l^T = [W_{1L}, W_{2L}, \dots, W_{nL}]^T$$

$$\tilde{w}_m^T = [W_{1m}, W_{2m}, \dots, W_{nm}]^T$$

$$\tilde{w}_n^T = [W_{1n}, W_{2n}, \dots, W_{nn}]^T$$

$$\tilde{w}_u^T = [W_{1u}, W_{2u}, \dots, W_{nu}]^T$$

$$g_L = \tilde{p}_l \, \tilde{w}_l = [g_{1L}, g_{2L}, \dots, g_{mL}]^T$$

$$g_m = \tilde{p}_m \, \tilde{w}_m = [g_{1m}, g_{2m}, \dots, g_{mm}]^T$$

$$g_n = \tilde{p}_n \, \tilde{w}_n = [g_{1n}, g_{2n}, \dots, g_{mn}]^T$$

$$g_u = \tilde{p}_u \, \tilde{w}_u = [g_{1u}, g_{2u}, \dots, g_{mu}]^T$$

Step 8: Calculate the expected values (fuzzy averages) and standard deviations using the following equations: [2, 3]

$$g_{i,e} = \frac{g_{iu}^2 + g_{in}\, g_{iu} + g_{in}^2 - g_{il}^2 - g_{il}\, g_{im} - g_{im}^2}{3(g_{iu} - g_{il} + g_{in} - g_{im})}$$

$$6_i = \left[\frac{g_{iu} \cdot (g_{iu}{}^2 + g_{iu}\, g_{in} + g_{in}^2) + g_{in}^3 - g_{im}^3 - g_{il}\,(g_{il}^2 + g_{il}\, g_{im} + g_{im}^3) - (g_{il}^2)}{6(g_{iu} - g_{il} + g_{in} - g_{im})}\right]^{1/2}$$

$$CV_i = \frac{6i}{g_{ie}} \qquad i = 1, 2, \dots, m$$

Step 9: Modeling Project Management with a Systems Dynamics Approach:

After prioritizing the projects, we move on to allocating time, cost, and resources for project execution with a system dynamics perspective. In this regard, to prevent the accumulation of errors and deviations from the objectives, we simultaneously calculate errors and deviations during project execution. Using the system dynamics model, we address and rectify them, thereby preventing their accumulation and the problems arising from them.

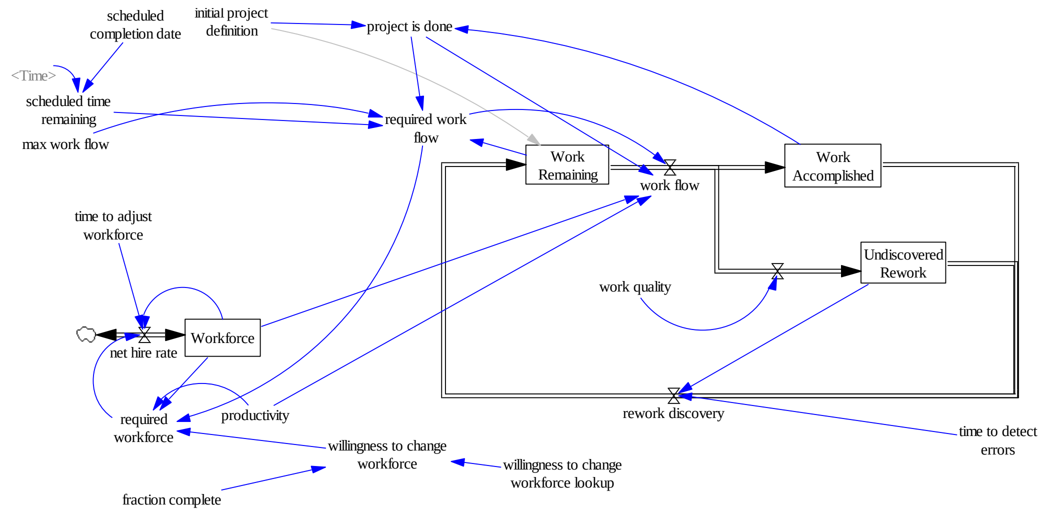

Figure 1. Project Management Model with a System Dynamics Perspective

(01) FINAL TIME = 24

Units: Month

The final time for the simulation.

(02) fraction complete=0.1

(03) initial project definition=1000

Units: Drawing

(04) INITIAL TIME = 0

Units: Month

The initial time for the simulation

(05) max work flow=500

Units: Drawing/Month

(06) net hire rate=(required workforce - Workforce)/time to adjust workforce

Units: person/Month

(07) productivity= 1

Units: Drawing/person/Month

(08) project is done= IF THEN ELSE(Work Accomplished >= initial project definition,1,0)

Units: Dmnl

(09) required work flow=

IF THEN ELSE(project is done,0,XIDZ(Work Remaining,scheduled time remaining

,max work flow))

Units: Drawing/Month

(10) required workforce=

IF THEN ELSE(Workforce<requiredwork flow/productivity,willingness to change workforce

*required work flow/productivity

+ (1-willingness to change workforce)*Workforce,required work flow/productivity)

Units: person

(11) rework discovery= Undiscovered Rework/time to detect errors

Units: Drawing/Month

(12) SAVEPER =

TIME STEP

Units: Month [0,?]

The frequency with which output is stored.

(13) scheduled completion date=10

Units: Month

(14) scheduled time remaining= MAX(0, scheduled completion date-Time)

Units: Month

(15) TIME STEP = 0.03125

Units: Month [0,?]

The time step for the simulation.

(16) time to adjust workforce=2

Units: Month

(17) time to detect errors=3

Units: Month

(18) Undiscovered Rework= INTEG (work flow*(1-work quality)- rework discovery, 0)
Units: Drawing

(19) Willingness to change workforce= willingness to change workforce lookup (fraction complete)

(20) willingness to change workforce lookup([(0,0)-(10,10)],(0,1),(0.5,0.8),(0.8,0),(1,0))

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(21) Work Accomplished= INTEG (work flow-rework discovery, 0)

Units: Drawing

(22) Work flow= IF THEN ELSE (project is done, required work flow, Workforce*productivity)

Units: Drawing/Month

(23) Work quality=0.9

Units: Dmnl

(24) Work Remaining= INTEG (rework discovery-work flow, initial project definition)

Units: Drawing

(25) Workforce= INTEG (net hire rate, 0)

Units: person

Case Study

Prioritizing projects using the Fuzzy Analytic Hierarchy Process (FAHP) technique and allocating resources with a System Dynamics and System Thinking approach.

First, we'll start by presenting the table that converts linguistic variables into fuzzy equations and the 8 criteria as follows:

Table 1. Fuzzy Equations of Linguistic Variables

Linguistic Variable	Fuzzy Number	Fuzzy Number inverse
Equal	$\tilde{1} = (1,1,1.5,2)$	$\tilde{\mathbf{1}}^{-1} = (\frac{1}{2}, \frac{1}{1.5}, 1, 1)$
Slightly more	$\tilde{2} = (2,2.5,3.5,4)$	$\tilde{\mathbf{3}}^{-1} = (\frac{1}{4}, \frac{1}{3.5}, \frac{1}{2.5}, \frac{1}{2})$
Much more	$\tilde{5} = (4,4.5,5.5,8)$	$\tilde{\mathbf{5}}^{-1} = (\frac{1}{8}, \frac{1}{5.5}, \frac{1}{4.5}, \frac{1}{4})$
Very much more	$\tilde{7} = (6,6.5,7.5,8)$	$\tilde{\mathbf{7}}^{-1} = (\frac{1}{8}, \frac{1}{7.5}, \frac{1}{6.5}, \frac{1}{6})$
Absolutely more	$\tilde{9} = (8,8.5,9,9)$	$\tilde{\mathbf{9}}^{-1} = (\frac{1}{9}, \frac{1}{9}, \frac{1}{8.5}, \frac{1}{8})$

$$\tilde{\mathbf{2}}, \tilde{\mathbf{4}}, \tilde{\mathbf{6}}, \tilde{\mathbf{8}} = (\boldsymbol{x} - \mathbf{1}, \boldsymbol{x} - \mathbf{0.5}, \boldsymbol{x} + \mathbf{0.5}, \boldsymbol{x} + \mathbf{1})$$

The selected criteria for prioritizing projects and initiatives, based on the PMBOK-2021 standard, are as follows:

1. Attention to Stakeholders

2. Project Team
3. Project Life Cycle Approach
4. Planning
5. Work and Project Scope
6. Deliverables
7. Preparedness for Uncertain Conditions
8. Measurability

The objective of this research is to rank and select the best project among several options using the Fuzzy Analytic Hierarchy Process (FAHP) technique, and to allocate resources optimally.

The pairwise comparison matrices of criteria and options, based on Table 1 and the opinions of 10 industry experts with a minimum of 15 years of experience in project management, are extracted as follows:

$$\tilde{c}=\begin{bmatrix} 1 & \tilde{3}^{-1} & \tilde{4}^{-1} & \tilde{3}^{-1} & \tilde{3}^{-1} & 2 & \tilde{3} & \tilde{5} \\ \tilde{3} & 1 & \tilde{3}^{-1} & \tilde{4}^{-1} & 2^{-1} & \tilde{5} & \tilde{3} & \tilde{4} \\ 4 & \tilde{3} & 1 & \tilde{2}^{-1} & \tilde{1} & \tilde{5} & \tilde{6} & \tilde{4} \\ \tilde{3} & \tilde{4} & \tilde{2} & 1 & \tilde{3} & \tilde{5} & \tilde{4} & \tilde{6} \\ \tilde{3} & \tilde{2} & \tilde{1}^{-1} & \tilde{3}^{-1} & \tilde{1} & \tilde{3} & \tilde{2} & \tilde{2} \\ \tilde{2}^{-1} & \tilde{5}^{-1} & \tilde{5}^{-1} & \tilde{5}^{-1} & \tilde{3}^{-1} & \tilde{1} & \tilde{2}^{-1} & \tilde{4}^{-1} \\ \tilde{3}^{-1} & \tilde{3}^{-1} & \tilde{6}^{-1} & \tilde{4}^{-1} & \tilde{2}^{-1} & 2 & 1 & \tilde{3}^{-1} \\ \tilde{5}^{-1} & \tilde{4}^{-1} & \tilde{4}^{-1} & \tilde{6}^{-1} & \tilde{2}^{-1} & \tilde{4} & \tilde{3} & 1 \end{bmatrix}$$

$$A^{(1)} = \begin{bmatrix} 1 & \tilde{3} & \tilde{2} & \tilde{4} \\ \tilde{3}^{-1} & 1 & \tilde{3} & \tilde{2} \\ \tilde{2}^{-1} & \tilde{3}^{-1} & 1 & \tilde{2} \\ \tilde{4}^{-1} & \tilde{2}^{-1} & \tilde{2}^{-1} & 1 \end{bmatrix}$$

$$A^{(6)} = \begin{bmatrix} 1 & \tilde{1}^{-1} & \tilde{2}^{-1} & \tilde{2}^{-1} \\ 1 & 1 & \tilde{2}^{-1} & \tilde{1}^{-1} \\ \tilde{2} & \tilde{2} & 1 & \tilde{1}^{-1} \\ \tilde{2} & \tilde{1} & 1 & 1 \end{bmatrix}$$

$$A^{(2)} = \begin{bmatrix} 1 & \tilde{2}^{-1} & \tilde{3}^{-1} & \tilde{2}^{-1} \\ \tilde{2} & 1 & \tilde{4}^{-1} & \tilde{1}^{-1} \\ 3 & \widetilde{41} & 1 & \tilde{2} \\ \tilde{2} & \tilde{1} & \tilde{2}^{-1} & 1 \end{bmatrix}$$

$$A^{(4)} = \begin{bmatrix} 1 & \tilde{2}^{-1} & \tilde{3}^{-1} & \tilde{4}^{-1} \\ \tilde{2} & 1 & \tilde{1}^{-1} & \tilde{3}^{-1} \\ \tilde{3} & 1 & 1 & \tilde{2}^{-1} \\ \tilde{4} & \tilde{3} & \tilde{2} & 1 \end{bmatrix}$$

$$A^{(7)} = \begin{bmatrix} 1 & \tilde{3}^{-1} & \tilde{4}^{-1} & \tilde{5}^{-1} \\ \tilde{3} & 1 & \tilde{1}^{-1} & \tilde{2}^{-1} \\ \tilde{4} & 1 & 1 & \tilde{1}^{-1} \\ \tilde{5} & \tilde{2} & \tilde{1} & 1 \end{bmatrix}$$

$$A^{(8)} = \begin{bmatrix} 1 & \tilde{2} & \tilde{3} & \tilde{4} \\ \tilde{2}^{-1} & 1 & \tilde{1} & \tilde{5} \\ \tilde{3}^{-1} & \tilde{1}^{-1} & 1 & 2 \\ \tilde{4}^{-1} & \tilde{5}^{-1} & \tilde{2}^{-1} & 1 \end{bmatrix}$$

$$A^{(3)} = \begin{bmatrix} 1 & \tilde{2}^{-1} & \tilde{3}^{-1} & \tilde{4}^{-1} \\ \tilde{2} & 1 & \tilde{2}^{-1} & \tilde{4}^{-1} \\ \tilde{3} & \tilde{2} & 1 & \tilde{2}^{-1} \\ 4 & \tilde{4} & \tilde{2} & 1 \end{bmatrix}$$

$$A^{(5)} = \begin{bmatrix} 1 & \tilde{2} & \tilde{4} & \tilde{4} \\ \tilde{2}^{-1} & 1 & \tilde{5} & \tilde{5} \\ \tilde{4}^{-1} & \tilde{5}^{-1} & 1 & \tilde{2}^{-1} \\ \tilde{4}^{-1} & \tilde{5}^{-1} & \tilde{2} & 1 \end{bmatrix}$$

To calculate the fuzzy criteria matrix $\tilde{C}$, we first form the crisp matrices C_l, C_m, C_n, and Cu. Then, we find the principal eigenvalues of the problem.

$$\tilde{\lambda}_{max} = (6.65\,, 7.20, 2.80, 13.20)$$

After calculating the eigenvalues, we proceed to compute the corresponding eigenvectors (weights of the criteria): $\tilde{W} = (Wl\,, Wm\,, Wn\,, Wu\,)$

Table 2. Fuzzy Weights of the Criteria

criteria i	$\widetilde{W}_L$	$\widetilde{W}_m$	$\widetilde{W}_n$	$\widetilde{W}_u$
C_1	0.75	0.13	0.15	**0.15**
C_2	0.13	0.13	0.16	**0.16**
C_3	0.29	0.29	0.29	**0.29**
C_4	0.30	0.31	0.31	**0.31**
C_5	0.14	0.14	0.15	**0.17**
C_6	0.39	0.08	0.09	**0.09**
C_7	0.09	0.09	0.09	**0.09**

C8	0.10	0.10	0.11	**0.12**

The eigenvalues and eigenvectors related to the pairwise comparison matrix of the options are also calculated to form the fuzzy priority matrix.

Table 3. Eigenvalues of the Option Comparison Matrix ($\widetilde{\mathbf{A}}^{(i)}$)

$\widetilde{A}^{(j)}$	$\widetilde{W}_L$	$\widetilde{W}_m$	$\widetilde{W}_n$	$\widetilde{W}_u$
$\widetilde{A}^{(1)}$	3.4	3.8	5.3	**6.4**
$\widetilde{A}^{(2)}$	3.7	4.0	5.2	**5.8**
$\widetilde{A}^{(3)}$	3.4	3.8	5.3	**6.3**
$\widetilde{A}^{(4)}$	3.5	3.9	5.3	**6.1**
$\widetilde{A}^{(6)}$	3.7	3.9	5.1	**5.8**
$\widetilde{A}^{(7)}$	3.7	3.9	5.1	**5.8**
$\widetilde{A}^{(8)}$	3.7	3.9	5.1	**5.8**

The Fuzzy Priority Matrices P_l, P_m, P_n, and P_u is as follows:

$$\tilde{P}_L = \begin{bmatrix} 0.43 & 0.24 & 0.18 & 0.20 & 0.13 & 0.13 & 0.55 & 0.45 \\ 0.29 & 0.27 & 0.20 & 0.27 & 0.25 & 0.25 & 0.29 & 0.34 \\ 0.22 & 0.35 & 0.30 & 0.32 & 0.31 & 0.34 & 0.13 & 0.25 \\ 0.18 & 0.31 & 0.47 & 0.36 & 0.33 & 0.33 & 0.06 & 0.13 \end{bmatrix}$$

$$\tilde{P}_m = \begin{bmatrix} 0.46 & 0.25 & 0.17 & 0.20 & 0.13 & 0.13 & 0.45 & 0.44 \\ 0.30 & 0.27 & 0.20 & 0.27 & 0.26 & 0.26 & 0.41 & 0.35 \\ 0.22 & 0.35 & 0.29 & 0.33 & 0.35 & 0.35 & 0.13 & 0.26 \\ 0.19 & 0.31 & 0.47 & 0.36 & 0.34 & 0.34 & 0.06 & 0.13 \end{bmatrix}$$

$$\tilde{P}_n = \begin{bmatrix} 0.45 & 0.25 & 0.19 & 0.23 & 0.12 & 0.12 & 0.50 & 0.46 \\ 0.33 & 0.28 & 0.21 & 0.27 & 0.29 & 0.29 & 0.32 & 0.35 \\ 0.23 & 0.35 & 0.33 & 0.34 & 0.35 & 0.35 & 0.14 & 0.29 \\ 0.19 & 0.32 & 0.50 & 0.37 & 0.46 & 0.46 & 0.15 & 0.13 \end{bmatrix}$$

$$\tilde{P}_u = \begin{bmatrix} 0.46 & 0.25 & 0.19 & 0.23 & 0.13 & 0.13 & 0.52 & 0.47 \\ 0.34 & 0.29 & 0.21 & 0.28 & 0.29 & 0.29 & 0.42 & 0.35 \\ 0.24 & 0.38 & 0.33 & 0.35 & 0.35 & 0.35 & 0.14 & 0.29 \\ 0.19 & 0.33 & 0.50 & 0.39 & 0.46 & 0.46 & 0.15 & 0.13 \end{bmatrix}$$

calculated fuzzy matrices are compatible (CR ≤ 0.1). Now, let's calculate the overall rankings of options based on trapezoidal fuzzy numbers:

Table 4. Overall Rankings of Options Based on Trapezoidal Fuzzy Numbers

Options	$g_{i,L}$	$g_{i,m}$	$g_{i,n}$	$g_{i,u}$
Project1	0.20	0.21	0.24	**0.25**
Project2	0.22	0.23	0.27	**0.27**
Project3	0.25	0.27	0.31	**0.32**
Project4	0.33	0.333	0.37	**0.38**

We use the formula below for de-fuzzification of trapezoidal fuzzy numbers corresponding to each plan and calculating the trapezoidal fuzzy average:

Mean value $= \frac{a_l+2am+2an+au}{6}$

Table 5. Ranking of Projects based on expected value and CVi assuming uniform distribution.

Options	Expected Value (Fuzzy Mean)	Ranking based on Fuzzy Mean	6_i	CVi	CVi-Based Ranking
A_1	0.21	**4**	0.014	6.6	**4**
A_2	0.25	**3**	0.012	5.8	**2**
A_3	0.29	**2**	0.016	6.3	**3**
A_4	0.35	**1**	0.013	4.5	**1**

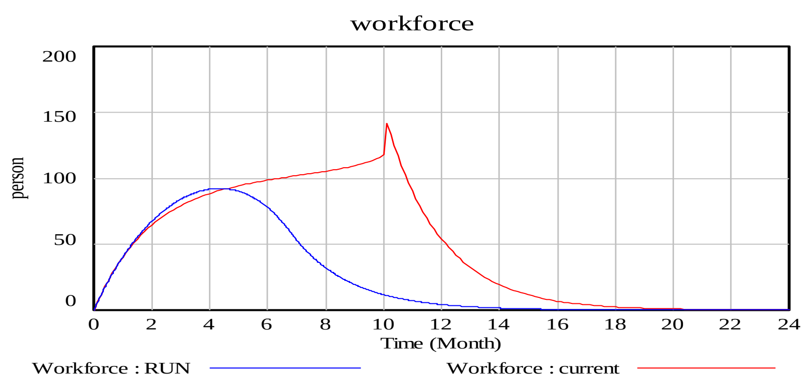

Chart 1. Project Management Diagram with System Dynamics Approach

As seen in Chart 1, employing the System Dynamics approach in project management will lead to a more balanced need for workforce at the end of the project, contrary to the sudden increase in workforce demand in the static and linear approach.

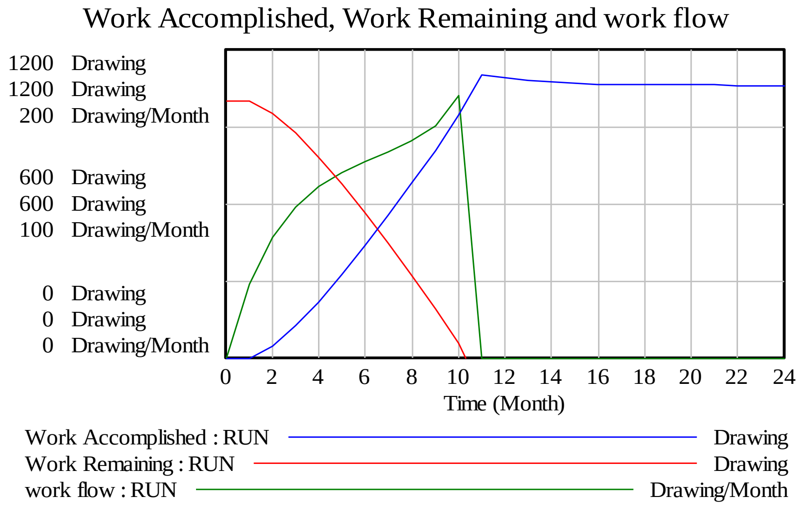

Chart 2. Completed Work, Remaining Work, and Work in Progress Diagram in the System Dynamics Model

As observed, due to the implementation of System Dynamics and timely management of errors and deviations from project objectives, the activities remain stable towards

the end of the project. Unlike the linear and static perspective, there is no sudden surge in the need for time and resources.

CONCLUSION

In this paper, we present FAHP methodology for project ranking. FAHP effectively reflects the vagueness connected with human thoughts. The benefit of utilizing a fuzzy approach is to assign the relative importance of criteria by utilizing fuzzy numbers rather than precise numbers. Multiple criteria decision-making techniques based on FAHP helps project manager to choose the best decision-making strategy using a weighting process through pairwise comparisons. The research area will be extended by using another criteria(stakeholder ,team ,development approach and life cycle, planning , project work ,delivery , measurement , uncertaining) in multiple criteria decision-making approach.

Finally, considering that the project execution environment is dynamic, after prioritizing the projects, we will develop a dynamic model using the System Dynamics approach for execution, design, and simulation. Based on the results in Table 5, it can be seen that the project rankings according to AHP F and Coefficient of Variation (CVi) are as follows:

$A_4 > A_3 > A_2 > A_1$

$A_4 > A_3 > A_2 > A_1$

As seen, the ranking based on FAHP aligns with actual information, providing higher accuracy and validity. After prioritizing the projects using the System Dynamics approach, we can manage and control errors and deviations from objectives in real-time, preventing the accumulation of problems at the end of the project.

The utilization of system thinking and a system dynamic approach will significantly assist project managers in competitive project environments. This approach not only ensures successful project execution but also reduces costs associated with static planning.

Since projects are highly complex systems that require substantial resources for execution, it is imperative to initially prioritize them for optimal allocation of limited resources. Then, with the application of a dynamic and continuous approach along with system thinking, they can be effectively managed.

Due to the high complexity of large-scale projects and the uncertain environmental conditions they face, ensuring the success of project execution requires prioritization based on comprehensive criteria followed by combined simulations. Therefore, it is recommended for future research to integrate the System Dynamics approach with other methodologies such as Expert Systems, Machine Learning, Artificial Intelligence, and Soft Operations Research to bring the results of system analysis and simulation closer to reality and undergo a more comprehensive study.

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