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Article

Strategic decision-making in project management: Applying FAHP to select research agendas

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Abstract: This study proposes a fuzzy analytic hierarchy process (FAHP) method to support strategic decision-makers in choosing a project management research agenda. The analytical hierarchy process (AHP) model is the basic tool used in this study. It is a mathematical tool for evaluating decisions with multiple alternatives by decomposing them into successive levels according to their degree of importance. The Sustainable Development Goals (SDG) oriented theme of project management was chosen from among four themes that emerged from a strategic monitoring study. The FAHP method is an effective decision-making tool for multiple aspects of project management. It eliminates subjectivity and produces decisions based on consistent judgment.

Keywords: project management; Sustainable Development Goals (SDG); management of technological innovation and R&D; operations research; statistical decision theory; fuzzy AHP

1. Introduction

The development of project management has been recognised as essential for organisations to manage projects, programs, and portfolios (Chofreh et al., 2019). However, Marcelino et al. (2015) argued that the philosophy of this concept is limited to profit without considering societal and environmental aspects. Conventional project management is inadequate for the sustainable management of projects, programs, and portfolios. Sustainability principles must be integrated into project management.

Currently, the fourth industrial revolution is emerging—with artificial intelligence, big data, and the Internet of Things at its core—where work is increasingly digitised and automated (Hirschi, 2018). This changes the job roles of project management team members. In addition, climate change and environmental sustainability have forced us to rethink economic and productive systems. Therefore, the role of project management begins to leave its roots as a niche technical discipline to become an area that integrates different disciplines of knowledge (Müller et al., 2019).

Although many organisations today have invested in project management in different fields and have seen some success, 68% of the organisations studied by the Project Management Institute (PMI) indicated that they were involved in digital transformation projects in 2020. A quarter of the projects did not meet the planned objectives (PMI, 2021) and 35% of these projects failed. One of the main reasons for such failures is the lack of identification of the new challenges demanded by the discipline and practices of project management. Therefore, it is imperative for university institutions and public and private companies to identify and prioritise a research agenda in project management that contributes to disciplinary and professional development within the framework of new social, technological, economic, political, and environmental factors.

According to Rodríguez (2020), different methods and strategies have been used to define fields and topics of research, including systematic reviews using elements of content analysis (Ruiz, 2004), bibliometrics (Benítez, 2012; Van Raan, 1998), scient metrics of degree works (Ortega, 2010), production associated with a journal or database in particular, data mining (Losiewicz et al., 2000), the construction of national (Boden et al., 2006), sectoral, and institutional agendas generated by the entities that organise and manage the research (Vendrell and Ángel, 2008), and consulting experts through Delphi methods (García et al., 2011). In response to this research deficiency, this study proposes a fuzzy analytic hierarchy process (FAHP) method to support strategic decision-makers in choosing a project management research agenda.

The remainder of this study is organised as follows: Section 2 reviews the theoretical foundations of project management, project management education, and the research background of the methods used in project management; Section 3 demonstrates the application of the proposed method; a discussion and explanation of the results are presented in Section 4; and Section 5 concludes the paper.

2. Theoretical background

2.1. Project management

In a review of project management literature and theories, Packendorff (1995) stated that project management is largely seen as a general theory that is not sufficiently empirical. Furthermore, he emphasised that in the dominant research topics, projects are seen as tools and project management is seen as a set of models and techniques for planning and controlling complex undertakings. Thus, several writers in recent years have stressed the importance of diverse theoretical perspectives and in-depth studies in constructing ‘middle-range’ theories about different types of projects. Similarly, Shenhar and Dvir (1996) stated that most research on project management ‘suffers from a poor theoretical base and lack of concepts.

According to Soderlund (2004), project management research has two primary theoretical traditions. The first tradition has intellectual roots in engineering science and applied mathematics; the first focused on project management planning techniques and methods. The other tradition has its intellectual roots in the social sciences, such as sociology, organisation theory, and psychology are interested especially focused on organisational and behavioural aspects of project organizations. The first tradition is also called the task perspective and the second is the Organisational Perspective. The project management Task Perspective is also known as the ‘hard’ perspective, whereas the Organizational Perspective is generally known as the ‘soft’ perspective; however, the terms ‘hard’ and ‘soft’ have been used imprecisely and ambiguously (Crawford and Pollack, 2004).

Biedenbach and Müller (2011) and Turner et al. (2013) proposed various classifications of perspectives and schools of thought in project management. In the last two publications, the authors agreed on an elaborate set of nine schools of thought that were extensively discussed in a series of articles published in 2007/2008 (Bredillet, 2008). A tenth school called sustainability was included by Silvius (2017), who concluded that due to the integration of sustainability in processes, international standards and practices, project management is an emerging and growing field of study.

The sustainability school adopts a social perspective in projects and considers them as instruments of social change. It guides and develops the satisfaction of needs and expectations (identified and unidentified requirements) of interested parties and balances the interests in competition because it is considered a fundamental activity for a project's success (Eskerod and Huemann, 2013). Another aspect of this school is the triple bottom line, which establishes that it is about the balance or harmony between economic, social and environmental sustainability (Silvius and Schipper, 2015).

2.2. Changes in project manager education

Notably, the type of projects plays an important role in the state of project management education in modern companies. According to the PMI (2015), between 2010 and 2020, 15.7 million new project management roles were established globally. Along with job growth, the PMI predicted a significant increase in the profession's economic footprint. As project management becomes more central to project delivery, effective education and talent management for project managers are vital to organisational competitiveness. This is one of the main reasons that graduates of university project management programs are in high demand in various industries.

However, current education inadequately prepares managers for complex realities (Thomas and Mengel, 2008; Winter et al., 2006). Seidler-de Alwis and Hartmann (2008) believe that the traditional approach to educating project managers has been substantially based on throwing large amounts of data and expecting them to generate correct programs and successful outcomes.

Project staff will require a significant increase in the use of higher-level capabilities. For example, practices that ensure greater sensitivity to environment and society are needed to deliver a 'successful' project. New and higher standards are expected in infrastructure projects because technology already makes them attainable (Schoberova, 2015). This has the potential to provide project staff with challenging, rewarding, and interesting roles in the future. However, it comes with new skill requirements.

PMI Regulation Changes in Project Management Education:

The Project Management Institute (PMI) serves as the benchmark for project management practices globally. As such, the updates to PMI regulations are critical, reflecting the shifts necessary to keep pace with economic, technological, and societal trends.

Recent years have seen substantial revisions in PMI's framework, notably the expanded inclusion of competencies such as agility, resilience, and responsiveness within the PMBOK Guide—PMI's core publication. This shift suggests a broader move from traditional project management frameworks toward methodologies that prioritize adaptability and fluidity. By integrating these principles, educational programs can equip future project managers with the tools necessary for success in complex project environments.

The recent revisions in PMI's framework to include competencies like agility, resilience, and responsiveness signify a notable shift towards methodologies that prioritize adaptability and fluidity (Kadenic and Tambo, 2023). These changes emphasize the importance of integrating principles that enable project managers to navigate the increasingly complex and unpredictable landscape of project management. By incorporating these competencies into educational programs, future project managers can enhance their ability to succeed in dynamic environments.

Agility and resilience have been identified as crucial components in ensuring the operational resilience of project management models (Kadenic and Tambo, 2023). The integration of agile methods can contribute to the resilience of the operating model by facilitating rapid adjustments and conscious decision-making in the face of changes. This highlights the significance of adopting agile practices to enhance the adaptability of project management approaches.

Moreover, expertise and experience play a vital role in the success of projects, particularly concerning scope, cost, and deadlines (Sposito, 2023). Project managers' technical competencies are essential for ensuring project efficiency and effectiveness. Therefore, a combination of technical skills and competencies like emotional intelligence can significantly impact project outcomes.

The adoption of methodologies and standards, such as PMI's PMBoK, can enhance project performance and provide effective performance measurement tools (Jarlsberg, 2023). These standards are recognized as valuable resources in project management, contributing to improved project success rates and reduced risks and costs (Javaid et al., 2022).

With the acceleration of technological innovation, PMI has updated its standards to encompass essential technological competencies. One of the technical skills required of a project manager is Artificial Intelligence systems management. This will replace traditional project management skills, such as detailed time and cost management, risk forecasting and contingency planning management skills (Shury et al., 2014).

Today's project managers must navigate the complexities of artificial intelligence, data analytics, and cybersecurity. These elements are now integral to the PMI's training and certification processes, underscoring the importance of technical acumen in modern project management. With the continuous evolution of technology, the Project Management Institute (PMI) has updated its standards to encompass essential technological skills (Arikumar et al., 2022). In the current project management environment, professionals must adeptly handle artificial intelligence, data analytics, and cybersecurity (Arikumar et al., 2022). These components have now become integral parts incorporated into PMI's training and certification procedures, emphasizing the importance of technical proficiency in contemporary project management (Arikumar et al., 2022).

The integration of technical skills in project management is crucial for enhancing innovation capabilities and fostering organizational success (Chen et al., 2022). By transitioning from imitative innovation to independent innovation, organizations can utilize post-merger integration and network reconstruction to enhance their innovation capacities (Chen et al., 2022). This transformation underscores the necessity of keeping pace with technological advancements to sustain competitiveness in the market (Chen et al., 2022).

Furthermore, the focus on technical expertise aligns with the changing requirements of the industry, where project managers are expected to possess advanced skills and analytical capabilities in applying relevant methodologies and techniques (Abdelmasseh et al., 2022). The effective utilization of technology not only improves project outcomes but also contributes to the overall success of projects (Abdelmasseh et al., 2022).

The integration of technological competencies into project management methodologies reflects the evolving landscape of the field and the increasing reliance on advanced tools and techniques. Project managers who possess technical skills in areas such as artificial intelligence, data analytics, and cybersecurity are better equipped to lead successful projects and drive innovation within their organizations.

2.3. Use of a hierarchical process analysis in project management

The selection of an appropriate project management tool is critical for the success of a project. Traditionally, this selection is influenced by subjective factors such as personal preferences, which may lead to inaccuracies. To mitigate these biases, the Analytic Hierarchy Process (AHP) provides a structured and systematic evaluation method, facilitating more accurate choices of project management tools (Fudzin et al., 2022).

The versatility of AHP is demonstrated across various decision-making scenarios, showcasing its effectiveness in ensuring methodical evaluations. Its applications extend beyond project management to include vendor selection (Fudzin et al., 2022), project manager selection (Faisal et al., 2022), sustainable building material selection (Tegegne et al., 2023), and more. Such diverse applications underscore AHP's capacity to systematically address multiple criteria and alternatives, enhancing decision-making in fields as varied as sports facility site selection (Erturan-Ogut and Kula, 2022) and flood susceptibility analysis (Sharir et al., 2022).

Moreover, AHP supports critical business functions such as project prioritization, risk management, supplier selection, and team formation. By embedding AHP within project management practices, organizations can improve decision-making, enhance resource allocation, and increase project success likelihood. The objective framework provided by AHP ensures decisions are grounded in solid criteria and comprehensive evaluations rather than subjective judgments (Kurniawan et al., 2022; Soam et al., 2023).

In addition to AHP, the study highlights the Fuzzy Analytic Hierarchy Process (FAHP), which enhances decision-making by integrating fuzzy set theory to address uncertainties and subjective judgments. This approach is evident in the work of Ghorbani et al. (2022), who successfully applied FAHP in conjunction with SWOT analysis to evaluate rubber dam projects, achieving a nuanced analysis that promotes informed and strategic decision-making.

Further extending the applications of AHP and FAHP, several studies illustrate their utility in various sectors. For instance, Demirtas et al. (2014) applied these methodologies in software development, while Al Qubaisi et al. (2016) developed a framework using AHP to evaluate school performance systems. These methodologies not only facilitate precise and useful outcomes but also support strategic planning across different contexts, from educational settings to energy research and industry-specific applications like in the oil and gas sector (Alkarbi et al., 2022).

Overall, the extensive utilization of AHP across various domains to facilitate decision-making processes underscores its value as a robust framework for decision-making. Its systematic approach to evaluating and selecting options based on multiple criteria proves essential for decision-makers facing complex scenarios. This discussion not only reaffirms the effectiveness of AHP and FAHP in enhancing project management practices but also suggests their broader applicability in strategic planning and operational management across diverse sectors. The analysis clearly demonstrates that the Analytic Hierarchy Process (AHP) is a highly effective decision-making tool for various aspects of project management. By systematically reducing subjectivity, AHP allows for decisions that are based on consistent and reproducible judgments. This methodological rigor ensures that decision-making processes are both transparent and reliable, making AHP indispensable for achieving precise outcomes in project management scenarios.

3. Methodology

First, a multistage, scientometric, and bibliometric quantitative analysis was used to examine the trends in the research area of interest. The Scopus and Web of Science databases were selected, which are referents for the measurement of the world's scientific production in different topics. The search was oriented toward analysing project management, social development, public projects, and social entrepreneurship topics. It was limited to studies published from 2015 to 2020. Subsequently, the search equations were constructed using Boolean and proximity operators. There were 31,351 results in five selected areas: project management, social development projects, public and private projects, social entrepreneurship, methodologies for project management and social entrepreneurship.

Using VOSviewer software, bibliometric networks of co-citation and co-authorship relationships and keyword co-occurrence networks were created, among other types of analyses. To filter the keywords, we reviewed and validated the titles and abstracts to verify their relevance. Subsequently, we considered various scientometric indicators, such as the number of publications per year, main authors, number of citations, institutions, journals, and countries. The top 10 indicators were taken into account in the study.

Subsequently, the articles with the highest number of citations were selected. A total of 15,890 documents were used. The purpose, methodology, main conclusions, and recommendations for future studies were identified. **Figure 1** and **Table 1** illustrate the recurrence of the main keywords indexed in the databases.

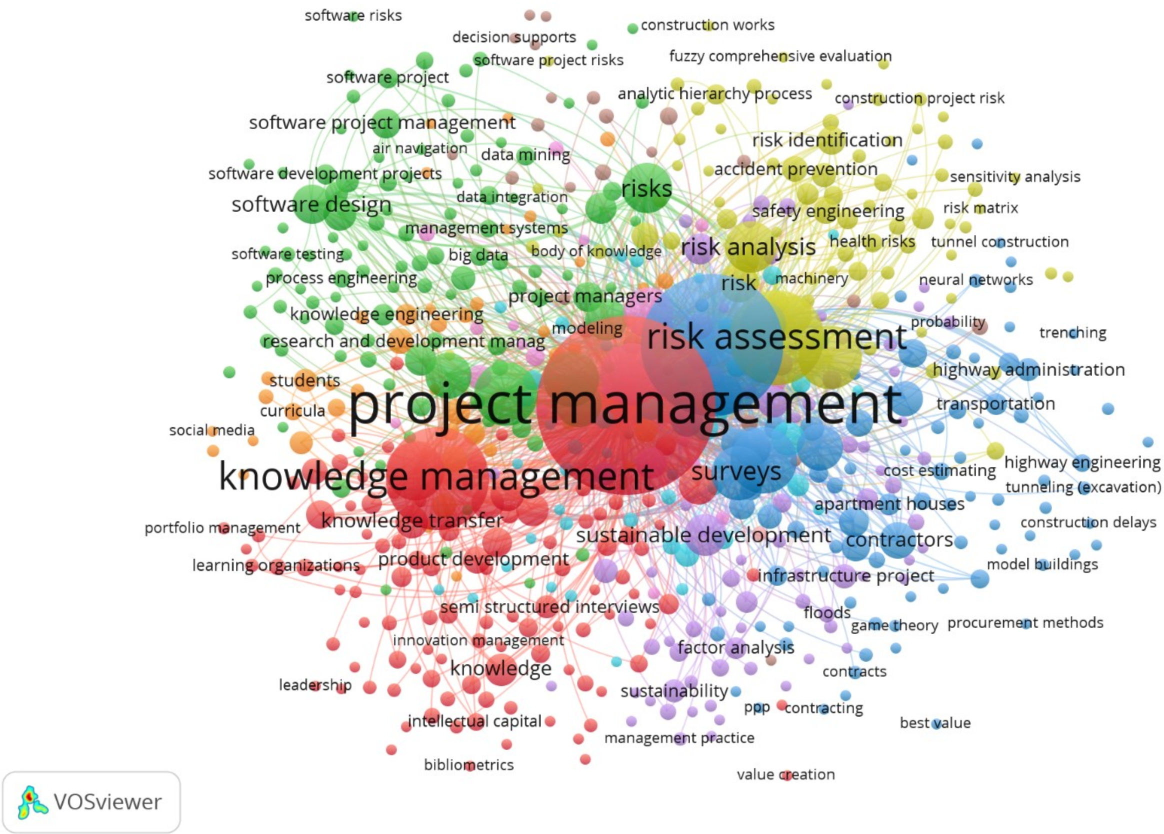

Figure 1. Indexed keywords project management.

Table 1. Links and total strength link in the project management area.

Keyword	Cluster number	Link	Total link strength	Occurrences
Project management	1	777	9346	1608
Decision making	3	481	1377	180
Human resource management	2	390	1052	133
Construction industry	9	461	1772	204
Managers	2	345	867	96
Information management	4	336	823	97
Risk assessment	8	318	733	88
Software design	2	202	519	71
Sustainable development	1	260	545	68
Budget control	3	234	529	60

Source: Authors' own elaboration based on Scopus (2020), using VOSviewer.

Finally, through the contextualisation and interpretation of the results, research trends (**Table 2**) were determined, representing impacts related to research groups, institutions, regions, countries, disciplines, fields of knowledge or research models. They also represented theoretical, methodological or social comparisons (Michán and Muñoz, 2013).

Table 2. Research topics identified for selection.

Code	Research topics
HAPM	Hybrid Approaches to Project Management
DSPM	Decision Sciences for Project Management
PMSDG	Project management focused on Sustainable Development Goals
PMSTI	Project management and scientific, technological and innovative approach

Through a panel of experts, the regional priorities and research trends around study were identified. The results were triangulated with other studies of international institutions recognised in the thematic area of the present research.

As a result of this exercise, the research topics were classified according to the experts' perceptions. It shows a predilection for project management focusing on SDGs, followed by project management with a scientific, technological, and innovative approach.

Simultaneously, a questionnaire was developed and applied to experts from Mexico, Venezuela, Chile, and Colombia as part of the FAHP technique (**Figure 2**). The topics identified around project management were prioritised, given the topics presented in **Table 2**.

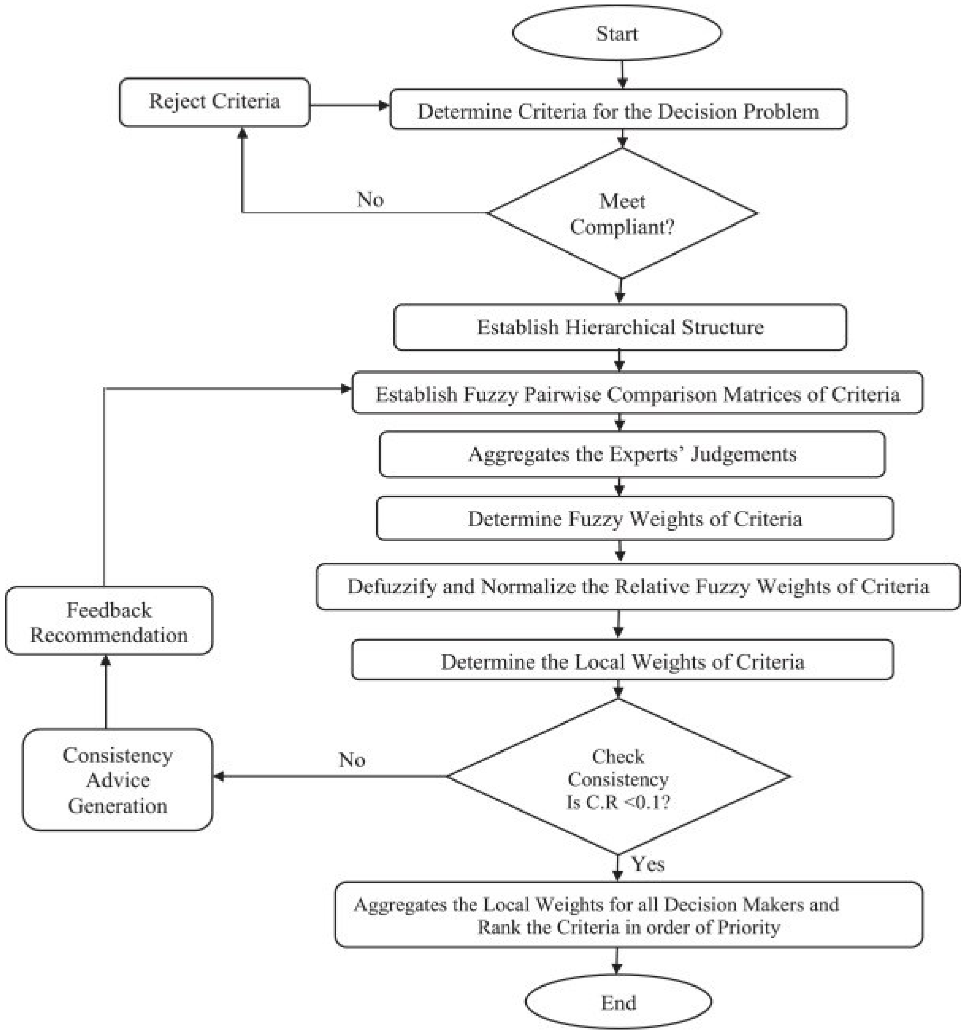

Figure 2. Hierarchical process analysis technique.

To enhance the comprehensibility of the Fuzzy Analytic Hierarchy Process (FAHP) used in the study, it's crucial to explain how this decision-making tool functions in practical contexts, especially for those unfamiliar with its application. FAHP aids in evaluating complex issues where multiple criteria must be considered, and human judgments might involve uncertainties.

In the study, the decision-making process for selecting research topics is structured around seven distinct categories, each defined by multiple subfactors, as detailed in **Table 3**, "Categories and subfactors for topic selection." These categories encompass a comprehensive range of criteria that are essential for assessing the viability and strategic alignment of research topics.

1) Relevance and Pertinence: This category assesses how well the research topics align with broader objectives and plans. It includes subfactors such as the relationship to Sustainable Development Goals (SDGs), national government plans, and local and regional government plans.
2) Opportunities: This focuses on the potential benefits that can arise from selecting a particular research topic. Subfactors include external funding opportunities, potential for student growth, and expert ratings of the topic's relevance and impact.
3) Costs: This category evaluates the financial implications of pursuing a research topic. It covers labour costs, expenses related to publication and reviews, and incentives that might be required to encourage research and development.
4) Benefits: This looks at the positive outcomes associated with a research topic, including potential for high-impact publications, citations, and funding opportunities that can enhance the institution's research profile.
5) Risks: This category identifies potential drawbacks or challenges, with subfactors including time requirements, quality risks, and budget constraints that might affect the project's completion.
6) Technology and Capabilities: This assesses the technical and logistical feasibility of the research topics, examining the availability of human resources, necessary software and equipment, and the existing knowledge base.
7) Feasibility: This evaluates external and institutional factors that could influence the success of a research topic, including institutional constraints, external conditions, and legal provisions that need to be considered.

These categories and their corresponding subfactors provide a structured framework for evaluating research topics, ensuring a holistic assessment that considers a diverse range of criteria essential for making informed decisions in academic and research settings. In applying the Fuzzy Analytic Hierarchy Process (FAHP) theory, various criteria and paths outlined in the seven categories and their respective 21 subfactors were systematically compared to determine the highest-priority research topics. This structured evaluation aimed to enhance the impact of academic research at regional, national, and international levels, recognizing its vital role in advancing human development.

Table 3. Categories and subfactors for topic selection.

Factors	Subfactors
Relevance and pertinence	Relationship to SDGs Relationship to national government plans Local and regional government plans
Opportunities	External calls Students' growth Expert rating
Costs	Labour Publication/Reviews Incentives
Benefits	High-impact publications Citations Funding
Risks	Time Quality Budget
Technology and Capabilities	Human resource Software & Equipment Knowledge
Feasibility	Institutional constraints External conditions Legal provisions

The development of the FAHP methodology allows for the selection of problems with more complex subproblems. In this sense, the knowledge base is expanded to seven categories, as illustrated in **Table 3**. From these categories, 12 subfactors are defined; they are locally ranked to determine the global weights and valued according to the research areas and experts' criteria.

Fuzzy analytic hierarchy process (FAHP)

The AHP model is the basic tool used in this study. It is a mathematical tool for evaluating decisions with multiple alternatives by dividing them into successive levels according to their degree of importance. For instance, the model created by Saaty (1977) establishes a hierarchical order, at a general and particular level, based on the criteria and sub-criteria of a given complex context and the relative importance assigned. However, in human judgments, there is a degree of vagueness or imprecision derived from the human thinking model in a decision problem (Olabanji and Mpofu, 2020). To remedy this, we rely on an FAHP model, where the fuzzy sets proposed by Zadeh (1965) flexibly represent imprecise linguistic information based on triangular fuzzy numbers (TFN) to circumvent the vagueness in the verdicts. A membership function governs the fuzzy numbers to establish their degree of membership, whose range is from 0 to 1, as shown in **Figure 3**.

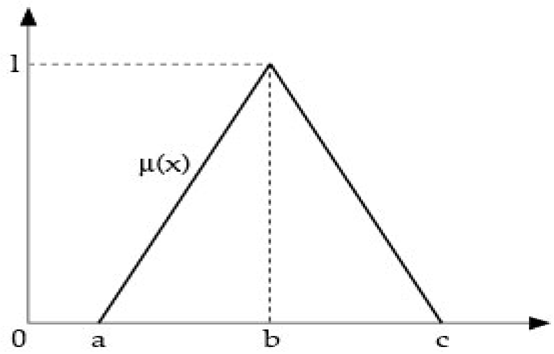

Figure 3. Triangular fuzzy set.

In **Figure 3**, each TFN comprises parameters *a*, *b* and *c*, corresponding to the smallest, largest and most promising possible values, respectively. They represent fuzzy events. Thus, instead of crisp numbers, the TFNs are described by intervals. For $\mu_{\tilde{A}}(x)$, the corresponding membership function is represented by Equation (1).

$$\mu_{\tilde{A}}(x) = \begin{cases} 0, & x < l \\ \frac{(x-l)}{(m-l)}, & l \leq x \leq m \\ \frac{(u-x)}{(u-m)}, & m \leq x \leq u \\ 0, & x > u \end{cases} \quad (1)$$

Arithmetic laws of fuzzy sets.

Given two TFNs $\widetilde{A}$ and $\widetilde{B}$, expressed as $\widetilde{A} = (l_1, m_1, u_1)$ and $\widetilde{B} = (l_2, m_2, u_2)$.

The following arithmetic laws allow operations with each other:

Addition:

$$\widetilde{A} \oplus \widetilde{B} = (l_1 + l_2, m_1 + m_2, u_1 + u_2) \quad (2)$$

Multiplication:

$$\widetilde{A} \otimes \widetilde{B} = (l_1 \times l_2, m_1 \times m_2, u_1 \times u_2) \quad (3)$$

Division:

$$\widetilde{A} \oslash \widetilde{B} = (l_1/u_2, m_1/m_2, u_1/l_2) \quad (4)$$

To determine the general and specific weights of the research topics in the FAHP model, the above laws should be considered, and the following activities should be followed:

Step 1: Obtain expert judgments from the rating of the hierarchical structure of the research topics shown in **Table 3**.

Step 2: Once the judgments on the criteria are obtained, each of the general and specific ratings of the linguistic scale are converted into a TFN according to the conversion scale in **Table 4**.

Table 4 represents the form that experts filled out to conduct pairwise comparisons of the seven criteria used in the evaluation of project management alternatives. This pairwise comparison method is crucial in the Analytic Hierarchy Process (AHP) and is used both for evaluating main criteria as well as lines and subcriteria associated with each.

Table 4. Conversion scale.

Pairwise comparison											
Escale	**Absolutely**	**Strongly**	**Fairly**	**Weakly**	**Criteria**	**Equally**	**Criteria**	**Weakly**	**Fairly**	**Strongly**	**Absolutely**
	Important	**Important**	**Important**	**Important**		**Important**		**Important**	**Important**	**Important**	**Important**
Fuzzy	**(9, 9, 9)**	**(6, 7, 8)**	**(4, 5, 6)**	**(2, 3, 4)**		**(1, 1, 1)**		**(2, 3, 4)**	**(4, 5, 6)**	**(6, 7, 8)**	**(9, 9, 9)**
Crisp AHP	**9**	**7**	**5**	**3**		**1**		**3**	**5**	**7**	**9**
					C1		C2	3			
					C1		C3		5		
					C1		C4			7	
					C1		C5		5		
					C1		C6			7	
					C1		C7		5		
					C2		C3	3			
					C2		C4				
					C2		C5			7	
				3	C2		C6				
					C2		C7		5		
			5		C3		C4				
					C3		C5			7	
					C3		C6		6		
				3	C3		C7				
			5		C4		C5				
					C4		C6			8	
					C4		C7	4			
					C5		C6		6		
					C5		C7		6		
					C6		C7			8	

Explanation of the form format:

Comparison scales:

Table 4 includes two types of scales: Fuzzy and Crisp AHP. These scales help experts assign numerical values to their judgments regarding the relative importance of each pair of criteria.

- Fuzzy: Provides a range of values (e.g., (9, 9, 9) for "Absolutely more important") that allows capturing the uncertainty or variability in the experts' perceptions.
- Crisp AHP: Uses fixed values (e.g., 9 for "Absolutely more important") and is a more traditional and deterministic form of the AHP scale.

Direction of comparison:

The form is designed so that each cell intersects two criteria, indicating the importance relationship between them. The row and column correspond to a specific criterion, and the value placed at the intersection represents how much more important one criterion is over the other, according to the provided scales:

- Columns "Absolutely Important" to "Equally Important" (left to center): Indicate how much more important the criterion in the column is compared to the criterion in the row.

- Columns "Equally Important" to "Absolutely Important" (center to right): Represent how much less important the criterion in the column is compared to the criterion in the row.

Example of form usage:

For example, if an expert believes that Criterion 1 (C1) is "strongly more important" than Criterion 2 (C2), they will place a 7 in the cell that intersects C1 in the row and C2 in the column under the "Strongly More Important" column. If it is considered that C2 is "weakly less important" than C1, then a 3 would be placed in the corresponding cell, but in the opposite direction.

This format is replicated for all comparisons between the main criteria and can similarly be employed to evaluate subcriteria and other breakdown levels within the study, thus ensuring a thorough and consistent assessment across all dimensions of the analysis.

When a middle ground between the above values is required, the intermediate values 2, 4, 6, and 8 are used.

Then, the new TFN judgments are compared according to Equation (5).

Let $\widetilde{D}^k = \left[\tilde{a}_{ij}^k\right]$ be the fuzzy pairwise comparison matrix of k-th decision maker, where $k = 1, 2, \dots, p$.

$$\widetilde{D}^k = \begin{vmatrix} (1,1,1) & \tilde{a}_{12}^k & \dots & \tilde{a}_{1n}^k \\ \tilde{a}_{12}^k & (1,1,1) & \dots & \tilde{a}_{2n}^k \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{n1}^k & \tilde{a}_{n2}^k & \dots & (1,1,1) \end{vmatrix} \quad (5)$$

where $\tilde{a}_{ij}^k \times \tilde{a}_{ji}^k = 1$ with $i = j = 1, 2, \dots, n$.

Step 3: To summarise the judgments in a matrix by category, fuzzy matrices are combined using the proposed geometric mean as shown in Equation (6).

Let $\widetilde{D} = [\tilde{a}_{ij}]$ be the combined fuzzy pairwise comparison matrix.

$$\widetilde{D} = \begin{vmatrix} (1,1,1) & \tilde{a}_{12} & \dots & \tilde{a}_{1n} \\ \tilde{a}_{12}^k & (1,1,1) & \dots & \tilde{a}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{a}_{n2} & \tilde{a}_{n2} & \dots & (1,1,1) \end{vmatrix} \quad (6)$$

where $\tilde{a}_{ij} \times \tilde{a}_{ji} = 1$ with $i = j = 1, 2, \dots, n$ and $\tilde{a}_{ij} = \left(\tilde{a}_{ij}^1 \otimes \tilde{a}_{ij}^2 \otimes \dots \otimes \tilde{a}_{ij}^p\right)^{\frac{1}{p}}$.

Step 4: The fuzzy number was defuzzified to calculate the consistency of the combined pairwise comparison matrix.

Step 5: The fuzzy weight $\widetilde{w}_i$ for each criterion (i) is calculated using the geometric mean based on Equations (7) and (8).

$$\tilde{r}_i = (\tilde{a}_{i1} \otimes \tilde{a}_{i2} \otimes \dots \otimes \tilde{a}_{in})^{\frac{1}{n}} \quad (7)$$

$$\widetilde{w}_i = \tilde{r}_i \times (\tilde{r}_1 \otimes \tilde{r}_2 \otimes \dots \otimes \tilde{r}_n)^{-1} \quad (8)$$

where $\tilde{r}_{ij} = \left(l_{ij}, m_{ij}, u_{ij}\right)$ and $\left(\tilde{r}_{ij}\right)^{-1} = \left(\frac{1}{u_{ij}}, \frac{1}{m_{ij}}, \frac{1}{l_{ij}}\right)$.

Step 6: With the fuzzy weights of each general and specific criterion, the fuzzy weights

$\widetilde{w}_i = (l_i, m_i, u_i)$ are defuzzified using the center-of-area method to obtain the crisp number representing the final weight in Equation (9).

$$w_i = (l_i + m_i + u_i)/3 \quad (9)$$

Step 7: Finally, the weights above are normalised, as shown in Equation (10).

$$w_{n_i} = \frac{w_i}{\sum_{i=1}^{n} w_i} \quad (10)$$

4. Discussion and results

The first evaluation exercise used the Fuzzy and Saaty's (1977) scale and paired comparisons based on the experience and trajectory as director/academic/researcher in the project management area. The topics were evaluated using the scales in **Table 4**. The classifications of the topics are shown in **Table 5** and **Figure 4**.

Table 5. Prioritization of the topics of research according to the FAHP matrix and expert judgement.

CRITERIA	Weights (Ni)	A1	A2	A3	A4
Relevance and pertinence	31.4%	56.5%	28.4%	7.2%	7.9%
Opportunities	15.6%	52.1%	31.5%	7.8%	8.6%
Costs	9.6%	58.5%	28.1%	6.3%	7.1%
Benefits	7.5%	57.6%	27.0%	7.6%	7.7%
Risks	10.1%	49.6%	31.2%	8.4%	10.8%
Technology and Capabilities	7.9%	57.4%	27.7%	7.2%	7.7%
Feasibility	17.9%	51.6%	30.8%	7.9%	9.7%
TOTAL (Score Alt × weight criteria)		54.6%	29.4%	7.5%	8.5%

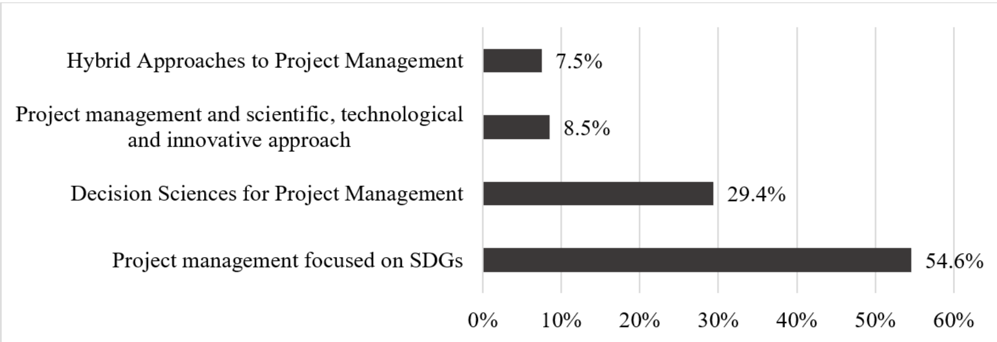

Figure 4. Prioritization of the topics of research according to the FAHP matrix and expert judgement.

Source: Authors' own elaboration.

Table 5 presents a summary of the evaluations conducted by seven experts from Colombia, Venezuela, and Mexico, making the assessment more global in scope. It evaluates four research lines alternatives for project management (A1 → Project management focused on Sustainable Development Goals, A2 → Decision Sciences for Project Management, A3 → Hybrid Approaches to Project Management and A4 → Project management and science, technology, and innovation approach) using the Fuzzy Analytic Hierarchy Process (FAHP) across seven critical criteria, each with a specified weight (Ni) indicating its importance in the decision-making process. The scores for each research line under these criteria quantify their alignment with strategic research priorities.

Detailed Analysis of the Criteria and Research Lines:

1) Relevance and Pertinence (31.4% weight):
    - A1 scores the highest at 56.5%, indicating a strong alignment with essential strategic goals, particularly SDGs.
    - A2 follows with 28.4%, showing a good alignment, though significantly less than A1.
    - A3 and A4 score lower, suggesting their limited relevance in comparison to the overarching strategic goals.
2) Opportunities (15.6% weight):
    - A1 and A2 exhibit significant potential with scores of 52.1% and 31.5% respectively, indicating that these research lines could offer substantial benefits such as growth and external funding opportunities.
    - A3 and A4 register lower scores, reflecting fewer opportunities in these areas.
3) Costs (9.6% weight):
    - A1 incurs the highest costs at 58.5%, likely due to its broad and ambitious scope involving SDGs.
    - A2 presents slightly lower costs at 28.1%, while A3 and A4 are less expensive, potentially reflecting more focused or less resource-intensive research areas.
4) Benefits (7.5% weight):
    - A1 shows a significant potential for high-impact outcomes with a score of 57.6%, highlighting its capability to generate valuable research outputs.
    - A2 also demonstrates notable benefits, albeit to a lesser extent.
5) Risks (10.1% weight):
    - A1 involves higher risks at 49.6%, likely due to its expansive scope, while A2 has a lower risk profile at 31.2%.
    - A3 and A4 present lower risks, possibly due to their more specialized or contained focus.
6) Technology and Capabilities (7.9% weight):
    - A1 and A2 score highly in this criterion, indicating that these research lines are well-supported by current technology and expertise.
    - A3 and A4 show less capability, suggesting potential gaps in resources or expertise necessary for these areas.
7) Feasibility (17.9% weight):
    - A1 and A2 are more feasible compared to A3 and A4, as indicated by their higher scores, implying that implementing these research lines is more practical within the current institutional framework.

Overall Scores:

- A1 (54.6%) emerges as the most aligned and feasible research line, strongly supported by its relevance to global development goals.
- A2 (29.4%) ranks second, particularly favored for its contribution to decision sciences.
- A3 (7.5%) and A4 (8.5%) receive lower overall scores, indicating less alignment with the prioritized criteria.

This structured evaluation showcases the strengths and challenges associated with each research line, providing a quantitative foundation for selecting the most strategically aligned area of focus.

This first exercise allowed us to determine the following project management topics in order of prioritisation: Project management focused on SDGs (54.6%), Decision Sciences for Project Management (29.4%), Project management and scientific, technological and innovative approach (8.5%) and Hybrid Approaches to Project Management (7.5%).

With the factors and dimensions defined in **Table 3**, we established a weighed order of the subfactors and an overall weight for benefits/opportunities, costs and risks, as shown in **Table 6**.

Table 6. Local and global weights by criteria.

Aggregated results for each alternative according to each criterion		**Scores of Alternatives with respect to related Criterion**			
Criteria	**Weights (Ni)**	**A1**	**A2**	**A3**	**A4**
Relevance and pertinence	31.4%	56.5%	28.4%	7.2%	7.9%
Opportunities	15.6%	52.1%	31.5%	7.8%	8.6%
Costs	9.6%	58.5%	28.1%	6.3%	7.1%
Risks	7.5%	57.6%	27.0%	7.6%	7.7%
Benefits	10.1%	49.6%	31.2%	8.4%	10.8%
Technology and Capabilities	7.9%	57.4%	27.7%	7.2%	7.7%
Feasibility	17.9%	51.6%	30.8%	7.9%	9.7%
TOTAL (Score Alt × weight criteria)		54.6%	29.4%	7.5%	8.5%

As seen in **Table 6** and **Figure 5**, the following criteria for prioritisation emerged in order of weight: relevance and pertinence (31.4%), feasibility (17.9%), opportunities (15.6%), benefits (10.1%), costs (9.6%), technology and capabilities (7.9%) and risks (7.5%).

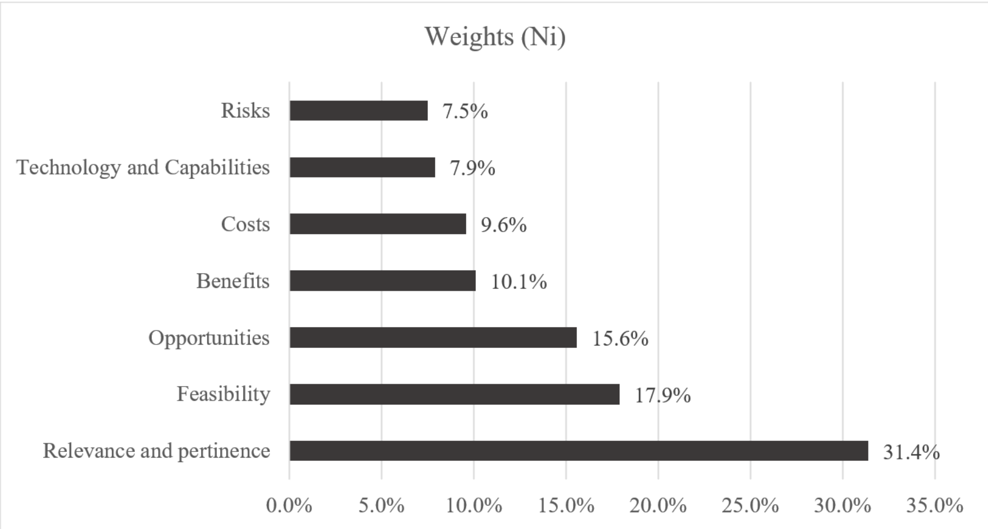

Figure 5. Local and global weights by criteria.

Source: Authors' own elaboration.

The overall weights were determined through evaluation by paired comparisons given by the experts for each of the subfactors. In the selection and prioritisation criteria, relevance is placed first, followed by possible citations, the group of researchers available for linkage, the possibility of access to funding resources through external calls and the increase in the number of students in the graduate programs.

Finally, rating scales were established for each criterion considering the subfactors selected to evaluate the topics. It was decided to use a 3-point scale for all criteria: High (A), Medium (M) and Low (B). The team of experts used each rating to assess the degree to which a specific topic fulfilled a particular criterion. Combining the criteria with the 3-point rating scale yielded the hierarchy in **Figure 6**.

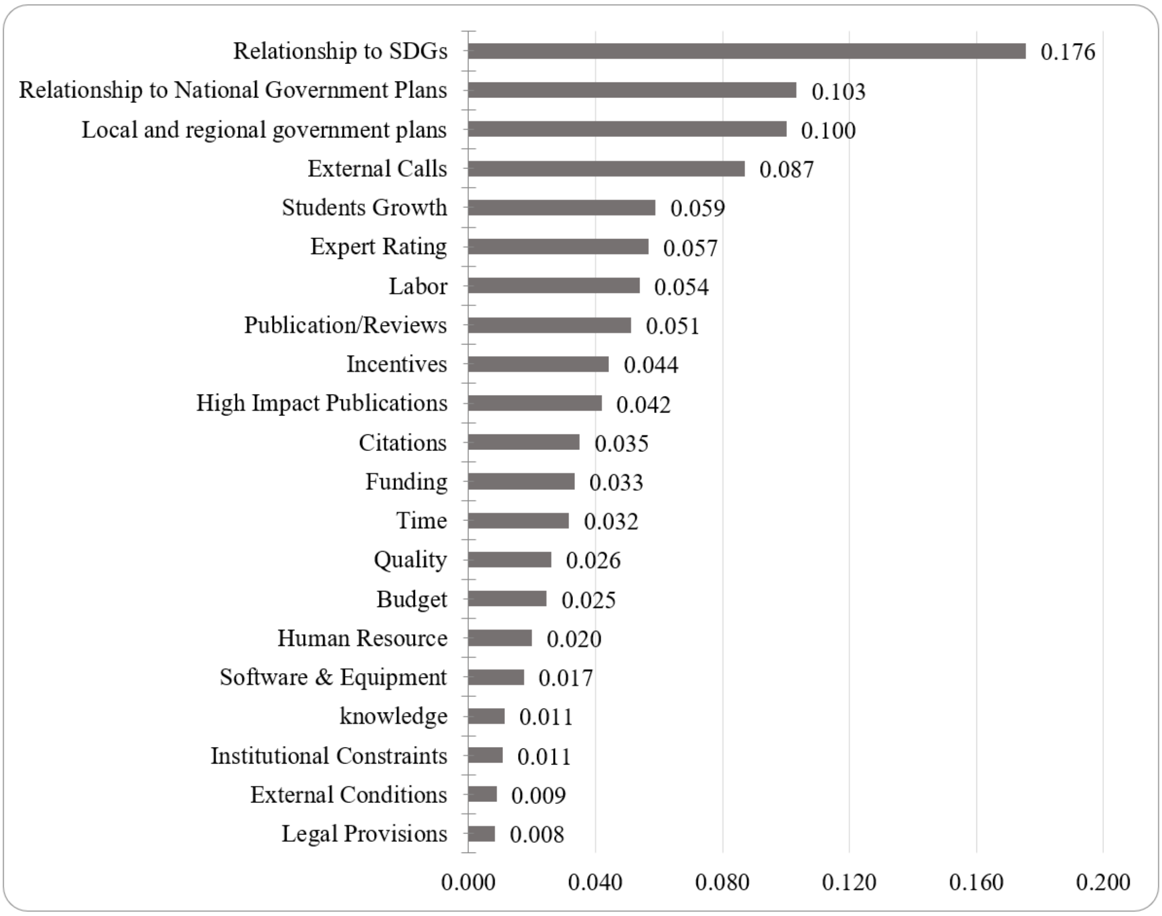

Figure 6. Rating scale of the topics according to the rating of the subfactors on the 3-point scale.

For the reader's understanding, the multiplication of the global weight by the value assigned by the expert constitutes the local weight for each sub criteria. The relationship with the SDGs has reached a high value. The relationship to national, local and regional government plans is in third place.

The results support the arguments of Müller et al. (2019), who unveiled the new role of project management as a discipline that integrates different areas of knowledge. In this sense, the prioritisation of the topics, headed by the topic of research management of projects focused on SDGs, demonstrates the role of the project area and its actors in shaping the future (corroborating the approaches of Lukianov et al. (2019) and PMI (2015)) and the importance of projects as a mechanism to achieve transformations in society through the generation of social, economic, commercial, and environmental results by companies and the government.

Similarly, Cicmil et al. (2017) affirmed that priority in higher education includes the imperatives of SDGs. It is a process that must involve all stakeholders in a responsible cross-institutional engagement with purpose, values, method, research, dialogue and partnership. In the context of business and management education, it is necessary to define how triple bottom line influences the curriculum, research and community projects.

According to the literature review, greater interest is being generated in relating project management to sustainability, which is an emerging field of study. However, it is necessary to generate more empirical studies to better explain this relationship (Silvius, 2017).

5. Conclusions

The bibliometric analysis conducted using VOSviewer software has effectively laid a foundational understanding that dovetails with the evaluation of four targeted research lines in project management. These lines, examined through the Fuzzy Analytic Hierarchy Process (FAHP), include A1 (Project management focused on Sustainable Development Goals), A2 (Decision Sciences for Project Management), A3 (Hybrid Approaches to Project Management), and A4 (Project management and science, technology, and innovation approach). Each research line was assessed across seven critical criteria, reflecting their strategic importance and the respective weight each holds in the decision-making process. The results from this evaluation underscore the alignment of each research line with strategic research priorities, with A1 emerging as particularly significant due to its focus on Sustainable Development Goals.

The integration of bibliometric insights with the FAHP evaluation proves crucial. The keyword analysis highlighted dominant themes such as ‘Project Management,’ ‘Decision Making,’ and ‘Sustainable Development,’ which are directly linked to the assessed research lines. This correlation not only underscores the relevance of the selected research lines within the broader academic and practical contexts of project management but also confirms the appropriateness of the FAHP approach in aligning research priorities with key themes in existing literature.

Moreover, the incorporation of scientometric indicators such as citation counts and publication frequency provides a solid empirical foundation that further substantiates the significance of these research areas. Notably, the prevalence and connectivity strength of terms like ‘Project Management’ and ‘Sustainable Development’ reflect their prioritization in the research, bolstering the credibility of the FAHP outcomes.

This methodological synthesis of bibliometric data and FAHP evaluation enriches the analytical depth of the study and strategically positions the research within both current and prospective project management landscapes. It ensures that the chosen research directions are not only grounded in theoretical rigor and methodological precision but also resonate with ongoing scholarly debates and practical challenges in the field.

The study has utilized the FAHP combined with expert judgments effectively to prioritize project management research topics, placing a strategic emphasis on sustainability and decision sciences. The rankings derived from this process reflect not only the current strategic directions but also address the urgent needs within the field. Detailed analysis has identified factors and dimensions that influence these topics, leading to a weighted ordering of subfactors and a thorough evaluation of the benefits, opportunities, costs, and risks associated with each topic.

Ultimately, the study provides a robust framework for selecting research topics in project management that align with global standards and effectively address regional needs. By focusing on strategically chosen topics, the research contributes significantly to the academic literature and guides practical implementations in project management education and practice. Future research should extend this work by examining the long-term impacts of these topics on academic advancements and industry practices, thus enhancing the developed framework.

The evolving project management landscape requires methodologies that prioritize agility, resilience, and responsiveness. By integrating these principles into educational programs and practices, future project managers are better prepared to navigate the complexities of modern projects. The study also underscores the utility of the Analytic Hierarchy Process (AHP) in refining decision-making within project management, offering a reliable, reproducible method that aids decision-makers in evaluating and selecting project management tools through a structured, multi-criteria approach.

Furthermore, the study encourages universities to actively engage in sustainable development through focused research and teaching, thus enhancing the relevance and impact of their academic programs. It is recommended that future studies explore the practical implementation of these prioritized methodologies in real-world project settings and continuously refine decision-making tools like AHP to maintain their relevance and effectiveness in a dynamically changing project environment. This ongoing effort will ensure that project management practices and education remain adaptive and forward-thinking, preparing project managers for success in a rapidly evolving global context.

Discussion of results

This study's effective deployment of the Fuzzy Analytic Hierarchy Process (FAHP) as a multi-criteria decision-making tool has significantly streamlined the intricate process of selecting research topics. Consistent with Prieto (2018), FAHP has demonstrated its capability to kick-start complex research initiatives through collaborations with universities and agencies, exemplified at University Institution Pascual Bravo. Here, FAHP's strategic implementation facilitated a thorough evaluation of diverse research topics without sidelining any potential alternatives, ensuring that the selection process was both comprehensive and focused.

The prioritization of research topics such as "Project Management focused on SDGs", "Decision Sciences for Project Management", among others, addresses the varied needs within the academic community. This aligns with the observations by Storey et al. (2017), who highlighted the importance of adapting educational practices to include Sustainable Development Goals (SDGs) and strategies reflective of real-world challenges. This study supports this need by preparing future leaders with the tools and knowledge to tackle societal and regional challenges effectively.

Furthermore, the study prompts a discussion on how universities can systematically tackle sustainability challenges. Isenmann et al. (2020) propose that universities should adopt multi-level strategies for sustainable development through focused research and teaching, enhancing the relevance of academic programs and ensuring universities' active contribution to sustainable development. Our findings support this view by showing how FAHP can help select research topics that align with strategic educational and societal goals.

Additionally, the Analytic Hierarchy Process (AHP) provided a reliable decision-making framework that complemented FAHP by facilitating the assessment and selection of project management tools through a structured, multi-criteria approach. This was crucial in minimizing the influence of subjective biases, enabling more informed and objective decision-making. The application of AHP in this context did not just validate its usefulness in academic settings but also underscored its broader applicability across various decision-intensive fields.

To sum up, the integration of FAHP and AHP within this research framework offers a robust model for academic institutions aiming to enhance their strategic decision-making processes. The outcomes contribute significantly to the academic literature and provide practical guidance for implementing effective project management practices. Future research should continue to explore the practical application of these methodologies in real-world settings and evaluate their long-term impacts on both academic advancements and industry practices, ensuring that the prioritization framework remains relevant and effective in addressing the evolving challenges of project management.

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