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Research Article

Analytical hierarchy process decision analysis and its application for the evaluation of barriers of construction technology

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Abstract

Potential solutions are therefore needed to remove barriers and promote the successful adoption of sustainable energy technologies, since impediments make it difficult to put sustainable energy technology into practice. Finding and prioritizing the most effective approaches to help the construction industry embrace sustainable energy technology and get over its obstacles is the aim of this study. The main strategies for lowering obstacles to the adoption of sustainable energy solutions are ranked using the approach this study suggests. The two approaches that form the foundation of the system are the analytical hierarchy process (AHP). In order to determine methods and obstacles, a comprehensive literature analysis is first conducted. The options are then appraised and the weights of the various obstacles to sustainable energy solutions are established using pairwise comparison and AHP. The building industry in the developing countries is the practical application of the proposed approach. The framework offers a comprehensive and practical instrument for decision-making on the adoption and application of sustainable energy solutions. The financial, political, and economic barriers rank as the biggest impediments, per the findings. The removal of these could be facilitated by funding, competent authorities, and the development of appropriate legislation.

1. Introduction

The building industry bears a larger portion of the burden for the highest energy consumption and environmental impact globally when compared to other industries [1]. Buildings provide more than 40% of global energy consumption and 40% of carbon dioxide emissions [2]. Adopting sustainable development practices in building projects can help mitigate these inverse effects. The use of green or sustainable energy technologies in building projects has drawn interest from researchers, contractors, developers, and legislators worldwide. Developing nations have also promoted this trend [3]. Technologies that lower energy use, save money, and lessen negative environmental effects are known as sustainable energy technologies by Jarnehammar et al., [4]. The use of SETs in building projects has become crucial for the construction industries globally in order to eliminate environmental difficulties and conserve energy by Nguyen et al., [5]. For 21st century organizations, the use of sustainable energy technology (SET) in building projects has grown to be a top priority since it can lower energy and carbon emissions [6]. Adopting the Sustainable Development Goals (SDGs), particularly Goal 7, which centers on promoting affordable and clean energy for everyone, also advances the 'United Nations' global vision [7,8]. When used in construction projects, SETs reduce environmental pollution and make optimal use of energy

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resources. The use of sustainable energy technology in building projects is being driven by a number of factors in the construction sector. However, there are still certain major barriers that make implementing sustainable technologies more difficult, and these problems cannot be eliminated simultaneously [9,10].

In certain cases, breaking through a barrier within the same industry requires a combination of policies, actions, and resources. In order to address major concerns in a prioritized manner, building projects should incorporate sustainable energy technologies; nevertheless, appropriate strategies need to be designed and prioritized. Less focus has been placed on developing economies in previous research in an effort to lessen obstacles and impose tactics for integrating SETs into building projects Ahmed et al.,[11]. Nonetheless, there is still a lack of research on the evaluation of adoption hurdles for SETs in poor nations. More than 20% of energy could be preserved in building projects by using SETs, according to Sharma et al.,[12]. Nazari et al., [13] numerous important obstacles to the use of SETs in building projects have been covered in a number of previous studies. One major obstacle to the use of SETs in building projects has been regarded as the lack of subsidies and the underfunding of such initiatives by governmental bodies. They found that two major obstacles preventing the adoption of SETs in building projects are loan programs with lower interest rates and a lack of knowledge about SET adoptions. According to research by Osiro et al., [14], two major obstacles that impede the implementation of SETs in construction projects are a lack of building energy rules pertaining to energy management in buildings and a shortage of professionals with the necessary training and experience. Another significant factor impeding the adoption of SETs in building projects is the top leadership's lack of interest in the development of SETs and their incorrect application Montedonico et al.,[15]. Prior research on the adoption of SETs has primarily examined developed country perspectives. Developed nations have developed many approaches to evaluate and manage energy performance by integrating green technologies into building projects by Ahmad et al.,[16] Metinal and Ayalp [17] using a barriers factor (week policy framework, low contractor engagement, supply chain fragmentation and lack of training on circular methods). They found that effective circulation practices are hindered by insufficient regulatory support and poor industry collaboration. According to Bux et al.,[18] Singapore is dealing with a number of problems that make it difficult for the country to embrace energy management systems. These problems include inadequate employee training, improper management of SET expertise, and a lack of a master plan to inform tenants about energy-efficient solutions. The implementation of green technologies in construction projects can be complicated, which is recognized as a major obstacle in the Swedish construction sector Hussain et al.,[19].

Therefore, it can be claimed that governments in industrialized nations have implemented a number of programs, like as incentives, green certification, and funding for research and development, to force developers and contractors to employ energy-saving technologies in their construction projects. However, because of disparate political environments, shifting cultural norms, disparate economic circumstances, and disparate governmental actions, the findings of these developing countries cannot be extrapolated to other developing nations. Energy conservation is crucial for construction projects, however in developing nations like Pakistan, proper planning for the creation of SETs programs is lacking, and the regulations needed to solve the issues associated with SETs are inadequate by Karamat et al.,[20]. Innovative methods to improve energy management in building projects are highlighted by a positive outlook, solid understanding of cutting-edge technologies for SET optimization, and professional involvement in the formulation of SET adoption policies. In Pakistan, the necessity and long-term advantages of SET adoption have already been investigated. Nonetheless, the building sector is very concerned about identifying obstacles and creating plans to get through them. In order to help developers, contractors, and legislators create effective strategies, this study aims to identify, evaluate, and rank the hurdles to the adoption of SETs. Two integrated approaches, AHP and Technique for order preference by similarity to ideal solutions (TOPSIS), are used to evaluate various energy policies and look at important ones. The hybrid decision-making process used to rank SETs adoption techniques in building projects makes it challenging to evaluate specific numerical values because linguistic factors are used to incorporate expert opinion. In order to handle uncertainty, the AHP or TOPSIS model falls short. Consequently, in order to address issues that fall under the categories of ambiguity and uncertainty, a fuzzy technique must be applied. India's offshore wind energy sector faces many obstacles, which have been classified and recognized. To prioritize the barriers, an AHP with fuzzy logic technique is applied. Implications for these obstacles from a managerial and practical standpoint. The primary obstacle to offshore wind energy is the technological one Dhingra et al.,[21].

This research First off, the problems preventing the application of Green Construction Technologies (GCT) were the exclusive focus of the current investigation. In a subsequent study, policies and tactics for speeding up GCT application will be examined in more detail. Second, the contractor group and other stakeholder groups which consisted solely of clients and consultants were the basis for the comparison study by Wang et al.,[22]. This study offers fresh perspectives on the intricate patterns of effect among the various barriers that are gathered together to affect the adoption of Ephemeroptera, Plecoptera, Tricoptera Richness Index (EPT) in the building sector. It is the knowledge of the influence patterns of obstacles that researchers and practitioners possess. The building sector can benefit from this insight by developing more effective strategies that reduce the combined groupings of barriers and encourage a wider adoption of EPT by Yevu et al.,[23]. There are several obstacles to using block chain technology in environmentally friendly building projects. The barriers are analyzed in terms of their cause-and-effect linkages. Modelling their intricate relationships allows us to identify the most important obstacles.

Kumar et al.,[24] examined the biggest obstacles are end users' ignorance and the absence of wise policies. The three most important obstacles are accessibility, market unpredictability, and technological immaturity. Using a comparison of factors, the AHP is a multi-criteria decision-making strategy that evaluates the weight of criterion and sub-criteria. This method permits ambiguity and uncertainty in the decision-making process. Both integrated techniques have been applied in practical settings, and approach is incredibly straightforward and user-friendly. Demonstrated how often AHP is used in tandem with one another in study. Abdulsalam [25] investigated the infrastructure project barriers of lack of government mandates, resistance from traditional professionals, cost related concerns and absence of common data environments by fragmented implantation strategies. They found that biases in data collection due to unequal online access. Vaghefi-Rezaee et al.,[26] examined the primary obstacles (regulatory inertia, cultural opposition to change, absence of life-cycle assessment tools, economic pressure for short-term savings to achieving long-term sustainability objects. As the primary element for the subsequent study, offering a structure for scrutinizing and assessing the diverse facets and ramifications of the topic. Desai and Vasanwala [27] examined the relation or model of determine the critical storey height for design and code developed using full load condition and CSM analysis under gravity. Mai et al.,[28] examined the flexural performance of composite beams (high-strength steel girders and engineered cementitious composite slabs (ECC)) under flexure. They found that the ECC slab better alternative to conventional concreate.

Accordingly, this research adds the following, as stated in the paragraph above: Firstly, by examining the obstacles and strategies to support SETs in the construction sector, this study expands the corpus of information regarding SETs in developing countries. Since SETs are still in the early phases of acceptance, this study advances sustainable practices in the construction industry. By integrating AHP and other cutting-edge framework-building methodologies, it prioritizes SETs hurdles and tactics. Finally, an implication-based design is recommended in order to facilitate the smooth integration of SETs in India's construction sector.

2. Barriers to Technologies for Sustainable Energy

It has been observed that the implementation of stringent regulations imposed by the government on customers and contractors makes it feasible for technologies for sustainable energy to be adopted in developing country construction projects. But the adoption of technologies for sustainable energy is still in its infancy in developing nations like India. Emerging economies face challenges in implementing sustainable energy technology in construction projects because of several factors such as low awareness, environmental concerns, high costs, government intervention, and lack of legislative support. The adoption of sustainable energy technologies can be facilitated by stringent policy directives from the government and interest-free credit programs offered by financial institutions. The implementation of sustainable energy technology in construction projects can be successfully facilitated by the planning and design of professionals and policymakers. The study's barriers are divided into five categories, each of which has a sub-criterion, and are applied to the Indian construction industry. Data was gathered via a questionnaire survey in order to look into adoption hurdles in Indian. In order to identify potential impediments, the questionnaire's initial measuring scales were based on the literature research mentioned above. Prior to dispersing the questionnaire, a focus group discussion and pilot research were carried out to enhance the validity and reliability of the measurement scales. The focus group meeting was opened to questions and clarifications regarding additions, deletions, and grouping of various criteria. Three experts in sustainable construction were invited to participate. Twenty-two copies in all were gathered from the preserve. The original questionnaire barrier, "senior managers pay insufficient attention to adoption," was changed to, "senior managers working for contractors pay insufficient attention to adoption," in order to make sure the responder knew what "senior managers" meant. The original questionnaire was reworded with the problem item "Senior managers pay insufficient attention to adoption" replacing "Senior managers working for contractors pay insufficient attention to adoption" to ensure the respondent understood the original question. The restriction "The adoption of reduces the quality of construction project" was lifted because two experts claimed that a project's quality standard is a vital necessity and that if some technologies impair project quality, they are not useful technologies. Additionally, the accuracy of technical phrases and the coherence of the questionnaire's framework had to be evaluated by a professor with experience in questionnaire survey methods. These are some of the obstacles to using sustainable energy technologies in building projects, along with some strategies to overcome them.

2.1. Barriers from the Government

Governmental barriers include a lack of funding and subsidies, a government that is uninterested, a lack of attempts to promote, a lack of rules, and a lack of government participation in research and development carried out in educational institutions. There is insufficient legislation implemented by the government to regulate energy-saving measures and the implementation of Technologies for Sustainable Energy in the construction sector. Funding for stakeholders to implement and promote the Technologies for Sustainable Energy in building projects was not something the government was interested in doing. A key obstacle to the effective application of Technologies for Sustainable Energy in building projects is the lack of research and development in research institutes. One major barrier that impedes the implementation of technologies for sustainable energy in construction projects is the absence of laws and regulations and the legislators' indifferent attitude towards enforcing policies. Government rules that help stakeholders and experts remove various barriers can go a long way towards encouraging the use of energy-efficient technologies.

2.2. Barriers of Human

Cultural opposition to adopting green energy technologies over traditional technologies, a lack of labor and skilled professionals, a lack of professional interest in the adoption of technologies for sustainable energy, and occupant behaviors like using energy-saving devices and consuming more electricity while doing so are all examples of human barriers. Because of cultural norms, ancestry, and beliefs, people in emerging nations are hesitant to adopt novel technologies in their building projects. Therefore, it is also believed that cultural resistance is a significant barrier to the adoption of green technologies. A lack of skilled workers is impeding the use of sustainable energy technology in construction projects in developing countries. Experts and skilled workers are essential to maximizing an organization's revenue and decreasing its costs. The primary barriers impeding organizations' adoption of sustainable energy technology practices are staff members lacking experience and a lack of enthusiasm from green technology experts. Occupant behavior is a major barrier to comprehending and assessing the effective usage of energy-saving equipment since it can influence the construction industry's ability to properly implement sustainable energy technology.

2.3. Barriers of Economic

Barriers within an organization include Lack of education, workshops, and training; lack of knowledge of sustainable energy technology; lack of support from upper management; absence of a framework for measuring performance; lack of communication among stakeholders; and absence of incentives. The use of sustainable energy technology in construction projects is significantly hampered by employee ignorance about sustainable energy technologies, inadequate training, and a lack of workshops. Researchers found that a lack of knowledge about environmentally friendly technologies among key players makes developers and contractors less inclined to include sustainable energy technologies into their projects. Lack of knowledge about adopting sustainable energy technologies has been identified as a major barrier since incomplete and inaccurate information about green technologies prevents the implementation of sustainable energy technologies in building projects. Social awareness is further hampered by the dissemination of inaccurate information on sustainable energy technology. Any organization's top leadership is crucial in encouraging the use of green technologies. Regrettably, upper management in developing nations—including India—is unwilling to encourage and assist staff members in using cutting-edge sustainable energy technology rather than traditional technology in building projects. Because of this, the implementation of sustainable energy technology has been hampered significantly by a lack of senior management support. To increase the use of sustainable energy technologies, middle managers and lower-level managers require the backing of their top leadership. It has been noted that one major obstacle affecting the effectiveness of energy-saving equipment in building projects is the lack of a performance measurement system. Inadequate performance measurement systems in building projects might lead to costly issues. One major barrier to the use of sustainable energy solutions in construction projects is a lack of communication among stakeholders. Conflicts of interest regarding the adoption of sustainable energy technology might be anticipated throughout the various stages of construction projects due to the lack of communication between stakeholders. Examine the relationship between a lack of communication among stakeholders and a lack of support from top leadership. This is because top leadership inspires and motivates their staff to increase productivity. Leaders that engage in direct communication with their staff and other stakeholders can effectively deploy energy-saving solutions. A major barrier to organizational barriers has been the absence of benefits; offering rewards like green certifications has also drawn clients' and developers' attention to the use of sustainable energy technologies.

2.4. Barriers within Organizations

Barriers within an organization include Lack of education, workshops, and training; lack of knowledge of sustainable energy technology; lack of support from upper management; absence of a framework for measuring performance; lack of communication among stakeholders; and absence of incentives. The use of sustainable energy technology in construction projects is significantly hampered by employee ignorance about sustainable energy technologies, inadequate training, and a lack of workshops. Researchers found that a lack of knowledge about environmentally friendly technologies among key players makes developers and contractors less inclined to include sustainable energy technologies into their projects. Lack of knowledge about adopting sustainable energy technologies has been identified as a major barrier since incomplete and inaccurate information about green technologies prevents the implementation of sustainable energy technologies in building projects. Social awareness is further hampered by the dissemination of inaccurate information on sustainable energy technology. Any organization's top leadership is crucial in encouraging the use of green technologies. Regrettably, upper management in developing nations—including India—is unwilling to encourage and assist staff members in using cutting-edge sustainable energy technology rather than traditional technology in building projects. Because of this, the implementation of sustainable energy technology has been hampered significantly by a lack of senior management support. To increase the use of sustainable energy technologies, middle managers and lower-level managers require the backing of their top leadership. It has been noted that one major obstacle affecting the effectiveness of energy-saving equipment in building projects is the lack of a performance measurement system. Inadequate performance measurement systems in building projects might lead to costly issues. One major barrier to the use of sustainable energy solutions in construction projects is a lack of communication among stakeholders. Conflicts of interest regarding the adoption of sustainable energy technology might be anticipated throughout the various stages of construction projects due to the lack of communication between stakeholders. Examine the relationship between a lack of communication among stakeholders and a lack of support from top leadership. This is because top leadership inspires and motivates their staff to increase productivity. Leaders that engage in direct communication with their staff and other stakeholders can effectively deploy energy-saving solutions. A major barrier to organizational barriers has been the absence of benefits; offering rewards like green certifications has also drawn clients' and developers' attention to the use of sustainable energy technologies

2.5. Barriers to the Market

Market barriers are divided into four categories: inadequate methods for consistently defining and assessing sustainable technologies; absence of suppliers of sustainable energy technologies; absence of advertisements pertaining to the adoption of sustainable energy technologies; and lack of demand from consumers. Energy-efficient technology is imported into developing nations from developed nations, which raises the adoption cost of sustainable energy solutions. Thus, one major obstacle to the application of green technology in construction projects is the lack of manufacturing companies of novel technologies in the domestic market. This crucial factor is regarded as a major barrier to the application of sustainable energy solutions in construction projects because the construction industry does not actively promote the culture of adoption of these solutions in construction projects. The process of implementing sustainable energy solutions in building projects is hampered by improper methods for systematically defining and evaluating sustainable technology. One of the main factors that encourage spreading incorrect information about sustainable technologies is employee under training. One more obstacle linked to the lack of sustainable energy solutions manufacturing in the local market is the absence of suppliers of sustainable energy solutions. The restricted number of suppliers worldwide further restricts the choice of sustainable energy solutions providers.

2.6. The Proposed Methodology's Literature Review

This study used both AHP methodologies because AHP uses interval numbers to help eliminate uncertainty, ambiguity, and complex issues from Multi criteria decision making (MCDM) valuation criteria. AHP is better suited to look at experts' opinions. Furthermore, AHP is more appropriate because a group of components might be adjusted and rationally investigated while considering their importance. These components might be used to evaluate the alternatives, yielding a rank score that replicates this significant mark. AHP is better suited to look into expert opinions and the main advantage of combining AHP techniques to improve decision-making processes. Furthermore, the decision-making process is enhanced by the combination of the AHP approaches. AHP eliminate many difficult issues that arise from AHP adoption on an individual basis. The AHP approach has eliminated several complexities that are unique to AHP solutions. When there are not enough criteria or solutions, the AHP solution may be employed separately; however, the threshold must be met by the number of pair wise comparisons made by experts. AHP is incorporated into this innovative study in light of the aforementioned advantages. This study employs three-stage techniques. The first step was illustrating the pertinent literature on tactics and obstacles to the adoption of sustainable energy solutions. The weights of the various criteria were evaluated in the second stage using AHP. The AHP method has been used in numerous studies to determine the relative weights of various options.

2.7. Research Methodology

The use of sustainable energy technology has been increasingly important to the Indian construction industry in recent times. However, there are still several major obstacles that prevent the Indian construction industry from implementing sustainable technologies. In order to ensure that sustainable energy technology is imposed in building projects, a number of significant obstacles that impede the adoption of sustainable energy technology are identified, and countermeasures are assessed. This study ranked the approaches for adopting sustainable energy technologies to reduce their barriers using a three-phase methodology. AHP is used to evaluate the weight of the barriers' a criterion is used to assess the obstacles' strategies. Complex decision-making difficulties are sorted out using the AHP methodology; however, the decision-making process could be strengthened. The framework's application with these multi-criteria approaches demands that all ambiguity and uncertainty be eliminated from the decision-making process. The study's research framework is shown in Fig. 1.

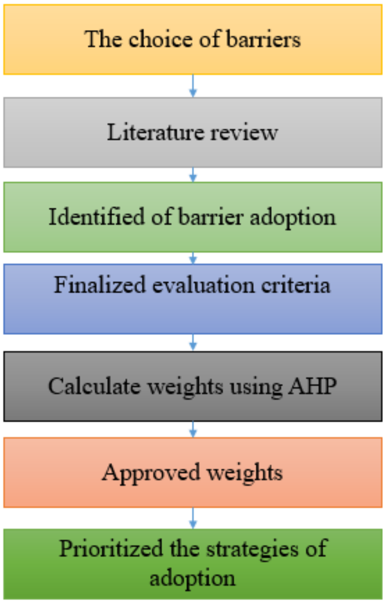

Fig. 1. Stages of the research methodology

2.8 Evaluation of the Barriers to SETs and Their Solutions

The initial stage of the technique involved the formation of an expert group comprising academics, business professionals, consultants, and engineers. As seen in Fig. 2, the assessment of the obstacles to the adoption of technologies for sustainable energy is divided into criteria and sub-criteria, and solutions to lessen these limitations are provided step by phase.

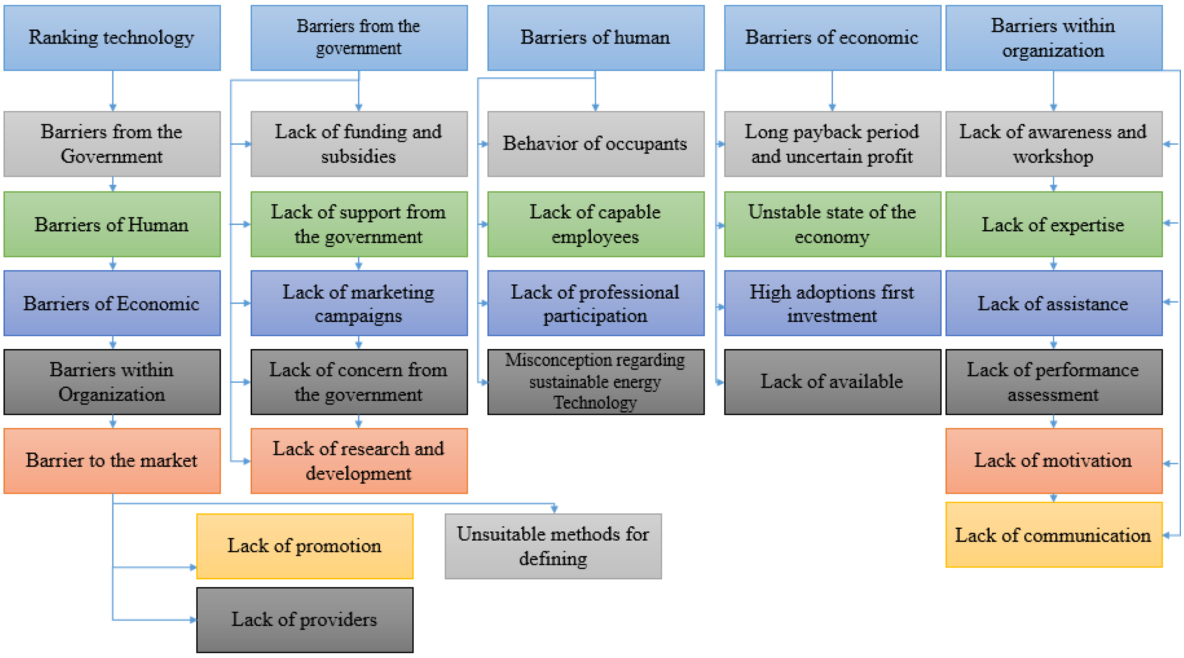

Fig. 2. Sequential diagram showing potential routes around various barriers

2.9 Analytical Hierarchy Process (AHP)

- Step 1: identify the objective or unstructured problem.

- Step 2: A hierarchical framework was created for the multi-criteria problem made up of a lot of tiny component elements. At the intermediate level, the assessment criteria are compiled, and at the lowest, the candidate options are located; and at the highest, the foundation is laid.
- Step 3: Judgment matrices are created for each assessment criterion using Saaty's nine-point scale, which is shown in Table 2. Pair-wise comparisons are made between items at the same level at the next higher level in a sequence of pair-wise comparisons. Pair-wise comparisons of several criteria, for instance, were used to generate Matrix A.

Table 1. Pair-wise comparisons using the Saaty's scale

Verbal assessment	Value in Numbers
Highly crucial	9 8
Strongly more significant	7 6
Significantly more crucial	5 4
Slightly more important	3 2
Equally significant	1

- Step 4: The comparison matrix A is then normalized and transformed as matrix B. Each component of a matrix B is determined as;

$$K = \frac{h_{ik}}{\sum h_{ik}} \tag{1}$$

The items in each matrix row B are averaged to create the weighted criterion vector w or compute eigenvector.

$$E = \frac{\sum N_{ik}}{n} \tag{2}$$

The largest eigenvalue is found using the following equation after step-by-step comparisons of the various criteria produced at step 4.

$$\gamma = \frac{1}{m} \sum_{k=1}^{n} \frac{Dq}{q} \tag{3}$$

Where in the comparison matrix, max is the highest possible eigen value.

- Step 5: A consistency evaluation of the order m matrix. The AHP offers a helpful way for confirming the constancy of the evaluations when developing each matrix used for pairwise comparisons utilized in the procedure. Verify the correctness of the matrix by computing the correctness Index (CI).

$$CI = \frac{\gamma - n}{n - 1} \tag{4}$$

- Step 6: Determine the consistency ratio (CR), which is the difference between the matrix's consistency index and a random-looking matrix's consistency index. The value of RI is derived from a randomly created matrix's consistency index.
- Step 7: For each criterion, local ratings, multiply the weighted average of each alternative's ratings according to the sub-criteria and add the results. The local ratings are then added together with the criteria's weights to produce the global ratings, which are then totaled. The choice rating process is finished by sorting the overall ratings into decreasing order.

2.10. Application of the Recommended Approach for SETs Adoption in Building Projects

This study's pair wise analysis of each element yielded five criteria and twenty-two sub-criteria. Table 1 shows the TFN values that were chosen to finish the process. Tables 2 through 7 provide the comparison matrix procedure along with the weights, criteria, and sub-criteria. Using Microsoft Excel, all of these computation procedures were carried out. Table 1 presents the final findings of the criteria and sub-criteria**.**

3. Results and Discussion

Although determining the relative relevance of each SET barrier is a challenging procedure, experts have found it to be straightforward and rational to priorities them by using the AHP approaches.

Table 2. Criteria pair wise for barriers

		BG	BH	BE	BO	BM	Weight	Rank
BG	B1	1.0	1.0	2.0	0.5	0.5	0.164374	3
BH	B2	1.0	1.0	2.0	0.3	1.0	0.164374	4
BE	B3	0.5	0.5	1.0	0.3	1.0	0.114869	5
BO	B4	2.0	4.0	3.0	1.0	0.3	0.286192	1
BM	B5	2.0	1.0	1.0	3.0	1.0	0.27019	2

Finding the barrier with the highest weight value was a necessary step in order to rank the SETs. This shows the following descending order of impediments related to commercial, personal, organizational, and governmental factors: Table 2. The findings indicate that barriers play a significant role in impeding the adoption of SETs in Indian construction projects. The sub-criteria ranking of government barriers is B4> B5> B1> B2> B3, indicating that barriers within organizations' support are more significant impediments to SET adoption in construction projects as sown in Fig. 3 (Criteria pair wise), lack of concern in Fig. 4 and the sub-criteria pair wise Rank in Fig.5.

Table 3. Comparison of lack of concern

		LFS	LSG	LMC	LCG	LR&D	Weight	Rank
LFS	A1	1.00	1.00	2.00	0.20	3.00	0.039299	2
LSG	A2	1.00	1.00	2.00	0.25	1.00	0.037892	3
LMC	A3	0.50	0.50	1.00	0.33	1.00	0.037892	4
LCG	A4	5.00	4.00	3.00	1.00	0.33	0.847024	1
LR&D	A5	0.33	1.00	1.00	3.00	1.00	0.037892	5

The sub-criteria of "Barriers from the Government" are ranked as follows: A4 > A1 > A2 > A3 > A5, indicating that the government's lack of concern is one of the main barriers preventing the adoption of SETs in construction projects as shown in Table 3. The sub-criteria for Barriers of human adoption have a weighted ranking of likewise high for C4 misperception about the impact of SET on the adoption of SET technologies, and lowest for L2 lack of competent people. Further barriers are as follows, in ascending order: C4>C1>C3>C2 as shown in Table 4. Table 5 shows that the barriers of economic ranking weightage is D3>D4>D2>D1, indicating that D3 high adoption first investment is prioritized a substantial obstacle to the use of SETs in building initiatives. Comparably, Table 6 shows that the order of Barriers within Organizations is M1>M2>M6>M3>M4>M5. Wherein the implementation of SETs in building projects has been found to be severely hampered by a lack of awareness and workshop. In a similar vein, Table 7 ranking of Market Barriers is U1>U2>U3, correspondingly. In which the adoption of SETs in building projects has been shown to be severely hampered by a lack of promotion. The remaining strategies are shown in Table 8 in decreasing order as S10, S6, S12, S2, S7, S15, S4, S14, S3, S5, S8, S1, S9, and S13.

These initiatives should be implemented by the NDIA construction sector and other relevant parties in a prioritized manner based on their respective rankings. The experts may evaluate and choose appropriate ways for the implementation of SETs to mitigate the hurdles by integrating AHP as shown in Fig. 6, Fig. 7 and Fig. 8.

Table 4. Sub-criteria for barriers of lack of competent people

		BO	LCE	LPP	MSET	Weight	Rank
BO	C1	1.00	2	2	0.3333	0.248486	2
LCE	C2	0.5	1	0.2	1	0.130041	4
LPP	C3	0.5	5	1	0.3333	0.220939	3
MSET	C4	3.00	1	3	1	0.400534	1

AHP is utilized in the compilation of the study's results. Strategies are ranked using the AHP, which is also used to determine the weights of obstacles. The study's conclusions made clear that the biggest obstacles to the application of SETs in building projects in developing economies particularly India come from the categories of governmental and economic hurdles. Governmental assistance is crucial in these endeavors as they are closely tied to societal well-being. The Indian government is not as enthusiastic in creating policies to encourage the use of SETs in the country's building sector.

Table 5. Sub-criteria for barriers of economic

		LPU	USE	HAI	LAR	Weight	Rank
LPU	D1	1.00	1.00	0.50	0.25	0.141639	4
USE	D2	1.00	1.00	1.00	1.00	0.238207	3
HAI	D3	2.00	1.00	1.00	2.00	0.336876	1
LAR	D4	4.00	1.00	0.50	1.00	0.283278	2

Table 6. The sub-criteria pair wise comparison with the criteria for barriers within organizations

		LCW	LE	LAIL	LPA	LCB	LM	Weight	Rank
LCW	M1	1.00	2.00	2.00	2.00	3.00	1.00	0.260274	1
LE	M2	0.50	1.00	3.00	4.00	4.00	1.00	0.260274	2
LAIL	M3	0.50	0.33	1.00	1.00	2.00	1.00	0.127607	4
LPA	M4	0.50	0.25	1.00	1.00	1.00	1.00	0.108363	5
LCB	M5	0.33	0.25	0.50	1.00	1.00	1.00	0.090232	6
LM	M6	1	1	1.00	1.00	1.00	1	0.153249	3

Table 7. The sub-criteria pair wise comparison with the criteria for market barriers

		LP	USET	LP	Weight	Rank
LP	U1	1.00	1.00	2.00	0.4	1
USET	U2	1.00	1.00	2.00	0.4	2
LP	U3	0.50	0.50	1.00	0.2	3

The absence of governmental laws and financial and governmental subsidies for the use of green technologies deters the building sector from promoting energy-efficient technologies (SETs) in construction projects. Furthermore, India's political unrest has an influence on the adoption of SETs as well since it makes it difficult for the construction industry to incorporate SET culture into building projects due to erratic political settings and inconsistent legislation across all governments. In industrialized nations, research and innovations are seen as the backbone of industries, supporting both the government's contribution to the national economy and the industries' ability to advance towards positive net profit trends.

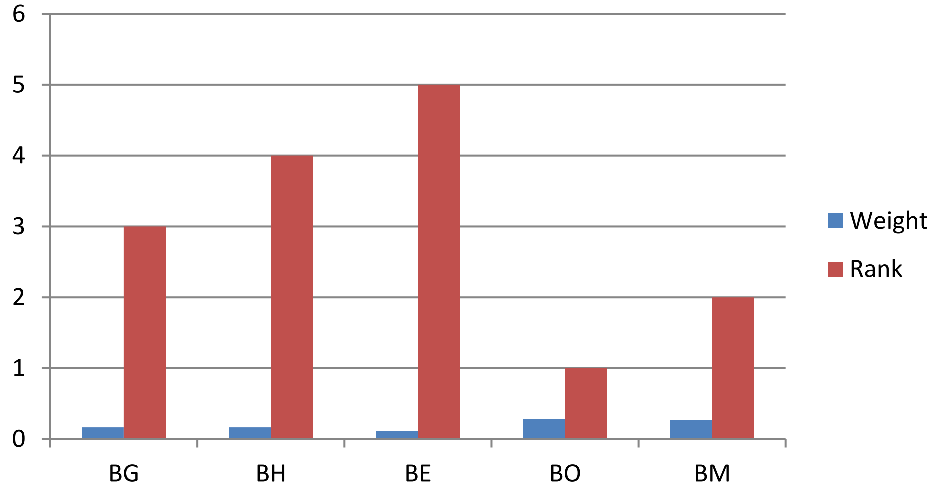

Fig. 3. Criteria pair wise barriers from the government

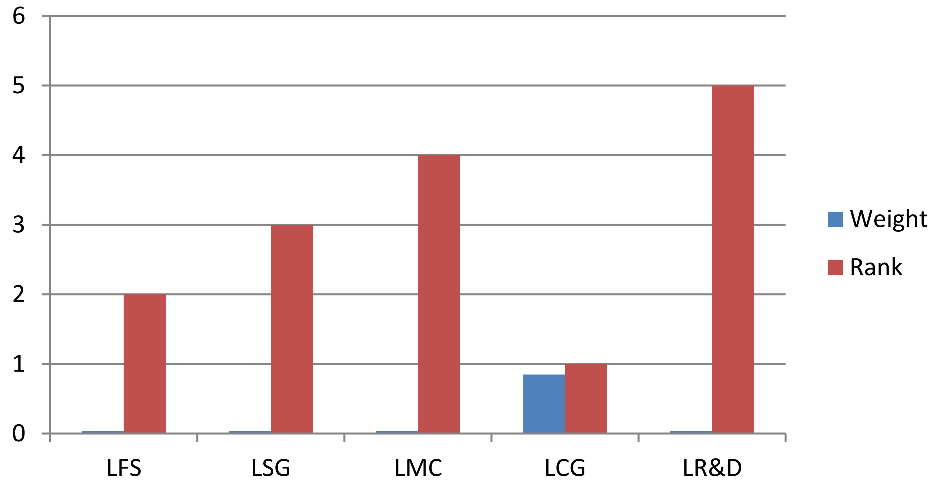

Fig. 4. Sub-criteria pair wise rank (lack of concern)

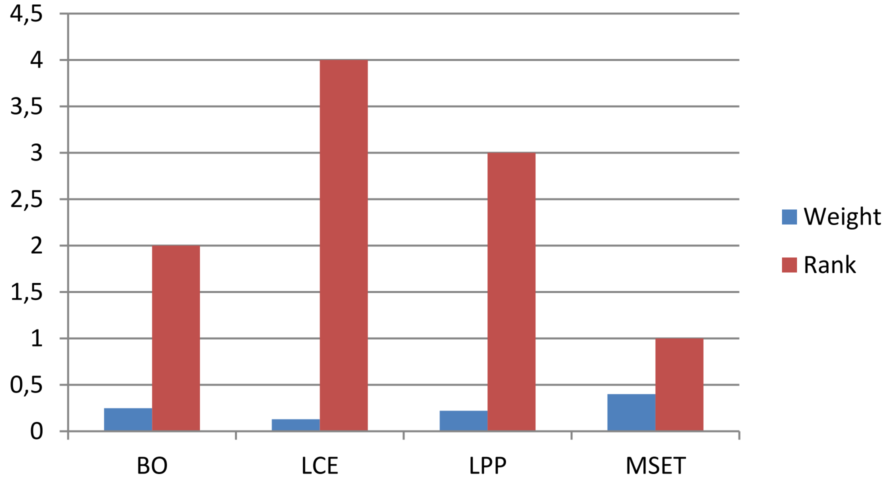

Fig. 5. Sub-criteria pair wise rank (lack of competent people)

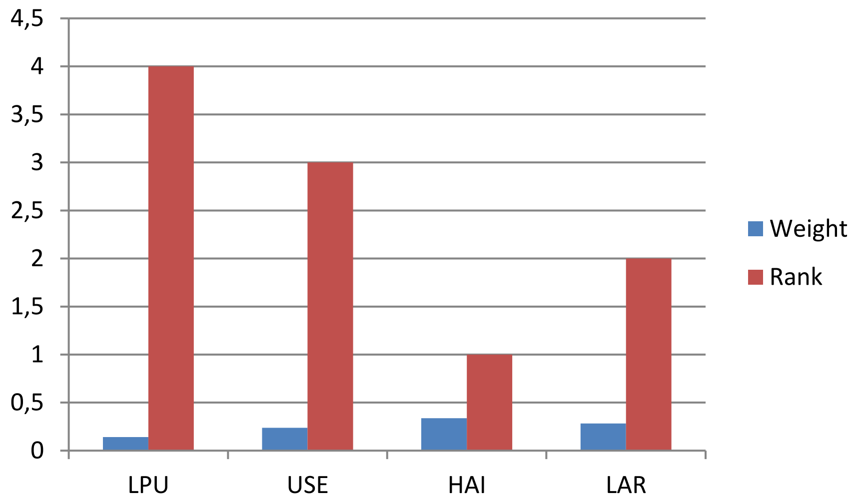

Fig.6. Sub-criteria pair wise rank (barriers of economic)

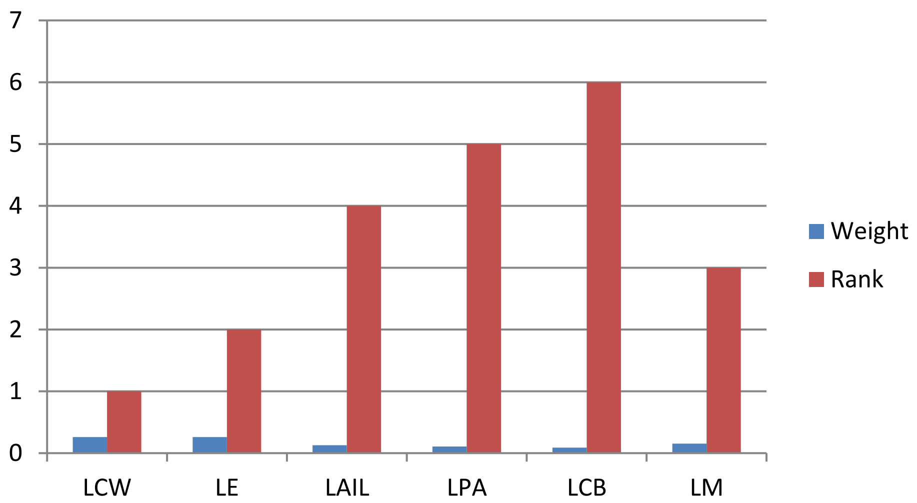

Fig. 7. Sub-criteria pair wise rank for barriers within organizations

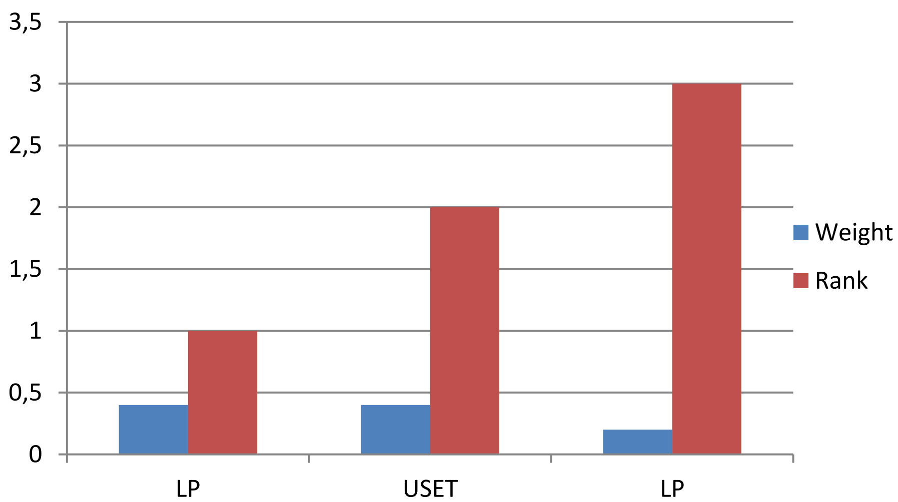

Fig. 8. Sub-criteria pair wise rank (market barriers)

Table 8. SETs barriers final ranking

Barriers	Weight	Criteria	Weight	Rank
Barriers from the Government	0.1643	LFS	0.039299	19
		LSG	0.037892	20
		LMC	0.037892	21
		LCG	0.847024	1
		LR&D	0.037892	22
Barriers of human	0.1643	BO	0.248486	8
		LCE	0.130041	14
		LPP	0.220939	10
		MSET	0.400534	2
Barriers of Economic	0.1148	BO	0.248486	9
		LCE	0.130041	15
		LPP	0.220939	11
		MSET	0.400534	3
Barriers within Organizations	0.2861	LCW	0.260274	6
		LE	0.260274	7
		LAIL	0.127607	16
		LPA	0.108363	17
		LCB	0.090232	18
		LM	0.153249	13
Barriers to the Market	0.3	LP	0.4	4
		USET	0.4	5
		LP	0.2	12

The results of the final calculations for the synthetic extent of the five criteria are provided in Table 8, which also includes the sub-criteria as shown in Fig. 9.

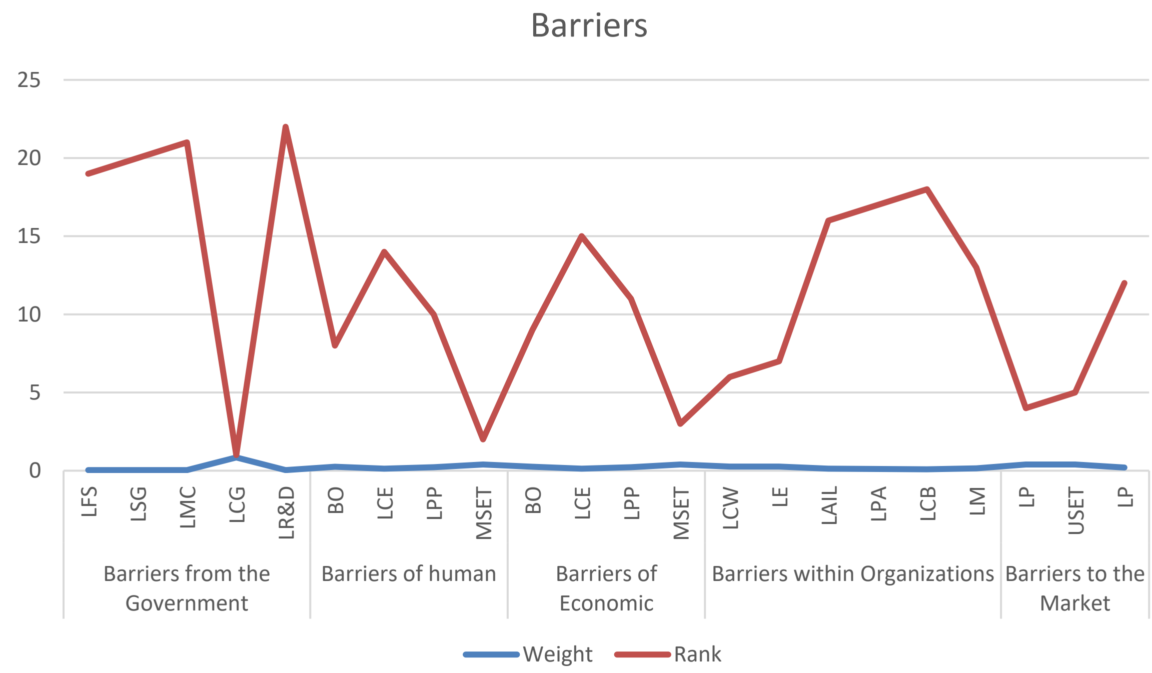

Fig. 9. SETs barriers final ranking

The following are a few achievable tactics to get beyond the financial obstacles posed by high investment prices and protracted payback times in sustainable energy projects:

- Manke use of creative financing model.
- Reducing risk to reduce financial stress.
- Fiscal plans, incentives, and subsidies.
- Make use of institutional investors and market mechanisms.

4. Conclusion

However, research and development are still in their infancy in underdeveloped nations, which pose a significant obstacle to the use of SETs in building projects.

- The Indian construction sector has recently focused more on cutting costs and time than on raising performance metrics. These kinds of activities have a detrimental effect on the adoption of cutting-edge, environmentally friendly technology.
- The barrier with the highest weight value had to be identified in order to rank the SETs. The findings indicate that barriers are a significant barrier to the adoption of SETs in Indian building project.
- One major challenge that impedes the adoption of SETs in India's construction sector is the extended payback period and fluctuating profit due to the bad economic situation in developing countries. The utilization of environmentally sustainable technologies in construction projects is hindered by insufficient finance from banks and scarce resources.
- The construction industry may alert stakeholders to the use of SETs in building projects if financial institutions assist investors with interest-free loans and provide them all the resources they need to promote the SETs in building projects.
- This article discusses the implications that the Indian construction industry should consider developing energy-saving techniques, overcoming difficulties, and stimulate the nation's economy.
- The ambiguity and inaccurateness of expert judgement are eliminated by combining these two multi-criteria techniques. Future analysis of this subject may make use of other multi-criteria approaches as TOPSIS, SAW, WPM, VIKOR, Graph theory, and best-worst method BWM.
- The achievable tactics to get beyond the financial obstacles posed by high investment prices and protracted payback times in sustainable energy in this work.

4.1 Future Scope

AHP may be utilized alongside other decision-making methodologies like fuzzy logic, TOPSIS, SAW, and WPM for the purpose of ranking alternatives. AHP can also serve to evaluate the challenges associated with adopting sustainable construction practices and technologies, such as green building materials and energy-efficient designs.

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Nomenclature

AHP	Analytical hierarchy process	TOPSIS	Technique for order preference by similarity to ideal solutions
BWM	Ballast Water Management	WPM	Weighted Product Method
SAW	Simple Additive Weighting	EPT	Ephemeroptera, Plecoptera, Tricoptera Richness Index
SET	Sustainable energy technology	LFS	Lack of funding and subsidies
MCDM	Multi criteria decision making	LSG	Lack of support from the government
TFN	Triangular fuzzy number	LCM	Lack of marketing campaigns
LR&D	Lack of government research and development	LPP	Lack of professional participates

BO	Barriers within Organizations	MSET	Misconception regarding sustainable energy technology
LCE	Lack of capable employees	BG	Barriers from the Government
BH	Barriers of human	BM	Barriers to the Market
BE	Barriers of Economic		

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