Evaluation of Social Projects Using Neutrosophic AHP

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Abstract

Recently, industrialization has led to a worldwide rise in energy usage. Consequently, satisfying rising energy demands has assumed more significance. Fuel, gasoline, and nat gas are all finite resources, making it all the more important to discover sustainable energy alternatives. To fulfill the current need for energy, renewable resources play a significant role. Therefore, energy decisions and government policy are of paramount importance for nations. Energy policy and judgment challenges, such as the appraisal of energy projects, the choice among fuel sources, the location of power plants, and the determination of energy policy, are solved using a variety of technical, financial, ecological, and social factors. Multi-criterion decision-making (MCDM) methodologies may be used to assess energy policy decisions, one of the important challenges for governments. Some of the challenges associated with making energy-related decisions and formulating policies are choosing between various energy sources, assessing the relative merits of various energy supply techniques, formulating an energy strategy, and carrying it through. Various forms of fuel sources are taken into account in the much research that has been conducted on energy decision-making challenges. Because they take into account several, sometimes competing, criteria in their assessments of potential solutions, MCDM techniques have proven useful in the resolution of energy-related decision-making issues. By combining MCDM with the neutrosophic set theory (NST), which captures the inherent ambiguity of human judgment, we may get more nuanced, tangible, and practical outcomes. This work intends to provide a thorough analysis of the methodology and implementations of neutrosophic MCDM in the power industry, as well as to synthesize the current literature and the latest recent breakthroughs to help guide researchers in this area. The neutrosophic Analytic Hierarchy Process (AHP) method is used to compute the weights of each criterion of energy in a social project. This research shows that neutrosophic AHP, either on its own or in combination with another MCDM approach, is the most often used MCDM technique.

Keywords: Neutrosophic; AHP; Energy; Social Project; MCDM

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1. Introduction

Energy is a common social project. The scientific, technical, sociopolitical, ecological, and financial significance of energy cannot be overstated. Energy consumption rises globally as a result of industrialization and technological development. Consequently, the notion of energy planning has grown in importance for nations. Countries that are well-positioned economically because of their access to plentiful energy supplies[1]. Considering the limitations of conventional fuels like gasoline, natural gas, and oil, the use of renewable energies is on the rise. In addition, the emissions of greenhouse gases (GHG) from these sources are lower than that of traditional forms of energy [1]. In light of its significance, energy has been deemed a promising study domain. Producing countries' economies and economic growth are highly dependent on fossil fuels, making climate change and energy consultation meeting frameworks all the more crucial to these nations. Since Iran possesses the world's fourth-largest oil reserves and the world's second-largest natural gas reserves but has historically put less emphasis on the creation of alternative energy, it would serve as an instructive case study in this regard[1-3]. A growing percentage of fossil energy export is being redirected to domestic use due to rising domestic energy demand (6.2% yr-1 during the previous decade) [4]. As a result, Iran is now the world's third-biggest user of natural gas, and it has the potential to become the biggest shortly. Iran's energy intensity is three times the global average, and it's per capita energy consumption is more than ten times that of Japan or the European Union [4-6]. If Iran is unable to expand its energy output, the country may one day have to import energy from other countries. As another worrying statistic, Iran ranks high on the list of countries that produce the most carbon dioxide (CO_2), contributing over 2% to global greenhouse gas emissions. Russia, as well as the Persian Gulf, are two additional major fossil fuel producers, and both share this problem. In the nations that produce fossil fuels, improving the efficiency with which they use local, renewable energy sources might help mitigate climate change and stimulate their economies [7]. However, this would need adjustments to the energy strategy to prioritize renewable energy sources throughout the strategic planning[4-7].

Decision-makers may use multi-criteria decision-making (MCDM) to narrow down their options and zero in on the best one based on how well they meet several criteria. Alternative evaluations using multi-criteria decision-making procedures are employed successfully as advanced instruments by decision-makers. However, neutrosophic MCDM techniques may be used to produce more nuanced findings when standard MCDM approaches are deemed insufficient to manage ambiguity in linguistic expressions [8-13].

Examples of energy applications include choosing where to put a power plant, evaluating energy options, setting energy legislation, and organizing a financial strategy for energy investments. These dilemmas in energy decision-making are tackled using a variety of criteria, including technological, ecological, financial, ethical, and political circumstances. This means that MCDM techniques may be used to these issues and assessed as such. Energy decision-making difficulties are common in the research literature, and MCDM approaches are often used to manage them. Neutrosophic logic is embraced because of its flexibility in dealing with ambiguity. In 1995, Smarandache proposed neutrosophic theory, which was further developed by the fuzzy set theory and the fuzzy hesitant fuzzy theory. In fuzzy theory, neutrosophic sets are categorized not only by their resemblance to triangular numbers, but also by their levels of truthiness, falsity, and indeterminacy. We used the neutrosophic theory with the AHP method to accomplish our study aims[14-16].

Maintaining human life depends on a constant supply of energy, which may be thought of as the capacity to do work. The two broad categories of energy supply are nonrenewable and renewable. Nonrenewable sources of energy are those that have finite supplies, such as coal, gasoline, nat gas, and nuclear power. Solar, wind, water, thermal, biofuel, methanol, and wave power are all examples of renewable energy. More details on these fuels may be found in the aforementioned studies. However, many researchers who evaluated energy issues have dealt with either nonrenewable or sources of renewable energy. The decision between renewable and nonrenewable energy sources, the location of power plants that use either kind of energy, and the planning of future energy supplies are all examples of the types of energy issues that fall under this category. Countries want to find solutions to energy challenges using analytical and more dependable approaches since energy is such an important notion for long-term growth [17]. In this light, multi-criteria decision-making (MCDM) procedures stand out as powerful resources for analyzing and ranking potential solutions over a wide range of dimensions before making a final, informed choice[6,18]. MCDM is also used to evaluate energy issues, with technological, financial, ecological, and social and political variables

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all needing to be taken into account. As it stands, Methodologies are recognized as suitable approaches to evaluate many facets of decision-making issues and arrive at a satisfying answer for experts. The most well-known MCDM techniques are applied to energy experts and policy matters, including the AHP, the ANP, the TOPSIS, the ELECTRE, and the PROMETHEE [18-19].

Thomas L. Saaty created the AHP, a method of MCDM. In the AHP technique, the issue is structured into a hierarchy including a set of objectives, a set of criteria, and a set of potential solutions. There are three distinct tiers to this organizational system. The objective is at the very top, the primary and secondary requirements are in the center, and the possible solutions are at the very bottom. In the traditional AHP technique, achieve a set is built using crisp numbers based on expert ratings of criteria and alternatives. Mathematical calculations are made on the weights of alternatives, and the one with the greatest weight is chosen as the optimal one. The AHP is a useful MCDM approach for energy decision-making issues since it does not rely on complicated mathematical operations and is instead based on a hierarchical framework that enables each criterion to be better focused. Even by way, it has some drawbacks, such as (i) having multiple decision-makers involved can make the issue more complex, (ii) having multiple decision-makers involved can make continuity complicated, and (iii) having interrelationships between goals and options can produce inaccurate results.

Saaty has created an improved version of the AHP approach called the ANP methodology. This method provides a "supermatrix" strategy for making decisions by factoring in connections and responses. The mathematical framework provided by the AHP approach makes it possible to methodically investigate various types of relationships and feedback. In addition, this approach facilitates collaborations and responses amongst clusters.

2. Assessing the Tools and Criteria Used for Making Energy-Related Decisions

We briefly discuss decision-making approaches and parameters to better appreciate their strengths and shortcomings in the context of planning and policy before introducing the method employed in this study.

2.1 Methods of Energy Policy Determination

Sustainable power management and oil reserves allocation are only two examples of sustainable energy management and resource policy where MCDM approaches are widely used. Energy planning choices that include competing criteria and competing goals might benefit from MCDM's problem-solving abilities. Methods like weighted averaging, weighted sums, prioritization, outranking, fuzzy logic, and other permutations thereof are used in MCDM. Numerous multi-criteria decision-making (MCDM) techniques have been developed, including the AHP, the ANP, the TOPSIS, VIKOR, the PROMETHEE, and the SWARA. There has also been much research into the viability of various MCDM strategies for giving preference to renewable energy sources.

There are four steps in MCDM: deciding on criteria, assigning weights to those criteria, evaluating the decisions made, and finally aggregating the results. Each step may use a unique strategy, tailored to the task at hand and the overall objective. Decisions about a sustainable energy source must take into account technological, financial, ecological, and social factors. In energy planning, the judgment procedures may get more complicated when many criteria are at odds with one another. Fuzzy multi-criteria decision-making methods might be used to deal with the added complexity introduced by taking uncertainties into account.

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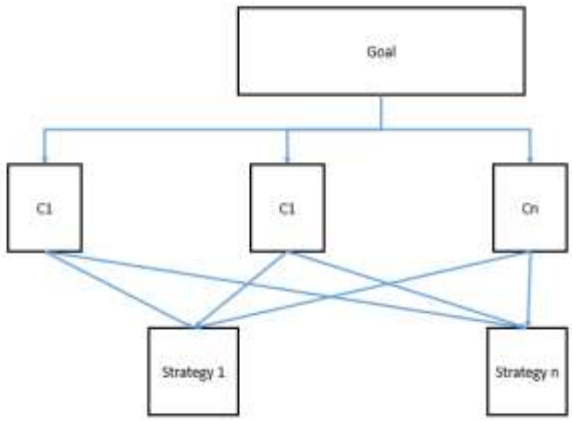

Figure 1: The AHP structure.

3. Methodology

Incorporating neutrosophic AHP, this part presents a complete technique for energy evaluation in social projects. The investigation consisted of three phases. To begin, we reached out to professionals in the social projects who are intimately familiar with energy operations and asked them to compile a list of the criteria for their energy. Second, we had professionals compile a set of assessment and management criteria. Third, we had professionals rate the merits of several approaches to energy social projects based on a neutrosophic scale. Using questionnaires and in-person interviews, we were able to wrap up the procedure in almost 3 hours. Figure 1 shows the AHP goal. This study presents a research framework, shown in Figure 2, based on existing literature on energy social projects and the choices made by social project specialists.

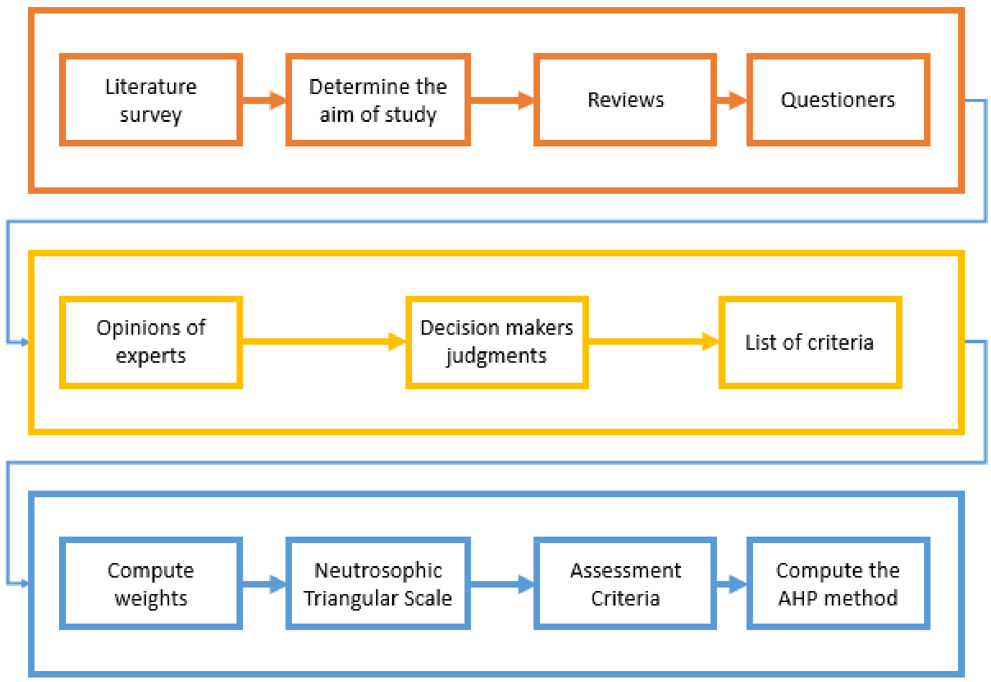

Figure 2: The Research Methodology.

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Definition 1:

Truth-membership function $TNe(x)$, indeterminacy-membership function INe(x), and falsity-membership function $FNe(x), where\ x \in X$ and X is a point-spread, are the three membership functions that describe the neutrosophic set N. The same is true for $TNe(x): X \in [0, 1+], INe(x): X \in [0, 1+], and\ FNe(x): X \in [0, 1+]$. When added together, $TNe(x), INe(x), and\ FNe(x)$ may take on any value from 0 to 3+.

Defintion 2:

$$a^{\sim} = \langle (a1, a2, a3); \alpha a^{\sim}, \theta a^{\sim}, \beta a^{\sim} \rangle\ and\ b^{\sim} = \langle (b1, b2, b3); \alpha a^{\sim}, \theta a^{\sim}, \beta a^{\sim} \rangle$$

$$a^{\sim} + b^{\sim} = \langle (a1 + b1, a2 + b2, a3 + b3); \alpha a^{\sim} \wedge \alpha b^{\sim}, \theta a^{\sim} \vee \theta b^{\sim}, \beta a^{\sim} \vee \beta b^{\sim} \rangle$$

$$a^{\sim} - b^{\sim} = \langle (a1 - b3, a2 - b2, a3 - b1); \alpha a^{\sim} \wedge \alpha b^{\sim}, \theta a^{\sim} \vee \theta b^{\sim}, \beta a^{\sim} \vee \beta b^{\sim} \rangle$$

$$a^{\sim} - 1 = \langle (\frac{1}{a3}, \frac{1}{a2}, \frac{1}{a1}); \alpha a^{\sim}, \theta a^{\sim}, \beta a^{\sim} \rangle, where\ (a^{\sim} \neq 0)$$

$$\frac{a^{\sim}}{\gamma} = \left\langle \left(\frac{a1}{\gamma}, \frac{a2}{\gamma}, \frac{a3}{\gamma} \right); \alpha a^{\sim}, \theta a^{\sim}, \beta a^{\sim} \right\rangle\ if\ (\gamma > 0)$$
$$\langle (\frac{a3}{\gamma}, \frac{a2}{\gamma}, \frac{a1}{\gamma}); \alpha a^{\sim}, \theta a^{\sim}, \beta a^{\sim} \rangle\ if\ (\gamma < 0)$$

$$\frac{a^{\sim}}{b^{\sim}} = \left\langle \left(\frac{a1}{b3}, \frac{a2}{b2}, \frac{a3}{b1} \right); \alpha a^{\sim} \wedge \alpha b^{\sim}, \theta a^{\sim} \vee \theta b^{\sim}, \beta a^{\sim} \vee \beta b^{\sim} \right\rangle\ if\ (a3 > 0, b3 > 0)$$
$$\left\langle \left(\frac{a3}{b3}, \frac{a2}{b2}, \frac{a1}{b1} \right); \alpha a^{\sim} \wedge \alpha b^{\sim}, \theta a^{\sim} \vee \theta b^{\sim}, \beta a^{\sim} \vee \beta b^{\sim} \right\rangle\ if\ (a3 < 0, b3 > 0)$$
$$\langle (\frac{a3}{b1}, \frac{a2}{b2}, \frac{a1}{b3}); \alpha a^{\sim} \wedge \alpha b^{\sim}, \theta a^{\sim} \vee \theta b^{\sim}, \beta a^{\sim} \vee \beta b^{\sim} \rangle\ if\ (a3 < 0, b3 < 0)$$

$$a^{\sim} b^{\sim} = \langle (a1b1, a2b2, a3b3); \alpha a^{\sim} \wedge \alpha b^{\sim}, \theta a^{\sim} \vee \theta b^{\sim}, \beta a^{\sim} \vee \beta b^{\sim} \rangle\ if\ (a3 > 0, b3 > 0)$$
$$\langle (a1b3, a2b2, a3b1); \alpha a^{\sim} \wedge \alpha b^{\sim}, \theta a^{\sim} \vee \theta b^{\sim}, \beta a^{\sim} \vee \beta b^{\sim} \rangle\ if\ (a3 < 0, b3 > 0)$$
$$\langle (a3b3, a2b2, a1b1); \alpha a^{\sim} \wedge \alpha b^{\sim}, \theta a^{\sim} \vee \theta b^{\sim}, \beta a^{\sim} \vee \beta b^{\sim} \rangle\ if\ (a3 < 0, b3 <$$

3.1 Aim of the study

Determine what you want to learn, and then outline the criteria and options that will be used in the hierarchical decision-making process (HDP).

3.2 Put up a Matrix of Comparisons Based on Pairs

We employed the neutrosophic scale shown in [20] to create a comparison matrix pairwise for criterion and sub-criteria. Experts recommend including (1,1,1) in the evaluation matrix if the first criteria are just as desirable as the second. Put (4,5,6) into the matrix if the first criteria are much favored over the second. Another option is to invert the criteria in the matrix, as in the case when the second requirement is much favored over the first (14,15,16). The truthiness, indeterminacy, and falsity levels should be added to the triangle numbers used by experts. When they are factored in, the comparison matrix becomes [(4,5,6); 0.80,0.25,0.2], where 4, 5, and 6 correspond to the minimum, intermediate, and maximum values, respectively, on the triangular neutrosophic range. In addition, a value of 0.80 indicates a high level of truthfulness, 0.25 indicates some uncertainty, and 0.20 indicates a low level of falsehood.

3.3 Create a crisp matrix from a Neutrosophic

As an example of a scoring function, here is one that may be used to convert the neutrosophic matrix into a crisp matrix [20]

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3.4 Quantify Importance of Criteria

Using the pairwise comparison matrix, divide the sum of each column by the number of entries in that column to get the weights for each criterion.

3.5 Verify the Weighted Matrix's Integrity

It is important to verify if the matrix is consistent with the expert's assessment. Divide the consistency index (CI) by the random index to test for consistency (RI). Next, the result should be below 0.1. figure 3 shows the steps of the proposed methodology.

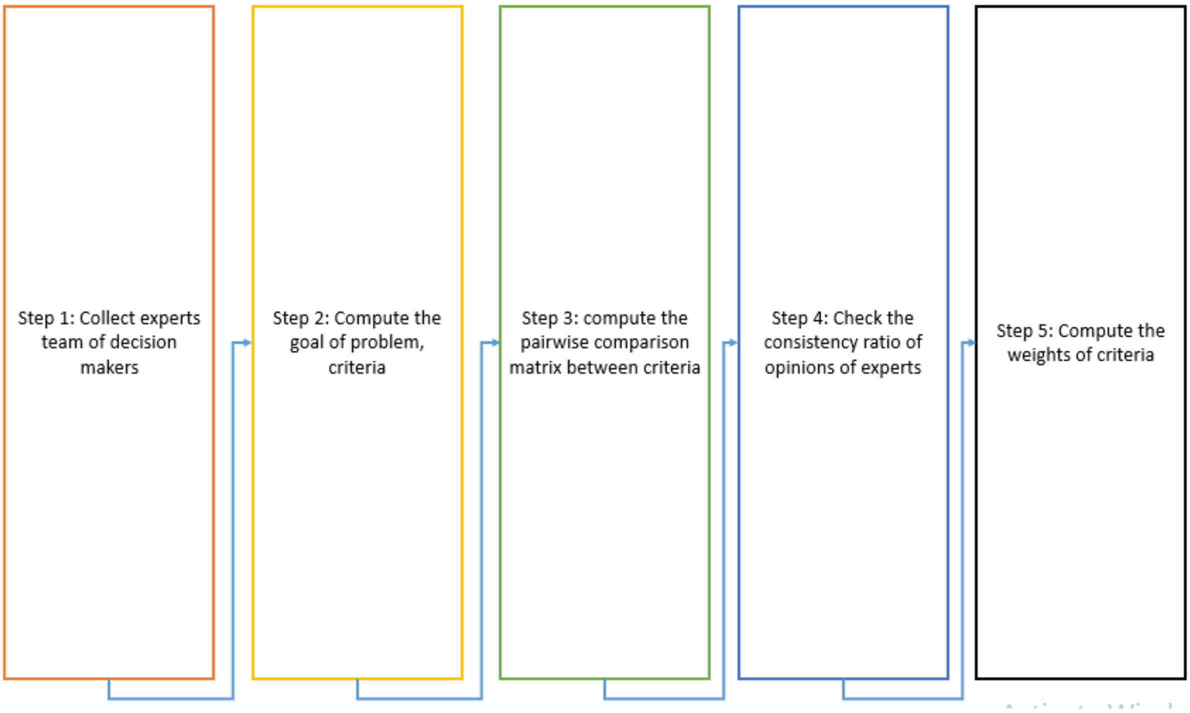

Figure 3: The steps of this paper.

4. Results and Discussion

Here, we detail the suggested methodology and present the relevant findings and discussion.

4.1 Setting up the decision-making committee of experts

The advisory group included professors from institutions, as well as representatives from the government's Department of Environment, Ministry of Hydrocarbons, and Electricity Generation Sector. The experiment was a collaborative effort amongst professionals from a dozen fields, including business and finance, power generation, geotechnical sciences, science and engineering policy, and technological foresight. All of our specialists participated in the parts of the study process where their expertise was called for.

4.2 Identifying the problem's logical framework, including its objectives, strategic criteria, and potential solutions

The objective is at the top of the control hierarchy, supported by the measurement standard. This study's decision issue has a target level of identifying and ranking renewable energy options in Iran. Different solutions are evaluated based on six factors, including the problem's stated objective and each of BOCR's four criteria. The major criteria are technological, business, safety, worldwide effect, and wellbeing, as determined by the expert team based on the research. Within the BOCR

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analysis, each component was represented by a subnetwork that illustrated the connections between the many nodes that made up that component's clusters.

The Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol are two international commitments that can be advanced through subnetwork efforts, along with the use of native resources, environmental protection, the growth of ancillary industries, and the pursuit of international commitments. Opportunities in the subnetwork include green employment growth, energy cost reduction, and the development of alternative sources. Subnetwork expenses include initial capital outlay, ongoing operations and maintenance, resource depletion, and environmental harm. Finally, the hazards subnetwork contains issues including reliance on foreign technologies, limited financial mechanisms to undertake RE growth, inadequate technical infrastructures, unstable energy resources, a lack of public knowledge of RE, and commercial failure. Hydraulic, thermal, solar, windy, and biomass are all interconnected via their subnetworks.

4.3 How much emphasis should be placed on each strategic criterion in light of the objectives?

Specialists will assess the strategy criteria to choose the best sources of renewable energy once the issue's hierarchical structure and needed linkages among levels and subnetworks have been established. A comparison matrix pairwise with the geometric mean is used to assign relative importance to the various strategic criteria. Pairwise comparisons are made using Saaty's 1–9 preference scales to measure how strongly one criterion is held in contrast to the others. Inconsistency rates (IRs) are determined for each set of comparison tables using the super decision program. This program is the only freely available educational application to perform AHP, and it was created by Thomas Saaty's team. Errors and discrepancies in judgment may be revealed by calculating the inconsistency rate (IR), which will also guarantee the validity of the comparison. If A is better than B and B is better than C, then A should also be better than C. We tolerate here a 15% discrepancy in the assessments during the comparisons because of the complicated political and economic scenarios typically faced in energy choices and because of the broad range of judgments in energy policy. Subjective evaluations must be reevaluated if the rate of inconsistency is higher than this threshold.

4.4 Creating a Comparative Matrix

Experts were asked to rate elements on the neutrosophic language scale to create a comparison matrix. The ratings for truthiness, indeterminacy, and falsity, as well as the neutrosophic triangular numbers translated from the experts' supplied scores. The following conditions for controlling energy social projects were each given a score by a different set of experts. To create the final comparison matrix, we added up the ratings from each expert and did so across all categories.

After doing all the necessary comparisons, we used the final comparisons matrix to generate the score matrix. Based on the resulting score matrix, safety is somewhat more desirable than technology and business more desirable than worldwide effect.

We used the score matrix transformation method after completing the final pairwise comparison.

4.5 Criteria Weighting Calculation

The resulting weights for each criterion were calculated by dividing the sum of each column by its respective cell in the score matrix. Figure 4 shows the final weights of the criteria. Table 1 shows the combined opinions of experts.

4.6 Ratio of Consistency

The computed value of 0.068 for the consistency ratio for the aggregated decision matrix of the experts using the N-AHP approach is lower than the cutoff value of 0.10. Accordingly, it has been concluded that the research is consistent and that more investigation is warranted.

Therefore, the importance of each criterion has been established, and supply chain risk assessment may go further since the research fulfills the prerequisites.

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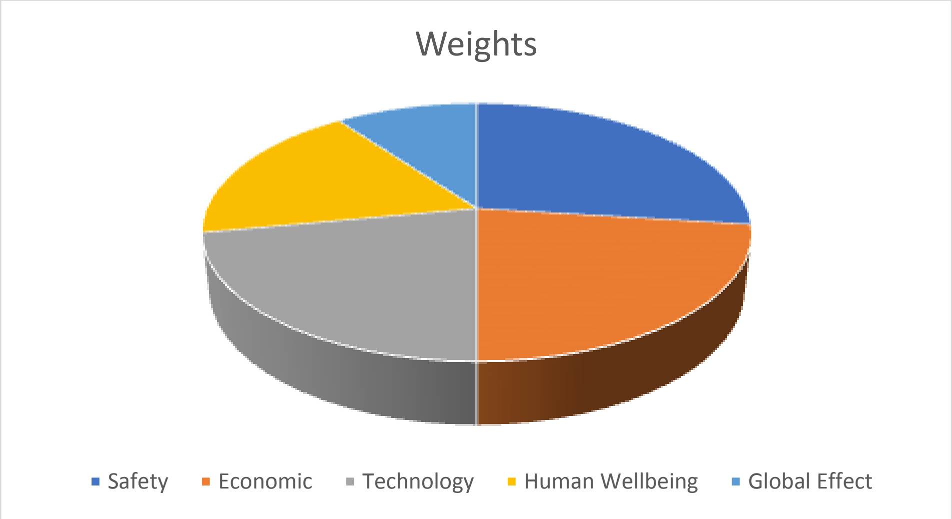

Figure 4: The weights of criteria.

Table 1: The combined values of experts' opinions

	C1	C2	C3	C4	C5
C1	1	0.572222	0.494444	0.477778	0.561111
C2	0.583333	1	0.638889	0.6	0.6
C3	0.372222	0.316667	1	0.666667	0.361111
C4	0.455556	0.361111	0.533333	1	0.316667
C5	0.533333	0.716667	0.588889	0.316667	1

5. Conclusion

Oil-producing nations will need to expand their energy sources, such as by increasing their use of renewable power. Increasing energy use, high energy intensity, widespread pollution, and political and financial issues are hallmarks of these nations. To aid such nations in energy policy and management, we have created a hybrid MCDM approach.

An examination of energy strategy and judgment issues is often a complicated study best dealt with in a multidimensional space of diverse characteristics and aims. Ranking power sources, renewable technologies, and energy development according to numerous aims, aspects, and criteria, as is done in MCDM, gives a dependable solution strategy. Thus, many different types of research have used MCDM techniques to address energy policy and justice issues. This article sheds light on the many MCDM approaches, highlights the progress gained when climate policy and judgment are taken into account using MCDM, and makes recommendations for further study.

Decision-making issues are best tackled with the help of multicriteria decision-making procedures, which allow for the evaluation of options based on many criteria. Judgment MCDM approaches may be categorized as pairwise comparing approaches AHP,

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