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Optimal site selection of Renewable Energy sources using Multi Attribute Decision Making techniques in Artificial Intelligence Scenario

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Abstract : Site selection of Renewable energy sources is complex task due to its use in global economic and industrial growth in last two decade. To meet this demand, the various countries want to achieve a target to increase the share of renewable energy from 50% to 100 % of the total installed capacity. As per United Nation (UN) general assembly unanimously the decade of 2014 to 2024 is declared the, "Decade of Sustainable Energy for All", namely to "ensure access to affordable, reliable, sustainable and modern energy for all". In the context the current situation is very far from this and condition is not much favorable in this regard. Here we mentioned the various site selection factors for sustainable renewable energy, which are selected by the review of different literature based on the goal of sustainable development of renewable energy or hybrid renewable energy. The importance of Data science is increasing in every area of engineering and technology. So, we can use Artificial Intelligence (AI) with Multi Attribute Decision Making (MADM) and Institutive Fuzzy Set (IFS) techniques for site selection of renewable energy sources from an Indian perspective. This is the first study that use AI in Institutive Fuzzy Set (IFS) and Multi Attribute Decision Making (MADM) for Site selection of renewable energy sources. It is not favorable to take the more criteria for optimization of site selection. We select solar and wind energy sources among various renewable energy sources based on various study that choose the optimal site selection criteria among them. As per the analysis solar energy and wind power is optimal sources for renewable energy production and work as the central pillars for sustainable energy. This paper introduces a well-defined and efficient decision support system that introducing the choice of decision-makers for the means to enhance the evaluation process and make informed choices in the selection of optimal locations for renewable energy installations This approach allows to comprehensively and effectively assess and tackle the impending issues in the field of renewable energy. These techniques can use in site selection in other industry

IndexTerms **- Site Selection, A.I, MADM, Renewable Energy.**

1.INTRODUCTION

Renewable energy is the key factor for sustainable development and economic growth of any country. So Government of India is transforming from the fossil fuels-based energy to the renewable sources-based energy, which are cleaner, safer, environment friendly and more sustainable for current and future conditions of India.

The production of electricity from conventional fossil fuels (Hydro, Coal, oil, Gas, Nuclear etc.) produces very harmful substances and greenhouse gases in the environment, which causes of environmental pollution, Global warming, and other related problems. The energy cost, crisis, causes health issues, destroys natural ecosystems, and environmental pollution problems have forced the various country to produce renewable energy instead of conventional energy. The unreasonable sources of energy production and utilization, the awareness of renewable energy production are the main reasons for the generation of renewable energy. To this end, various countries are actively developing renewable energy sources [1]

The most important task of human in set up or selection of renewable energy plant is decision-making problem, which deals with the issue of selecting the best source from a set of given alternatives that are described in terms of their attributes of defined problems.

This research is first to purpose Intuitionistic Fuzzy Set (IFS) and MADM using Artificial Intelligence (A.I.) Technologies. AI is helpful to increase efficiency and examined the impact of A.I. in renewable energy. Now Artificial Intelligence (AI) has reached from a research lab to reality for executives in renewable energy fields. Artificial intelligence advancements have prompted software and Renewable engineers to have novel approaches for selection of suitable place for selection of renewable energy for achieving maximum efficiency, lowering the costs for selection and setup of plant. This intelligence has been used successfully by compony to obtain a competitive edge over their competitors. It is widely assumed that AI would provide benefits such as human enhancement, which should be considered while considering economic growth in any area. In 2020, India released a draft of the National Strategy for Artificial Intelligence for adoption of AI in various sector in India. As such, this research is an understanding of how AI is being adopted by renewable energy company in India. It introduced IFS to deal with MADM problems. The proposed MADM framework enables a comprehensive evaluation and selection of sources through AI technologies and uncertainties in decision-making process. [1] [8] and [14], developed some intuitionistic fuzzy (IF) aggregation to aggregate the IFS information and applied the notion to

decision making problems [15]. The objective of this research paper is to select the best renewable energy source with the help of AI in the renewable energy sector using the IFS and MADM. The issue is to provide a comprehensive understanding of how AI technologies can be effectively use in renewable energy, considering the complex and uncertainty in site selection process. Here study objectives to achieve: The first to develop an innovative approach based on the IFS to determine the weights of the criteria. To apply four major criteria from the existing literature and choose the most important major criteria influencing at once adopted AI technologies based on decision Maker or experts. By automating the selection modeling process, AI tools can rapidly identify the best renewable energy option and second objectives: How AI can enhance the IFS-MADM integrated approach, perhaps by automating data collection, optimizing criteria weights, or predicting site performance. A Case studies for showcasing the value of AI in the framework. Select a geographical area and renewable energy type (e.g., wind, solar, biomass, geothermal). Apply the IFS-MADM framework with AI enhancements to select the best sites and analyze and discuss the results, comparing them with traditional methods

1.1-Motivation

MADM methods have demonstrated significant outcomes in the selection process of multiple areas like site selection of renewable energy. MADM procedures are more prevalent in the RES sector due to consideration real life problem, accuracy, flexibility and reliability in decision-making techniques[2]. To deal with the uncertainty that happens during the energy policy selection process utilizing MADM techniques, various concepts have been implemented including the IFS. IFS is a useful tool for depicting the uncertainty of MADM [3]. This study introduces a novel framework for solving the problem of RES selection which reduces human intervention by being systematically applied A.I. by transforming the linguistic terms presented into Fuzzy value, it finds systematic approaches for imputing missing values in the decision matrix using A.I. technique. Second, it determines the weight of each linguistic variable and attribute, and then creates a decision matrix for decision makers (DMs) or in other word experts. Finally, it calculates the ranks the alternatives.

2-Literature Review

In this study, a comprehensive review of the performance of RES based on solar energy, wind energy, biomass and geothermal energy as well as Artificial Intelligence adoption is presented. This study also discusses the latest trends of Artificial Intelligence in Renewable energy and research on future energy demand with provides relevant references. The number of publications has been increasing in recent years on renewable energy systems [4] and as well as citations is also increasing, which shows that the research on selection of RES a hot topic today.

The cases of renewable adaptation in various country are studied to analyze the sources site selection for the Indian condition are derived. AI are widely being utilized in these studies to handle very large data efficiently with respect to degrees of satisfiability and non-satisfiability[5] . The prediction of site availability a priori using AI can go a long way to provide the time. The site of renewable energy installations can be optimized using AI to maximize reliability and minimize costs. Authors found role of AI in renewable sources as listed in Table 1.

Authors	Summary
[6],[7]	This research acquired prominence to their capacity to hand in big data and stochastic nature of the problem.
[8]	It demonstrated easy and advanced algorithms that have penetrated almost in the field of renewable energy.
[9]	It employing back-propagation and supervised learning techniques to train datasets by using advanced ANN algorithm it referred a feed forward neural network (FFNN) to simplify the problem.
[10]	technique is an advanced interpretation of the ANN. Its show that advanced ANN techniques have very high learning speed and can be generalize properly
[11],[12] [13]	It shows that AI can be use more efficiently in recognizing the pattern, classification and regression analysis. It can be used in forecasting load.
[10]	This is a hybrid models algorithm made from various ML algorithms, AI and other soft computing algorithms.
[14]	It explains how AI and ML algorithms increase efficiency, reliability and safety of the given system.
[15],[16]	It is used in industries for analyzing patterns of consumption, leakage of energy and overall performance of the system very efficiently.
[17], [18],[[19]	These systems is cheaper so it can fulfill market demands of renewable energy These optimized models give better performance.
[20]	It reviews the top 10 most popular ML algorithms of energy systems, utilization and applications. The conclusion of the paper is that it is superior in terms of user-friendliness, accuracy and speed. However, the complexity of the hybrid models is more compared to others.
[21]	It reviewed various methods of AI for wind, solar, geothermal, hydro, ocean, biomass, hydrogen and hybrid energy systems. The review includes a discussion of each class of renewable source of energy, the authors have reviewed how different models of AI can be used in every class of previously mentioned renewable sources of energy.
[c8]	A complete review of the role of AI in the sustainable and renewable energy sector have done in this paper. The authors have mentioned how the AI methods are better than traditional methods in

	terms of handling big data explosion, higher computational power, ease of integration of AI with renewable energy sectors.
[22]	It has developed a photovoltaic and weather system that collect different environmental parameters for Qatar. These parameters will then be used as an actual dataset for multiple regression models and ANN.
[23]	The authors have recorded data of one year for created PV system.it was observed that GFF and MLP models attained the highest percentage accuracy.
[24]	an ANN-based model to predict solar power in the case of PV systems it developed. Daily values of solar irradiance, relative humidity, wind speed, air temperature was input and power was output of the PV system.
[25]	It combines two advanced models to predict solar irradiance. It shows that Solar irradiance is an important parameter to design efficient solar power generation systems and their distribution. it was observed that the hybrid model has lower variance as compared to its constituent models.
[26]	It explained and developed different ANN for the prediction of the performance of solar collector systems., the authors have made a review of the performance of these ANN models based on different papers from multiple sources.
[27]	It predicts energy output for a wind farm. They have taken considered the wind farms in Muppandal in Tamil Nadu (India). they have developed a model in an ANN also.

Table 1. Literature Review by various researcher .

Artificial Intelligence (AI) is a relatively simple computational techniques to determine Renewable energy sources globally. This paper`s novelty stems future perspectives for new innovative technologies of A.I. for hybrid renewable energy systems

(*a) Smart control of Data:* Due to processing of a lot of data. This data provides the view to expert with new ideas for improved site selection when combined with AI. It provides the control of energy as per demand cleverly. In addition, it provides forecasts of weather and load, which can increase renewable energy integration and efficiency.

(b) Improved reliability of Site Selection: The use of AI in the field of renewable energy boost stability and reliability of site selection. It understands the pattern of energy use in given area, energy fluctuation, and the plant's performance.

(*c) Expand the Criteria:* The expansion of new criteria can be found with AI integration. The AI-is enables to analyze energy collection data and provide new insights into energy usage.

AI algorithms analyzing huge amounts of data from different sources for site selection of renewable energy sources. AI can optimize the selection of location for RES. Artificial intelligence application can be effectively us in renewable energy systems, modeling, simulation, and development. Artificial intelligence has potential for challenges faced in the wider adaption in energy sector as in given table.2 energy sector as in given table.2

Ref.	Summery
[28]	AI done various human intelligence processes by machines. It specifically a computer-related branch.
[29]	AI is devoted to development for combination of computer science and machine's intelligence.
[30]	AI transforming inanimate objects into intelligent. AI is the top strategic for renewable energy businesses in future.

Table.2: Adaption of AI in renewable Sources

3.Proposed Research Framework

A multi-Attribute decision-making (MADM) strategy is use to manage the criteria in site selection of renewable energy. A framework consisting of IFS and MADM in context of A.I. This study provides a FAHP framework for analyzing, optimizing and ranking the RES resulting from the use of AI technology. The suggested framework's flow diagram illustrates in Figure1.

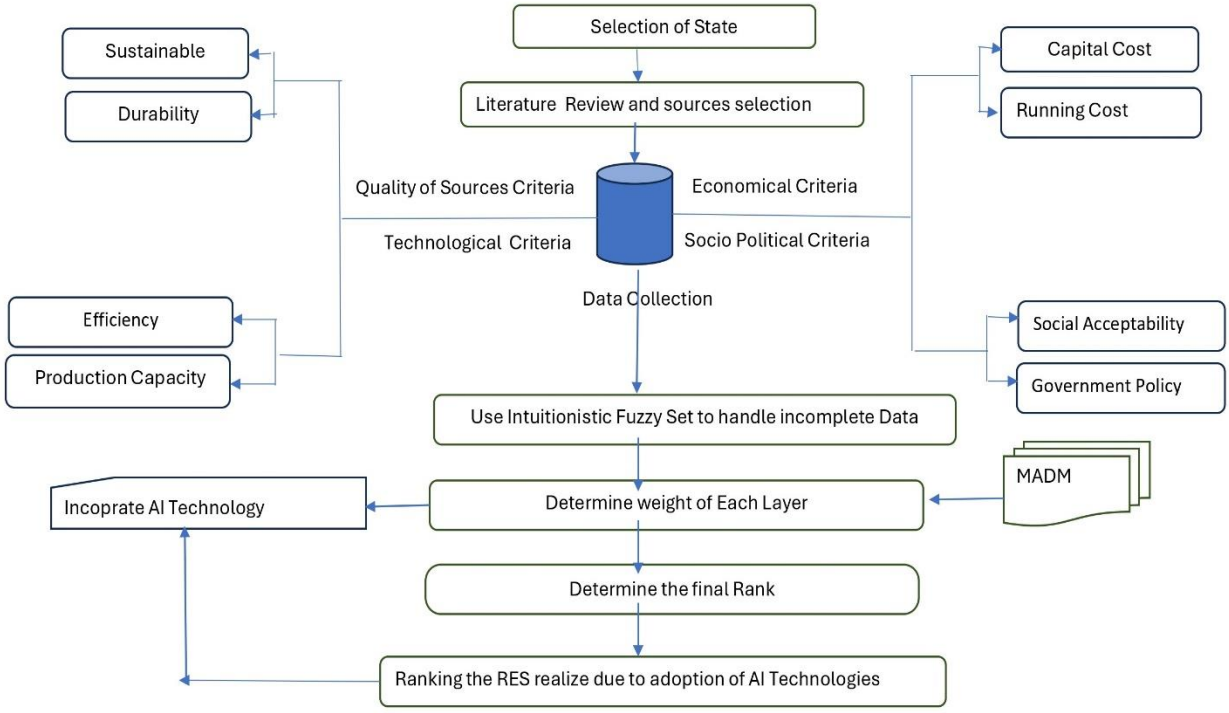

Figure 1. Suggested framework's flow diagram

Stage-I: Establish Criteria for Site Selection and Data Collection: Identifying the most common critical criteria and collect data for study

Stage- II: Utilize Intuitionistic Fuzzy Sets: it handles uncertain, ambiguous, or incomplete data during the site selection process. Given the complexity of the decision-making process with many variables at play, IFS offer a way to make more informed choices in the face of uncertainty

Stage-III Apply Multi-Attribute Decision Making (MADM): it Assign weights to each criterion using techniques using Analytical Hierarchy Process (AHP

Stage-IV Incorporate AI Technologies: Utilize machine learning models to predict potential energy outputs of selected sites. Identify key parameters that impact site selection

Stage-V Results and Analysis: After applying the above methodologies, the study present a ranked list of potential sites in Uttar Pradesh for renewable energy installations. This is based on a combination of feasibility, efficiency, and impact. It is offering recommendations for stakeholders in the renewable energy sector in Uttar Pradesh.

The use of AI can significantly enhance the accuracy and efficiency of decision-making processes in renewable energy site selection by analyzing large and complex datasets.

4 Case Study

This part discusses the utility of the suggested framework by considering a real-world context of RESs in Uttar Pradesh, India. It provides sustainable and reliable source(s) in Uttar Pradesh.

Uttar Pradesh, being one of the largest and most populated states in India, located in the northern region of the India. Energy demand is increasing steadily due to industry investment in the state. Due to limited conventional energy sources, production of renewable energy is given high priority[i1]. This study presents the current status of renewable energy in the state, renewable energy-based options for energy systems depending on availability of resources.

It has a varied topography and diverse climatic conditions, making it suitable for multiple renewable energy sources. The state has made efforts in recent years to boost its renewable energy capacity, with particular emphasis on solar, wind, biomass and Geothermal energy. The country's vision is to achieve a target of 500GW renewable energy capacity by 2030, [31] Efforts are being made to develop in Uttar Pradesh (UP) for renewable energy sources. About half of India's power requirement came from largest six Indian states as shown in figure 2. Although UP is most populous state with 17% of the population, accounted for a tenth of the country's total electricity market – second only after Maharashtra (12%).[32] after Maharashtra (12%).[32]

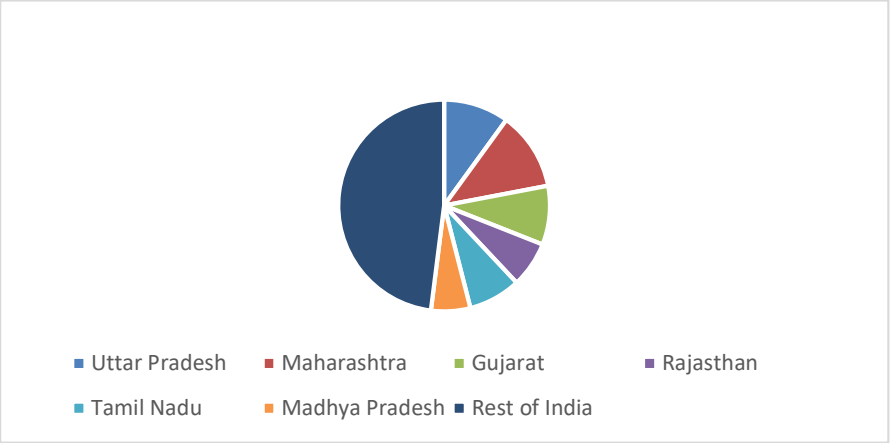

Figure 2. Power requirement in different state of India[32]

5 Data Collection

A questionnaire survey was performed for collection of all criteria's data for optimize site selection of Renewable energy sources. A questionnaire Survey is the most extensively used technique of collecting data from decision maker, local authority that concerning their ideas, opinions, attitudes, beliefs, values, habits, feelings, perceptions, plans, and demographics. A structured questionnaire is made for studies depending on perception of decision maker and human being [33] it was a very effective method for this study to achieve our goal. This study collected the data from academician, industry expert, local authority, contractors and other person working in the energy sector in Uttar Pradesh. A 9-point Likert scale was used to record the questionary survey. This scale measure ideas, approaches, and expectations about all phenomena. respondents determine particular level of disagreement or agreement on asymmetric disagrees or agrees scale for a sequence of statements[33],[34].The collected data was analyzed with the help of Microsoft Excel and SPSS software packages. The criteria were ranked based on random Index (R.I.) value by following the formula as adopted by

$$R.I.I. = \frac{\sum_1^5 a_i n_i}{5N}$$

where: a=constant expressing the weight assigned to each response, n=frequency of each answer, N=total number of responses. Further, the difference of the opinions amongst the people groups with different level of working positions and their experience that presented based on comparing means

6.Result

The ranking of four renewable energy sources have been done according to the proposed framework. As per the analysis the results are summarized. The aim of the study to find the site selection of renewable energy sources. This framework, tailored to Uttar Pradesh, take inputs from local experts, stakeholders, and authorities to ensure accuracy, relevance, and effectiveness. Eight factors under the Quality of sources, Technological, Economical and Socio-Political were selected based on previous literature and expert consents. Moreover, sub criteria were chosen for each criterion and used for decision on ranking four alternatives of renewable energy sources. The weight was calculated by F-AHP and expert view. Main Criteria initially compared pair wise to obtain the importance of each sub criteria. Table -1 Show that the Economic criteria is the most important criteria with a preference score of 0.4463 followed by the Technological, Socio-Political and Quality of sources. For wind energy sources, sustainability is the most important factor while efficiency is the second most factor. Government policy is the most important factor for Biomass energy production in Uttar Pradesh. Energy production criteria is the least preferred criteria in geothermal Energy sources in all the sources as shown in figure -3. For solar energy sources, social acceptability is the most important criteria and also in real life we see that solar energy sources in not much popular in Uttar Pradesh. Result indicates that solar energy the most suitable energy sources in Uttar Pradesh

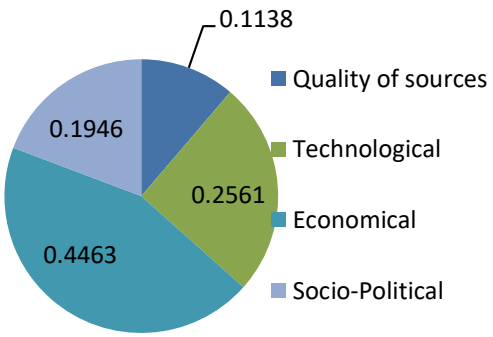

Figure 3. Relative weights of the criteria on the basis of goal

The proposed MADM framework enables a comprehensive evaluation and selection process that use AI technologies and uncertainties in decision-making. The findings of this paper will encourage the renewable engineer to implement AI in energy sector for selection of site or technology. This will also enhance the performance and take less time for chosen of goal of the energy sector. Relative weights of sub criteria with respect to alternatives are calculated and presented in bar diagram as in given figure 4.

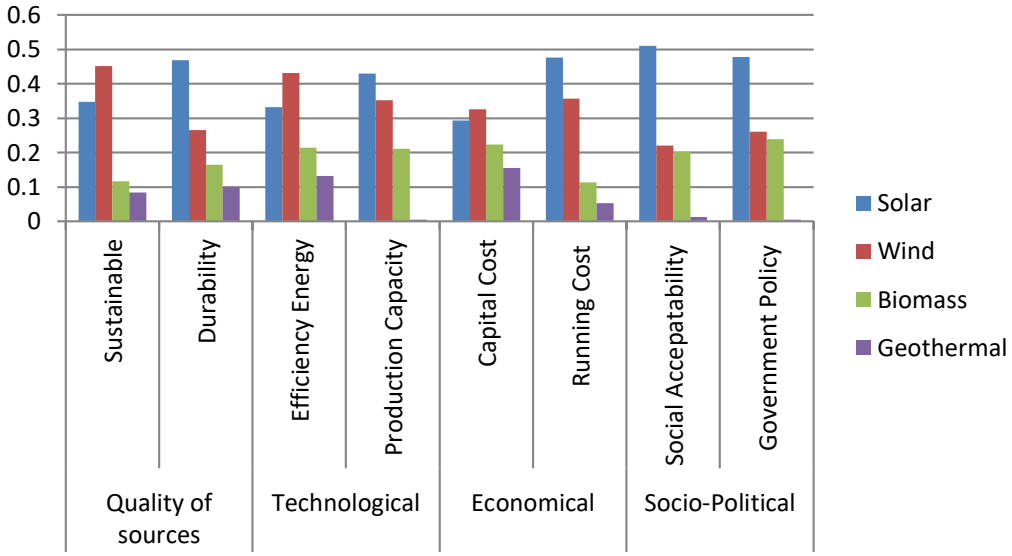

Figure 4. Priority weight of solar, wind, Biomass and geothermal energy Sources
In this figure all the alternatives are compared with respect to given sub-criteria. Weight of alternatives are given with respect to sub criteria. All the priority weight of criteria, sub criteria and alternatives with respect to our goal are given in the table 3.

Criteria Weight		Sub-Criteria Weight		Solar	Wind	Biomass	Geothermal
Quality of sources	0.1138	Sustainable	0.0751	0.3477	0.4511	0.1165	0.0847
		Durability	0.0387	0.4691	0.2653	0.1654	0.1002
Technological	0.2561	Efficiency	0.1394	0.3322	0.4311	0.2143	0.1324
		Energy Production Capacity	0.1137	0.4309	0.3523	0.2114	0.0054
Economical	0.4463	Capital cost	0.2938	0.2936	0.3264	0.2243	0.1557
		Running Cost	0.1525	0.4763	0.3574	0.1134	0.0529
Socio-Political	0.1946	Social acceptability	0.9482	0.5113	0.2215	0.2014	0.0134
		Government Policy	0.1946	0.4775	0.2611	0.2398	0.0058
Overall Priority Vector Weight				3.3386	2.6662	1.4865	0.5505

Table-3 Priority weight of Decision Criteria

The pie chart and table show the empirical results of proposed model for Uttar Pradesh. The evaluation of renewable energy sources in an achieving goal is presented in the figure 5.

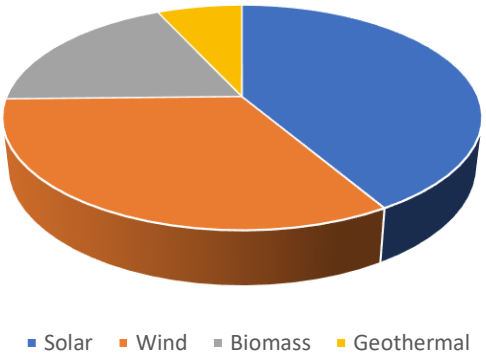

Figure 5. Pie chart of renewable energy on priority basis
Variables of the study contains dependent and independent variable. The study used pre-specified method for the selection

7 Conclusions

This study introduces MADM and IFS based novel approach to create a framework for selection the RES resulting from the use of AI technology in overcoming the obstacles and challenges. A questionnaire survey method was used to select the site of RES based on experts' opinions and literature review. In this study, 4 criteria, 8 sub criteria and 4 alternatives has been chosen. The data to select the site RES were collected from twelves experts in the renewable energy related sector and AI technology field. The obtained results show that Solar Energy is the most suitable renewable energy source in Uttar Pradesh.

Future research could extend this framework to use AI technology in other sectors of engineering application. This framework may be useful in medical field for selection of medicine by patients. This study evaluates AI at the state level; therefore, future studies might also consider AI technology at the country level. The selection of expert is also a field of research. This study used a limited experts for the process of weighting of criteria; therefore, to further improve the research accuracy, future studies can use more experts to evaluate and select the appropriate site.

It is Suggest this integrated approach can be apply in other state of India. This model can give more precise result by adapted with real-time data. With certain modifications, the proposed frameworks can be applied in other fields for selection of alternatives.

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