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Barriers to Solar PV Adoption in Developing Countries: Multiple Regression and Analytical Hierarchy Process Approach

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Abstract: The globe is transitioning from traditional methods of electricity generation to renewable resources in order to achieve sustainable goals. Solar energy is a promising and abundant renewable resource that shows great potential as a viable alternative to traditional energy. Furthermore, the production of electricity from solar energy is the most cost-effective compared to other kinds of renewable energy. Nevertheless, the execution of solar initiatives in underdeveloped nations is encountering several obstacles. Identifying the most significant obstacles in the execution of solar projects is of utmost importance. This study uses a linear regression model (LRM) and an analytical hierarchical process (AHP) to determine the main barriers to the implementation of renewable energy projects in a developing economy, i.e., Pakistan. By conducting an extensive review of the relevant literature and consulting with experts, the most significant categories of obstacles were determined. A survey based on 429 responses was collected from the participants working at solar projects. Subsequently, the responses were subjected to processing and analysis using the relative importance index (RII), AHP, and linear regression modeling techniques. The linear regression analysis revealed several significant variables that hinder progress, including financial conditions, policies, technological awareness, institutional support, social and environmental awareness, market stability, and other miscellaneous factors. The AHP analysis revealed the key factors that have the greatest impact, which include effective policies, financial stability, technological expertise, institutional support, market stability, various aspects, and social and environmental awareness. The study's conclusions are beneficial for all stakeholders and project managers in enhancing the project management of solar initiatives. It would also facilitate prompt decision-making regarding policy formulation and implementation.

Keywords: solar projects; barriers; sustainability; developing nations; relative importance indexing; multiple linear regression modeling; analytical hierarchical process (AHP)

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1. Introduction

A sustainable and environmentally friendly future is largely dependent on alternate energy resources. The significance of renewable energy sources cannot be over emphasized, especially considering climate change and the continual depletion of conventional fossil fuel stocks. Solar, wind, hydro, and geothermal, among others, are some of resources that are not only plentiful and readily accessible but also have a smaller effect on the environment than non-renewable options. Energy efficiency gains, a decrease in air pollutants, and controlling the adverse impacts of climate change are all beneficial outcomes that can be attained through gradual transitions toward renewable energy. The implementation of solar energy projects has a much greater prospect than any other resources, as all necessary ingredients are already ubiquitous and naturally available free of cost [1]. Many potential sites can easily be converted into solar power parks for electricity generation in developing countries [2]. Solar power plants convert sun lights into electricity though use of solar

PV panels. Mono-crystalline, polycrystalline, and thin-film solar cells are used for the conversion of sunlight into electricity. Solar projects provide quick fixes for the majority of problems faced by emerging nations [3]. This electricity is clean and green as it helps in reducing CO_2 emissions in air. Because of the great advantage of renewable energy, it is considered one of the rapidly growing transitions for energy generation in the coming years. Implementation of solar energy projects however is not at the required pace due to a variety of reasons [4]. Researchers and past studies have determined different factors and problem areas in its implementation. They have suggested various measures for controlling these barriers. These measures may vary from country to country due to the differing economic conditions and geographical locations [5]. The complete investigation of various factors and evaluation of their impact will help ensure the successful execution of solar energy projects. Statistical tools/software will be used to develop MLRM and help in overcoming identified barriers. Similarly, by using an AHP, the problem will be broken down and examined, allowing for pairwise comparison, measuring the relative weight of each factor associated with the priorities, which will help in understanding the extent of the effect of each factor/barrier. A comparison of the models will ensure internal validity of the methodology. The models developed will help in determining the impact and influence of various factors, which ultimately help in ensuring a successful execution. Case studies of recently completed solar projects project will be evaluated on these models to validate the methodology. The models developed will help the solar stakeholders to overcome hindrances and freely and confidently take their decisions. Mustafa and Omer [6] have has also suggested use of an AHP for determining the weight and impact of various factors.

Numerous research studies have been undertaken to examine the viability of renewable energy, particularly focusing on the potential of solar energy, in order to assess its practical application for achieving sustainability within a certain country. Dwivedi et al. [7] focused on the significant impact that political instability and interference have on the adoptability of solar thermal-based drying technology in India. Laktuka et al. [8] recommended transparency for installing wind farms and solar PV parks; these could be increased through publicly available guidelines. Shyu [9] recommended overcoming external factors, such as political, institutional, social, and cultural barriers; existing in the societal context is vital. Reyneke et al. [10] deliberated on water security in low- and middle-income countries and highlighted the advances in solar-based water treatment systems and the innovative ways that can safely be used, in combination with traditional water treatment methods, in developing countries. Belal Ghaleb et al. [11] identified the most significant barriers and their impact on the use of PV in buildings while studying the prospects and barriers in the GCC region. Sheng and Liu [12] suggested that residential solar development needs cooperation among political, market, and community actors. Some researchers found challenges associated with renewable energy [1,13–19].

The renewable energy projects, especially solar PV, are rapid sources of economic and sustainable development of society; however, its execution in developing countries is not very encouraging. It is significantly important to analyze and evaluate these variables to ensure successful execution. The past research work on the subject has used traditional and conventional methodologies such as mean score and RII for determining the barriers. The current study will utilize the linear regression model (LRM) and AHP techniques to measure the weight and influence of every barrier. Evaluation of both approaches will be used to check the rationality of the models. Before commencement of a project, the numerous stakeholders—including policy makers, solar companies, consultants, and energy managers—necessitate careful consideration of these factors. These variables have different effects on solar project implementation depending on the geography, financial stability, and acceptability of solar technology. The methodology and model developed can be used for successful implementation of solar projects in developing countries. This methodology will help the energy stakeholders to overcome these barriers and confidently take decisions with a view to achieve successful execution.

The remainder of the paper is structured as follows: An overview to related work is given in the next section. The research methods used in the current study have been described in Section 3. In Section 4, the findings of the study have been provided based on the three methods. These results have been discussed in detail in Section 5. The conclusion and recommendations have been provided in the last section.

2. Literature Review

The future of developing countries is largely dependent upon their decisions on future energy transitions. For sustainable economic growth of these countries, the energy requirement is ever increasing. The International Energy Agency [20] and various researchers recognized that developing countries have substantial prospects in the form of investments in renewable energy. Developing countries can also help reduce CO_2 gas emissions. They can also provide the best opportunities for investments as compared to advanced countries. However, developing countries are not receiving the right share of investments in renewable technologies [21,22], as only one-fourth of the investments reaches developing countries.

The provision of green energy is considered to be a financial opportunity in developing counties to concurrently alleviate energy issues by replacing fossil fuel-based electricity to renewable-based electricity and by making suitable environments for continuous economic progress [23,24]. In recent years, developing countries have achieved good progress in the development of large-scale energy projects [25,26]. However, they faced greater difficulty in resource utilization, precisely in low-income and low-investment countries. They are experiencing poor economic conditions, unsupported organizational and institutional structures and weak regulatory network, a lack of information, and weak financial structures [27].

To enable the economic development in emerging nations, governments are facing the issue of improving risk–return schemes to attract potential investors while ensuring the least cost integration of the energy supply [18,28]. A list of major barriers (factors) and sub-factors identified by various researchers [15,29–52] in previous studies are summarized in Figures 1 and 2. One of the most exciting developments in solar energy in recent decades has been the use of solar chimney power plants (SCPPs) to produce clean, green electricity. This method has recently attracted a lot of attention [53–58].

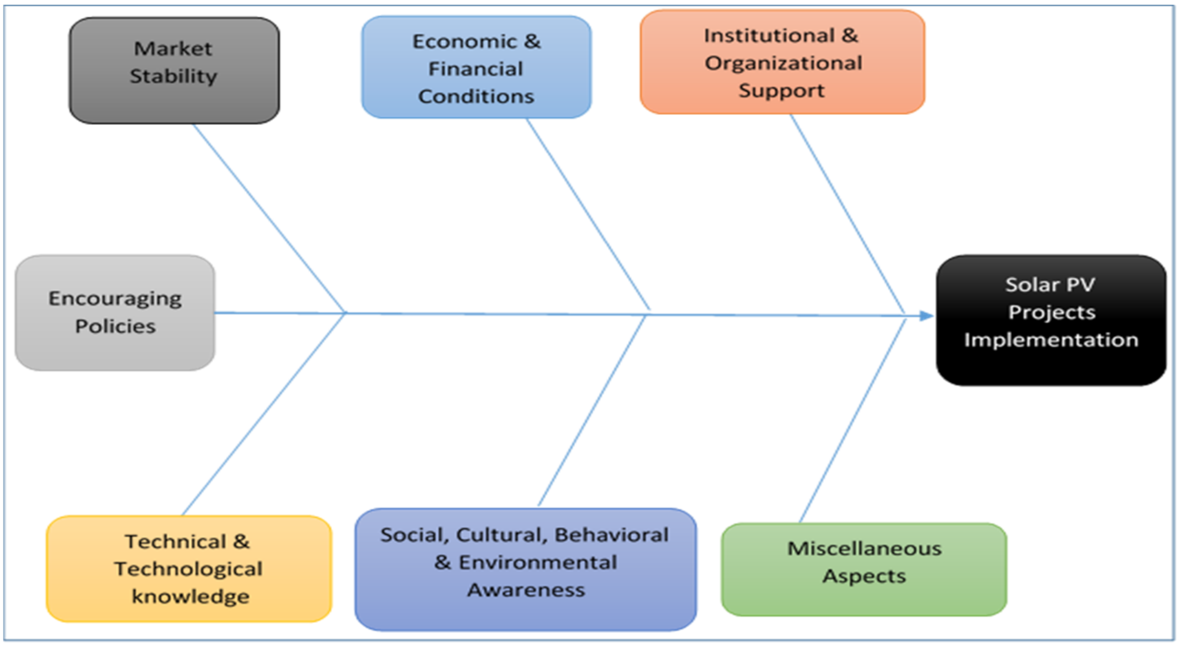

Figure 1. Major barriers impacting solar PV projects.

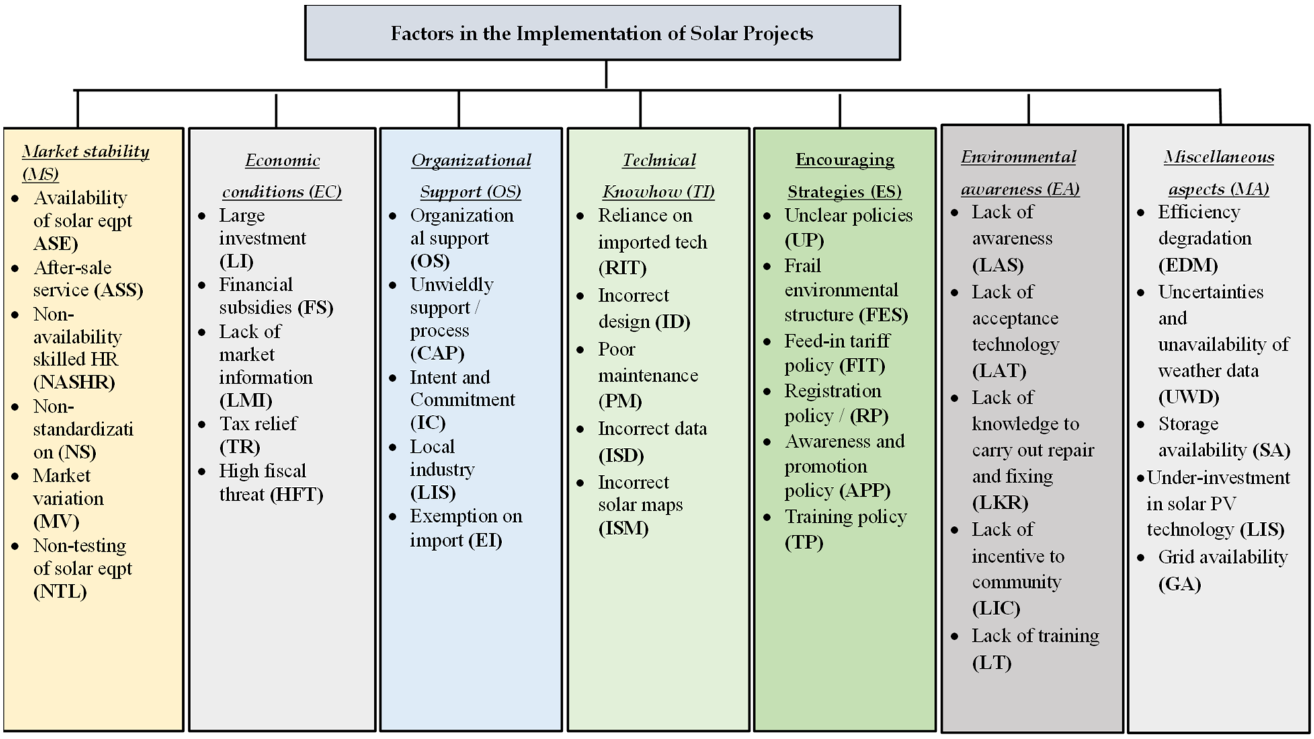

Figure 2. Sub-factors related to major barriers impacting solar PV projects.

Mehranfar et al. [59] emphasized that the use of solar chimney power plants (SCPPs) to produce clean and environmentally friendly electricity has gained significant interest in recent years and is now considered one of the most promising solutions in the world of solar energy. Adekanbi et al. [60] discovered that soiling lowered solar efficiency, raised maintenance expenses, and reduced the lifespan of PV panels. Naimoglu and Akal [61] highlighted that decreasing CO_2 emissions is positively affected by technical advancement, energy efficiency, and the use of renewable energy sources. In light of Turkey's energy import status and heavy reliance on fossil fuels, it is imperative to prioritize technological improvements in the energy sector. It is highly improbable that we will soon completely forsake fossil fuels. Wang et al. [62] used a bi-algorithm MCDM approach for enhancing efficiency and cost-effectiveness in the selection of machines in manufacturing businesses and recommend that it will help executives, engineers, and specialists.

3. Methodology

The critical review of the literature was carried out to identify different factors/variables impacting the solar projects implementation. A words-based searching method was used while utilizing the repositories of Science Direct, Elsevier, MDPI, and ASCE. Several key words were used such as solar projects execution, use of analytical hierarchy process in solar projects, barriers in execution, variable projects execution, and management. The identified variables are first used in a traditional method, i.e., a relative important index to determine the severity and impact, then these are used in SPSS for the creation of a linear regression model. This methodology will be used to calculate the importance and weight of each variable. Similarly, The AHP is used to discover the most influential factor and how these factors are impacting and causing failure in the execution of solar projects, which can be controlled to ensure successful execution.

Two research methodologies are employed: quantitative and qualitative [63]. Research is carried out in five stages, which are given in Figure 3. In the first stage is the implementation and challenges of the execution of solar projects. The objectives of the research are briefly explained. The reasons of poor implementation and the major variables that influence the execution are illustrated in a fishbone diagram [64], as shown in Figure 4. This helped in creating the questionnaire which determined the impacts of each factor which are responsible for low/poor execution. In the second stage, a detailed literature review for the identification of the critical factors and sub-factors is discussed. In the third stage, data collection are carried out using a mixed approach. In the second last stage, data are processed and detailed applied multivariate statistical analysis is carried. This is carried out by using Statistical Package for Social Sciences (SPSS) and an analytical hierarchical process. In the end, findings and recommendations are made on the basis of both models. The research is also validated and verified by applying the model on a case study. Finally, the research is concluded. The causes of poor implementation of solar projects are due to the poor economic conditions, absence of encouraging policies, lack of institutional help, technological acquaintance, social cognizance, and some other aspects identified through a fishbone diagram. A detailed literature review helped in extricating those factors which directly or indirectly affect the implementation of solar projects. A detailed Ishikawa diagram showing various factors and sub-factors is given below in Figure 4. These causes helped in developing a questionnaire. In order to ascertain the effects of each factor, a five-point Likert scale was employed [65–68]. The type of Likert scale used for the preparation of a questionnaire is given in Table 1. The face validity of the research was examined by four academic experts and eight experts from the field. The construct validity was examined using SPSS. Statistical analysis was carried out to validate the inter-items. The target population constitutes manufacturers, financiers, suppliers, energy managers, project managers, government organizations, consultant, academia, and clients/users. A pilot study was also carried out by distributing the sample to 11 experts and the questionnaire was validated before sending it to sample population [69,70]. Then, the questionnaire was distributed amongst various stakeholders. Out of 500 distributions, 429 responses were received.

Table 1. Likert scale used to measure the influence and impact.

Rating	Influence and Impact Significance
5	Highly significance
4	Moderately significant
3	Significance
2	Low significance
1	Lowest significance

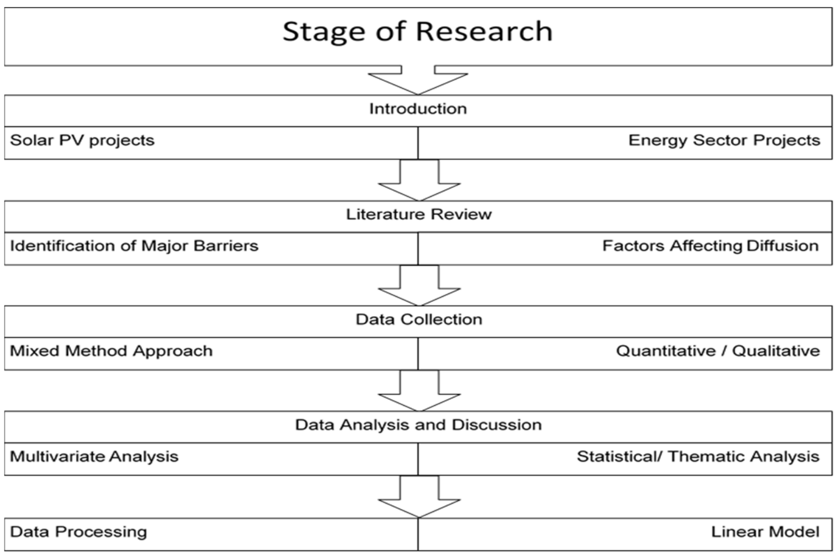

Figure 3. Outline of the study's stages.

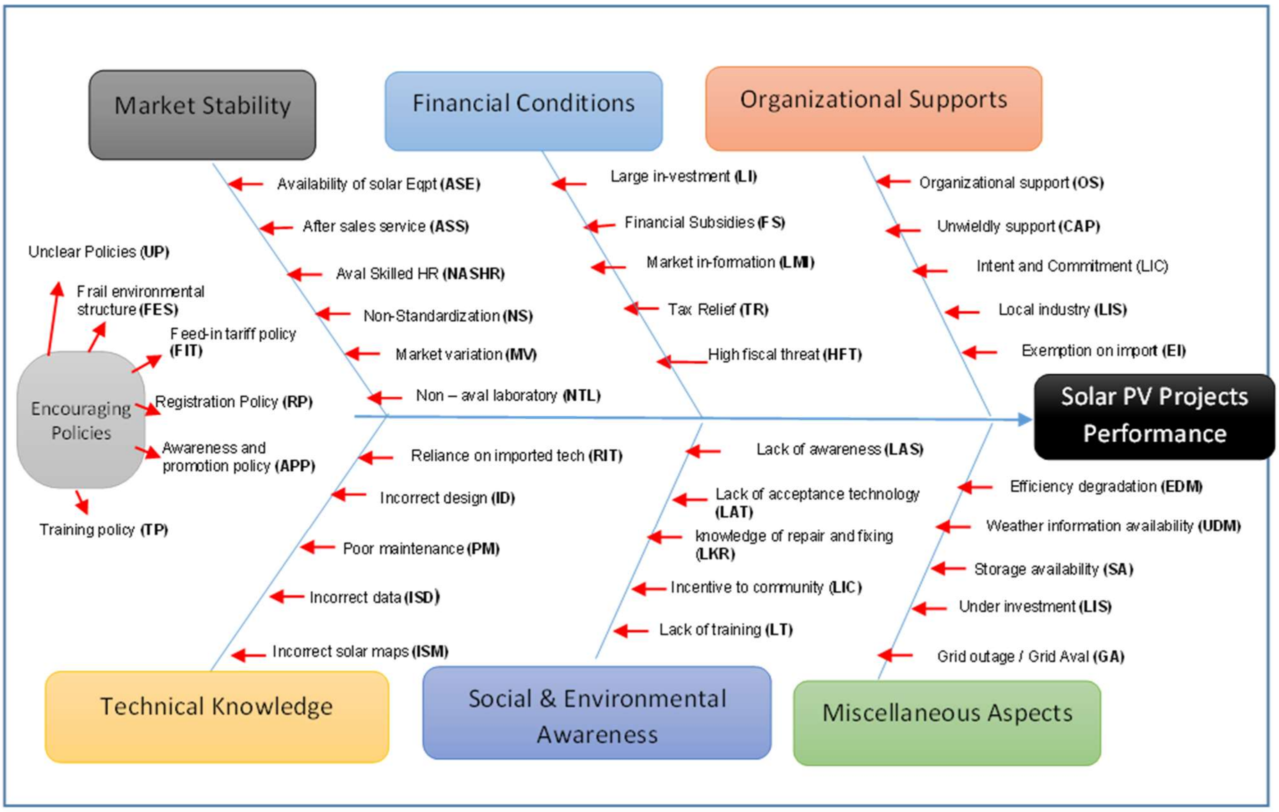

Figure 4. Fishbone/Ishikawa diagram showing relationships between various factors.

3.1. Relative Importance Index (RII)

Based on the results (i.e., mean score and relative weight), variables are categorized based on their influence, importance, and ranking [71]. The factors are ranked according to their RII score. A high score signifies greater significance and importance of the factor. Researchers and decision makers commonly use the relative important index for measuring the relative importance of various factors in a given situation. Giving each variable a numerical value based on its significance allows researchers to create a quantitative framework for comparison and ranking of these variables. Students can enhance their knowledge and validate their investigations in a more professional way by understanding and using the RII.

3.2. Multiple Linear Regression Model (MLRM)

Multiple linear regression model (MLRM) was used to establish a mathematical link between various variables. It is a statistical tool that predicts the result of a response variable while considering the number of independent variables. The goal of multiple linear regression is to model the linear relationship between the independent variables and dependent variables [72,73]. A MLRM helps in investigating how independent variables relate to a single variable. The result of a MLRM is used to predict the level of the effects of independent variables on the outcome variable.

3.3. Analytical Hierarchy Process (AHP)

An AHP is an appropriate and suitable MCDM technique which can be used to solve a complex problem with ease and confidence. An AHP provides flexibility and a pairwise comparison according to indices, providing various options to decision makers according to decision trees [74]. Various studies show that an AHP is most commonly used in the selection of the most appropriate choice for carrying out renewable energy projects [1,75–79]. The decision tree developed in an AHP based on criteria and its alternatives allows for pairwise comparison. This method systematically allows decision makers to make decisions by prioritizing and evaluating criteria. In the development of solar energy projects, the knowledge of average daily irradiation and sunny days are an important basis for the development of solar projects. Based on these criteria, countries make policies to control the investment in energy development projects. Investors and financiers make right choices considering all criteria and factors. Investors and financiers face difficulty in decision making due to doubts, uncertainties, and constantly changing factors affecting solar project implementation [80,81]. Complexities of these factors make decision making difficult and pose substantial risks for investors. Investment in solar energy projects depends on low-risk and high-profitability decisions. The AHP in this study was used to find out the critical influencing factors and how these are impacting and causing failure in the implementation of solar projects, which can be controlled to ensure successful implementation. Decision makers will carry out pairwise comparison and evaluate alternatives based on their knowledge, expertise, and experience.

3.4. Questionnaire Design and Collection of Data

A questionnaire survey was conducted to gather responses and comments from various stakeholders and solar industry specialists. The questionnaire encompasses two parts. The first part contains personal information, while the second part contains major barriers and sub-factors, as shown in Figure 2. A pilot study was planned and a questionnaire was sent to solar experts to gain their opinions and recommendations. The sample size of 10 is consider good for this pilot study. Therefore, 11 experts were asked to review and advise. After professional assessments, minor changes, deletions, and changes were made to the questionnaire.

3.5. Multi-Variant Study

A total of 500 questionnaires were sent to respondents through mail, electronic media, and in personal visits. The feedback of 461 respondents was received; 32 replies were found invalid/incomplete. The responses, of 429, were found valid for further processing/analysis. A response rate of 85.8% was achieved in the current study. Cronbach's alpha was used to access the reliability of the questionnaire instrument and statistical analysis. The strengths of the relationship between factors were analyzed by performing the Spearman correlation test, while the weight and influence of each factor were determined via regression, ANOVA, and relative importance index (RII). Figure 5 shows the details of the respondents.

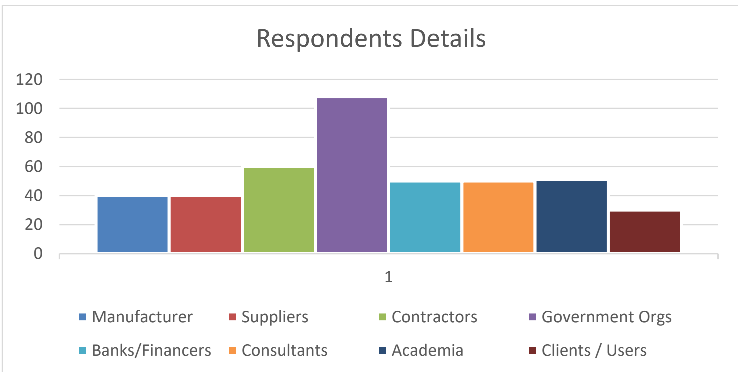

Figure 5. Respondent characteristics.

4. Results and Analysis

4.1. Reliability Analysis

The internal consistency of the data gathered from multiple respondents was checked using reliability analysis. SPSS software Ver 25 was used to analyze the data. The results obtained are shown in Table 2. The value of the Cronbach alpha is more than 7 which means that the data are reliable. The overall Cronbach alpha for 44 factors was 0.946.

Table 2. Reliability test results.

Variables	Cronbach's Alpha		No. of Items
	Overall	**Standardized Items**	
Market Stability	0.946	0.801	6
Economic Condition		0.816	5
Institutional Support		0.867	5
Technological Knowhow		0.788	5
Environmental Awareness		0.798	5
Encouraging Strategies		0.853	6
Miscellaneous Aspects		0.865	5
Project Implementation		0.813	7

4.2. Results of the Relative Importance Index (RII)

The result of the RII is shown in Figure 6. The graphical illustration shows the severity impact of various sub-factors. The severity impact of sub-factors is based on the mean and weight. The scores have shown that the most severely impacting factors for solar projects implementations were vision (81.20), under-investment (79.37), efficiency degradation (78.46), lack of storage capacity (77.22), and after-sale service (76.48), while low impacting factors were poor maintenance (65.54), repair knowledge (65.78), registration policy (66.02), cost variation (68.0), and non-standardization (68.39), respectively.

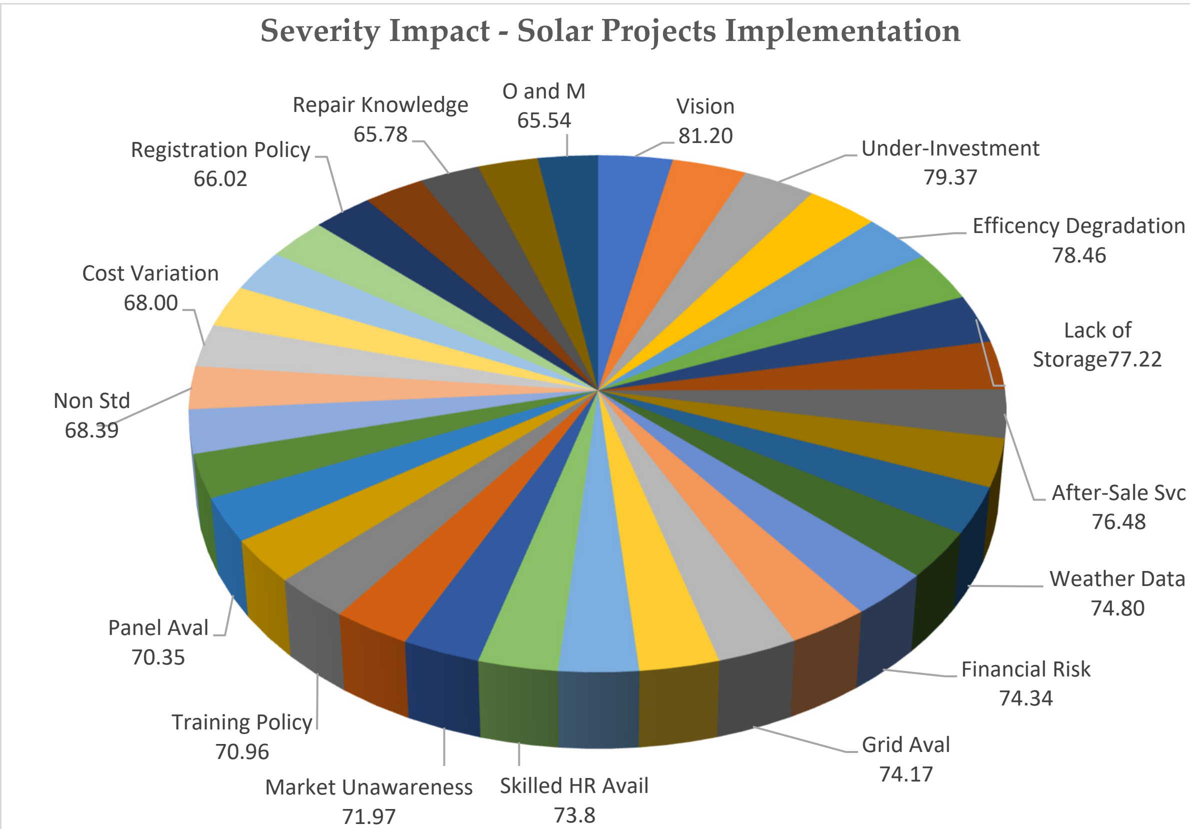

Figure 6. Results of the relative importance index.

4.3. Results of the Multiple Linear Regression Model (MLRM)

The results of the MLRM after computing the responses based on the survey are shown in Figure 6. Statistical software was used for the analysis. The statistical techniques related to multiple regression included the Spearman correlation, model summary, ANOVA, and coefficient of determination for all 44 variables. The Spearman correlation test result shows a medium to strong positive correlation between factors. The results of the MLRM are graphically illustrated in Figure 7. The highest impacting sub-factors as per the MLRM were unawareness of market potential (0.436), financial risk (0.388), financing schemes (0.354), frail environmental structure (0.291), and unclear policies (0.283). While low impacting sub-factors were poor maintenance (0.081), poor assessment (0.128), and incorrect design (0.132), lack of storage (0.137), lack of awareness (0.138), and lack of incentives for consumers (0.139). The results found are quite normal as economic stability and financial soundness help in the growth and intent of any nation/country. The results confirmed that the identified factors are most the impactful factors in solar project implementation [18–20,44]. The most influencing factors, i.e., financial stability, inspiring policies, technology knowhow and organizational help, and environmental and social cognizance, assist in execution [18–24]. Through a positive and forward-looking approach, research and development, training and awareness schemes, execution, and successful implementation can be increased [80].

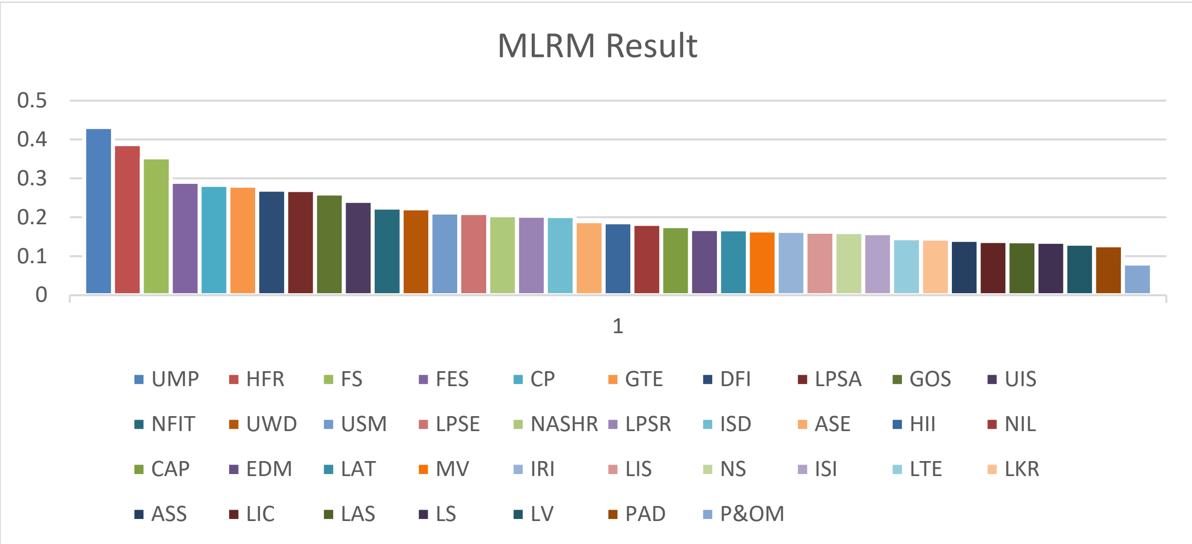

Figure 7. Results of the multiple linear regression model.

4.4. Multiple Linear Regression Model—Development of a Knowledge-Based Model

The model was created by incorporating it in statistical software for computing and collating [76]. The model is given below. The multiple regression equation is shown (1) as under the following:

$$Z = 0.172A + 0.281B + 0.192C + 0.244D + 0.182E + 0.260F + 0.161G \quad (1)$$

where Y is the project implementation/performance (in terms of time and cost, it will be calculated using the unity method);

A is the market stability factor;
B is the economic conditions factor;
C is the organizational support factor;
D is the technological knowhow factor;
E is the social cognizance factor;
F is the inspiring policies factor;
G is the miscellaneous aspects factor.

The model can deviate 10%, which is acceptable.

This can be used for three or four scenarios

4.4.1. Scenario 1—Ideal Conditions—Project executed under a Sovereign Government Surety

In ideal environments, a sovereign government surety and guarantee is available for the implementation of solar projects in a country. It means that the effects of major barriers are negligible: that the environment is rather conducive and supportive for the execution and implementation of a project.

$$Z = 0.172A + 0.281B + 0.192C + 0.244D + 0.182E + 0.260F + 0.161G$$

When A = 0, B = 0, C = 0, D = 0, E = 0, F = 0, G = 0, then Z = 0%.

The result obtained in this scenario with zero impact of any factors shows the ideal conditions, which concludes that the implementation of solar projects is easier. All government departments and organizations will help in implementing the projects. Moreover, necessary policy change, tax exemptions, relief, acquisition of land, and other aspects will be taken care of by the government itself. A 1-megawatt solar project costs approximately 110 M rupees and the time required is 12 months in an ideal environment.

4.4.2. Scenario 2—Worst Conditions

In the second scenario, the impact of the factors is enormously high on the execution of solar projects. These circumstances subsist with no support in relief, tax exemption, and subsidies are not available for implementation. When economic conditions are not very conducive, the policies are not very encouraging, the market condition are not stable, there is no organizational and institution supports in hand, and when technical, technological knowledge, and awareness among the masses are low, we arrive at the following:

$$Z = 0.172A + 0.281B + 0.192C + 0.244D + 0.182E + 0.260F + 0.161G$$

When A = 1, B = 1, C = 1, D=1, E = 1, F = 1, G = 1, then Z = 1.492 = 149.2%.

The influence of all the factors dictates the worst conditions for the execution of solar projects; the implementation cost will be 149.20. The corresponding time will also increase with the same ratio. For example, if the cost of solar projects is 110 million rupees in a conducive environment and its duration is 12 months, the cost of solar projects in the worst conditions should be 149.2 percent more (i.e., 274 million) and time will increase from 12 months to 30 months.

4.4.3. Scenario 3—Moderate Conditions

In the third scenario, the influence of various factors is moderate and implementation and execution is modest. The conditions exist, when some government, organizational, and institutional supports are available, when economic conditions are stable, when policies are encouraging, tax exemptions, relief, and subsidies are available, and when the masses are ready to adopt new technologies:

$$Z = 0.172A+0.281B +0.192C+ 0.244D +0.182E+ 0.260F+0.161G$$

When A = 0.5, B =0.5, C = 0.5, D=0.5, E = 0.5, F = 0.5, G = 0.5, then Z = 0.746 = 74.6%.

The result of the influencing factors reveals the moderate conditions. The cost of solar projects will be 74.6%. The time will also increase in a similar way. For instance, if the cost of a solar project is 110 million rupees and its duration is 12 months, the cost of a solar project in these conditions should be 74.6 percent more (i.e., 192 million) and time will increase from 12 months to 21 months.

4.5. Validation of the Model

Two case studies of solar project implementation in Pakistan were assessed by the researchers as validation of the multiple linear regression model [77].

4.5.1. Case Study 1—Ideal Environment

Quid e Azam Solar Park (QSP) is Government of Pakistan sponsored project, installed at Bawalpur, Punjab. Government sponsorship of the execution of solar projects is ideal. The project was started in 2014 and achieved its commercial operation date (COD) in July 2015. The project has been on time and on cost. The project has not deviated from its targeted cost and time milestone; hence, zero variation from the MLR model. The details about the project are as follows:

Project capacity	400 MW
Solar project cost	14,946 million rupees
Time to complete and implement project	12 months
Completion cost	14,946 million rupees
Completion time	12 months
As per the model	Ideal environment
Variation in cost and time	0%

Due to sovereign government guarantee, support and facilitation, and alignment of all other departments and organizations, the implementation of first-in-kind solar projects was carried out with a planned cost and time schedule.

4.5.2. Case Study 2—Worst Conditions

The second case study was the implementation of 10 MW solar projects through a public private partnership at Quetta, Pakistan. The original cost of the project was 1050 million and the duration was 12 months. However, due to various hurdles, i.e., changes in policies, political instability, weak economic condition, and a ban on the letter of credits (LC), the project was delayed (the worst scenario as per the model). The project was completed with a cost of 2657 million rupees and a duration of 31 months. The variation in the percentage of cost and time is 153% and 157%, respectively. Also, as per the model, the cost should be 149.2% more than the actual cost and, similarly, the duration of the project will follow the same ratio. A 4% deviation in cost and 8% in time was seen, with a variation of 10% that is acceptable. Hence, the model is verified. The details about project are as follows:

Project capacity	10 MW
Project cost	1050 million rupees
Time to complete and implement project	12 months
Completion cost	2657 million rupees
Completion time	31 months

In this case study, from considering all discussed scenarios above, a worst-case scenario will be applicable: the cost of the project should be 149.2 percent (2617 million) more than the planned cost (as per the model) and the duration should be 2.5 years.

Cost Variation from the Model

Planned cost of solar project	1050 million
Worst environment as per the model	149.2 percent
Completion cost as per the model	2617 million
Completion Cost Actual	2657 million
	153 percent more than the actual cost
Difference in Cost	2657 − 2617 = 40 million
Cost Variation	153 − 149 = 4%

Time Variation from the Model	
Planned duration of the solar project	12 months
Worst environment as per the model	149.2 percent
Completion time as per the model	30 months
Actual completion	31 months
	157 percent more than the actual cost
Difference in duration	157 − 149 = 8%
Variation	8%
Model	Validated

4.6. Results of the AHP Methodology

Results of the AHP methodology based on the comparison matrix and ranking of the main factors shown in Table 3. The results show that the top critical factors are inspiring policies (eigenvalue 0.0417), financial situations (0.0387), technology familiarity (0.0379), organization support (0.0362), miscellaneous aspects (0.0342), market stability (0.0338), and social awareness (0.0335), respectively. The weights of the sub-factors are illustrated in Figure 8. The results of the sub-factors show that high financial risk (0.0339), financial schemes (0.0331), unclear policies (0.0317), and a lack of policy for solar awareness (0.0312) are the most influential factors regarding the implementation of solar projects, whereas after-sale service (0.0215), lack of vision and intent (0.0223), lack of storage (0.0238), and approval process, (0.024) are low-impact sub-factors. The outcomes of the current studies are in line with previous research on the subject.

Table 3. Ranking of the main factors based on the AHP results.

Ranking Based on AHP		
Main Factors	**Ranking**	**Weight**
Encouraging Policies	1	0.0417
Economic Conditions	2	0.0383
Technical knowledge	3	0.0379
Organizational Support	4	0.0362
Miscellaneous Aspects	5	0.0343
Market Stability	6	0.0338
Social Awareness	7	0.0335

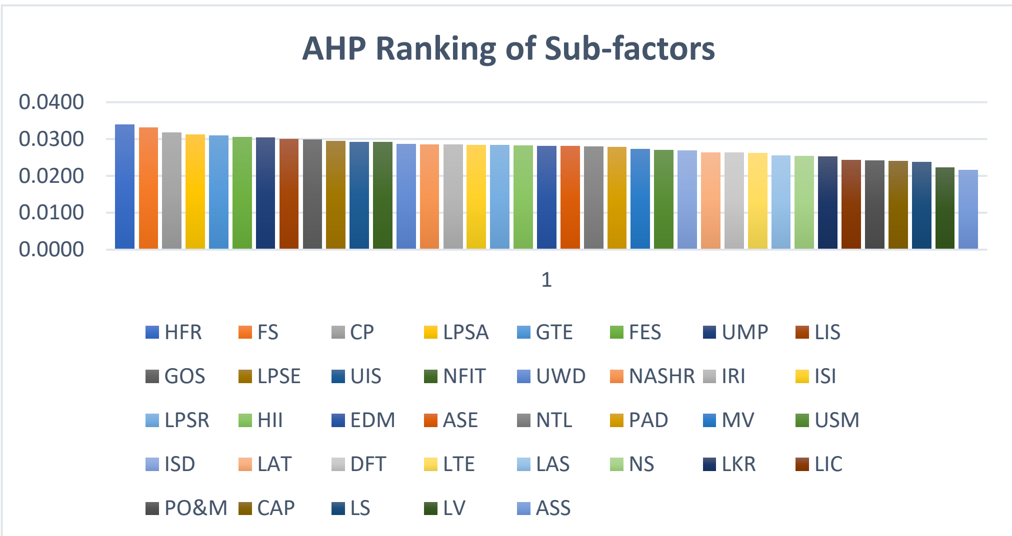

Figure 8. An AHP-based ranking of the sub-factors.

4.7. Comparative Findings Based on the RII, MLRM, and AHP

Figure 9 shows a comparison of all three approaches. The ranking of all significant factors is presented in comparison with the ranking determined by the weight, influence, and impact on the execution of solar projects. The most compelling factors are economic stability and motivating policies: organizational backing, technological knowhow, and societal awareness are all crucial for the successful implementation of solar projects. In a similar vein, a conclusive environment is created when primary variables are combined with minor ones.

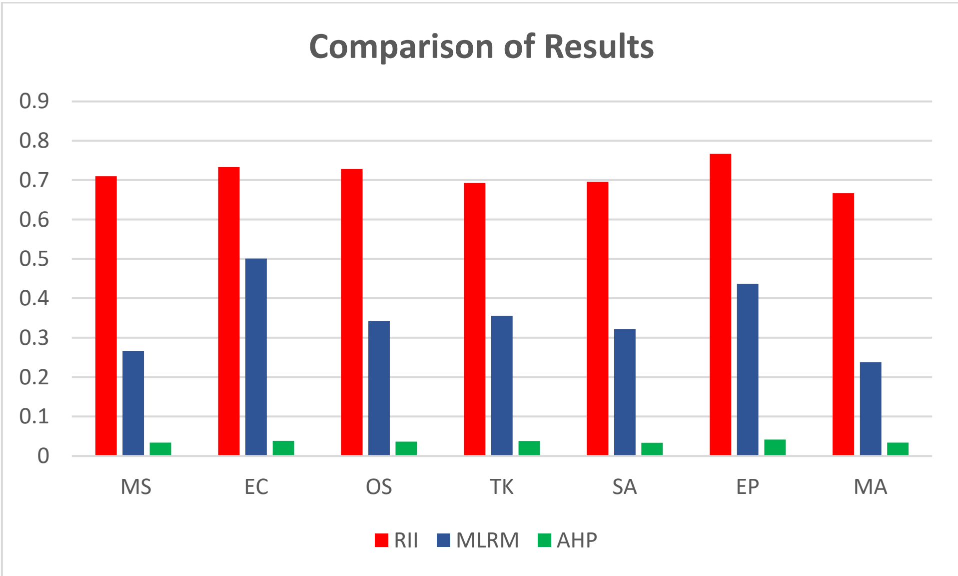

Figure 9. Comparison of the RII, MLRM, and AHP results.

5. Discussion

The importance and originality of this study is the combination and use of linear regression and AHP, which have been employed to measure the influence and impact of variables on the execution of solar projects. The scholarly contribution involves a methodical examination of engineering management in the energy sector. The comprehensive examination of the literature uncovered the necessity for further investigation into project management skills. This study establishes a connection between prior research and future initiatives for the implementation of solar projects in emerging nations.

5.1. Effects of Financial Stability

The results of the regression model and the AHP discovered that the financial soundness of a country is very significant for successful execution. In the absence of a stable financial state, it is hard to implement and execute projects. Similarly, subsidies provision, exemption in taxes, facilitation and relaxation in imports, and the creation of awareness amongst the population become challenging. The outcome of the study confirmed the results of prior studies [18]. Developed countries of Europe ensured the implementation based on timely decision making, a conducive environment, and a strong relationship between government and private organizations and departments (Climate Council Report 2019). Paraguay has been constantly investing in the energy sector [82]. Advanced countries of the world can help developing countries by providing required resources. Emerging nations can slowly move to renewable energy generation. Therefore, the absence of financial steadiness can adversely affect the execution of solar projects. Financial stability is one of the significant factors of a project's execution. Securing adequate financing, obtaining affordable funding, and receiving tax relief are crucial for the successful implementation of a capital-intensive solar project. Financial stability's sub-factors include knowledge about high initial investment, supporting financing schemes, awareness of market potential, and high financial risk [26] which require mitigation while executing a solar project. Mustafa and Omer [6] established this factor in their study. The control of all these sub-factors helped in the successful execution of solar projects.

5.2. Effects of Inspiring Policies

The results of the survey, linear regression, and AHP discovered that inspiring policies was the second most influential major factor in the execution of solar projects, whereas as per the AHP and relative index, it is the primary factor. Inspiring plans create a conducive atmosphere for the execution of projects. Optimal and resilient economic conditions facilitate the achievement of the desired objectives. The aim is to establish economic stability and implement promising policies that will chart a clear future direction and course. Consequently, tax exemptions, facilitation for investments, reliefs, and approval are necessary as part of a one-window operation to all potential executors. The USA used BEPTC and SROPTTC policies for the execution of solar projects [82,83]. This study confirms the previous results [10,11,18,23]. Developing nations can plan solar projects according to a program with their annual budget and finances. Hence, resolving any uncertainties and alleviating the concerns of prospective contractors are imperative. Developed nations have formulated and executed advantageous strategies to facilitate the attainment of their future objectives. Sub-factors linked to policy factors such as unclear and ambiguous policies [19], weak environmental structure [18], firm registration policy [14], policy for solar technology awareness and promotion [10], and policy for training/education and feed in tariff policy are other sub-factors which impede solar adoption [16].

5.3. Impact of Technological Familiarity

The next important major factor that impacts project execution in emerging countries, according to linear regression, AHP, and RII, is that knowing about technology makes people more aware of it, helps them learn how to use it, and eventually makes them accept it. Awareness and education regarding the benefits of technology are best provided by those with technical skills. Workshops, seminars, and media campaigns that encourage audience participation can help debunk common technological myths and misconceptions. This study confirms that technological knowledge is a significant element that influences the implementation of solar projects as previously reported [18,23,31]. The development of crucial technological knowledge and information has aided the modern world in the implementation of renewable initiatives [82]. Technological expertise sub-factors such as inadequate evaluation and improper design, reliance on foreign technology, and unauthenticated maps for accurate assessment are detrimental for the adoption of solar technology [40,42,43].

5.4. Impact of Organizational Support

In the results of the survey, linear regression, and AHP, institutional support was identified as the next most significant key element that influences the execution of solar projects. Organizational support facilitates the provision of essential resources inside an organization, including authority, machinery, and human resources. The organization provided assistance and support in obtaining various exemptions, waivers, permits, and subsidies to expedite the execution of solar projects. Public private partnerships can help organizations in the planning and implementation of solar projects. Organizations can take the lead in educating and raising public awareness. This study supports the need of organization support in the implementation of solar projects. The assistance of an organization acts as a stimulant in the implementation of solar projects. Developing nations have promoted organizational roles in the implementation of solar projects [82,83]. Sub-factors of institutional support, such as a lengthy approval process, delays in execution, and inadequate aid, create distress in the minds of stakeholders and a lack of institutional support derails the whole process [41,42].

5.5. Impact of Social Factors

According to the survey findings, linear regression, and AHP, social and environment awareness (SA) was rated as the fifth most significant main factor that impacts the execution of solar projects, while as per AHP and RII, it is the seventh and sixth factor, respectively. Societal and environmental awareness (SA) creates an environment that fosters the acceptance of new technologies and contemporary trends. The adoption and diffusion of new and modern technologies progresses slowly. However, adequate promotions and media campaigns can craft the way for acquiring and disseminating new technologies. The success of developed countries includes a recipe for strong promotions and strong media campaigns [82,83]. A media campaign can serve as an effective instrument to raise awareness and dispel misconceptions and worries among potential users. The findings of the study are consistent with earlier research on the subject [22,32]. Sub-factors associated with social and environmental factors such as a dearth of new knowledge (graded 23), deficiency of skill learning (graded 29), and knowledge of repair and maintenance (graded 30) have significance effects on solar technology acceptance [37,40].

5.6. Impact of Market Constancy Factors

According to the survey findings, linear regression, and AHP, market steadiness was regarded as the next most important main element that impacts the project accomplishment; similarly, according to the AHP and relative index scoring, it is graded as the fifth most significant factor. Market soundness is a key sign of a firm economy. The presence of ambiguous and volatile market conditions leads to confusion and a lack of clarity in the minds of stakeholders. These conditions are more prevalent in developing countries. External donors, investors, and developers are cautious about investing in such a setting. Market constancy and supportive policies can work together to help stabilize market conditions. A vibrant economy and robust market aid in the quick dissemination of new technology. The current study findings are consistent with earlier studies [22,26]. Other factors connected to market soundness such as trained manpower (graded 15), solar fixtures (graded 18), testing laboratories (graded 20), market variation (ranked 24), and non-standardization (graded 27) have negative impacts on technology acceptance [5,8,11].

5.7. Impact of Other (Miscellaneous) Factors

According to the findings of the survey, linear regression, and AHP, miscellaneous aspects (MA) was regarded as the seventh most relevant main element influencing the execution of solar projects, while the AHP and RII placed it as sixth and seventh. Other factors have a larger effect on the execution of solar projects; however, these minor factors still have an impact. When combined with the main factors, the minor factors have a more pronounced effect. During the planning phase of solar initiatives, miscellaneous elements require special consideration and must be managed with professionalism. Individually, miscellaneous elements have little impact; however, when combined with primary elements, they exert a much greater influence. The findings are consistent with prior studies [32,33]. Sub-factors related to various factors such as the non-availability of a grid (graded 9), lack of investment (graded 10), data uncertainties (graded 12), and efficiency degradation (graded 22) have an unfavorable influence on embracing solar technology [3,17,20].

6. Conclusions and Recommendations

The objective of this study was to identify key factors that affect the implementation of solar projects. The study evaluated multiple factors according to their impact and consequences. The primary parameters were identified by a comprehensive analysis of the existing literature and then subsequently adjusted with the assistance of energy specialists. The survey questionnaire was disseminated to solar and energy industry experts and stakeholders, who were requested to evaluate the impact of these specific elements on the execution of solar projects.

Based on the linear regression model, financial stability, motivating policies, technological knowhow, organizational support, societal awareness, and market steadiness were classified and evaluated as the primary critical elements. Comparably, favorable policies, economic conditions, organizational support, technological knowhow, market consistency, and social awareness were categorized as key factors by the AHP results. The findings and evaluation support the claim that effective strategies, proactive marketing campaigns and awareness campaigns, forward-thinking, creative policies, and careful monitoring, management, and control of the essential components are all necessary for the successful implementation of solar projects. Developing countries may take charge of and resolve these issues to create effective implementation strategies for solar projects. Developing countries need to switch to renewable energy production. This can be achieved by strong financial management, encouraging legislation, and forward-thinking planning for clean and green energy. The use of integrated methodology, i.e., the integration of linear regression and AHP for evaluating the weight and influence of each element, is the key contribution of this study. Prior research using the traditional methods have assessed the effect of the main impediments, whereas the current study, using the techniques mentioned above, has found that the effects of minor sub-factors, once combined with main factors, create pronounced effects on the implementation of solar projects.

Research Limitations and a Future Agenda

This research has some limitations which need to be addressed. The multiple regression model (MLRM) and analytical hierarchical process (AHP) have been used for measuring the influence and impact of main and sub-factors. Further research in this area may employ more sophisticated methodologies, such as modeling based on convolutional neural networks (CNNs) and rule-based decision support systems (RDSSs), to ascertain the variables that impact the execution of solar projects. The analysis excluded the off-grid and battery-based storage solar plants. Future researchers may look at solar projects that rely on batteries for storage and off-grid operation. In order to confirm the efficacy and viability of the suggested strategies in actual situations, they might also carry out empirical research. In order to get important insights, future research may also look at how well the recommended methodologies scale and adapt to various situations and geographical areas. To enhance the practical significance of the study's findings, a future study could center on exploring real-time monitoring systems and flexible strategies for overcoming challenges in the implementation of solar projects. An expansion in this context may seek to address the dynamic nature of obstacles and underscore the crucial role of timely interventions in guaranteeing the success of projects.

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