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RESEARCH ARTICLE

Entrepreneur barrier analysis on renewable energy promotion in the context of Pakistan using Pythagorean fuzzy AHP method

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Abstract

Ideal energy policies based on the identification of main obstacles might indorse the growth of renewable energy. In light of the importance of promoting entrepreneurship in renewable energy resources, the current study examined the barriers to develop renewable energy entrepreneurship in Pakistan. As a result, the current study proposes a systematic approach for prioritizing hurdles to entrepreneurship based on their relevance. The research was split into two parts. To begin, a literature survey and interviews with experts were used to identify potential obstacles. Second, the Pythagorean fuzzy analytical hierarchical process (PF-AHP) approach was hired to finalize and categorize the challenges. Twelve barriers were finalized, and they were then divided into four categories. Finally, PF-AHP was used to determine barrier weights and ranks. The final results showed that the legal and regulatory framework obstacle category is the most essential among the main categories, while the overall ranking of obstacles revealed that the lack of policy is more vital than the other twelve sub-barriers in various groups.

Keywords Renewable energy · Entrepreneurship · Barriers · Pythagorean fuzzy logic · AHP

Abbreviations

RE	Renewable energy
PF-AHP	Pythagorean fuzzy analytical hierarchy process
MCDM	Multicriteria decision-making model
NGOs	Non-governmental organizations
R&D	Research and development
PFS	Pythagorean fuzzy set
MB	Membership number
AHP	Analytical hierarchy process
LT	Linguistic terms
CR	Consistency ratio
DM	Decision-makers
C	Criteria/barriers
GDP	Gross domestic product
CEFC	Clean Energy Finance Corporation
GIB	Green Investment Bank

Introduction

The fundamental aspect of a supportable energy system is its capability to deliver prescribed duties without depleting resources. The first stage in developing such a system is to use existing resources while also increasing renewables effectively. The conversion to an applicable power system should raise the move from non-sustainable to sustainable energy resources. Stepped-up usage of renewable energy sources will support fulfilling growing power demand while also curtailing the conflicting environmental effects of energy use (Abdul et al. 2021; Tanveer et al. 2021). Improving RE is also critical for achieving long-term sustainable development goals (Haseeb et al. 2019; Deshmukh et al. 2021). Furthermore, non-RE energy sources like fossil fuels (coal, natural gas, and oil) degrade the climate and contribute to global warming (Shahsavari and Akbari 2018;

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Alizadeh et al. 2020). Accelerated economic expansion results in increased energy consumption, which has severe environmental effects (Hafeez et al. 2019). On the other hand, carbon emissions are a byproduct of economic activity, and power consumption is still a component of economic and social development. If we ignore economic growth in favor of emissions reduction from carbon dioxide emissions, capital accumulations can be terminated early, and long-term economic growth can be harmed (Kang 2021).

RE resources including solar, hydro, biomass, geothermal, and wind energy must be adopted to achieve long-term economic, environmental, and social growth. Additionally, RE resources are considered more economically and technically reliable (Solangi et al. 2021). Electricity is a fundamental commodity that has been determined to be a gift from science to humanity (Hansen and Xydis 2020). Off-grid electrification is a cost-effective approach to acquiring power in the developing world due to its dispersed and diversified populations. It is an economical energy source related to on-grid electricity generation systems, exclusively in isolated locations with limited electricity access (Xu et al. 2019). Additionally, economies with a sophisticated financial sector enable enterprises to upgrade to much more efficient equipment and use sustainable, renewable energy by providing financial resources. Financial stability opens the door to renewable and ecologically friendly technologies that reduce carbon emissions and improve ecological integrity (Safi et al. 2021). Promoting carbon neutrality will not only reduce carbon perpetuity but can also minimize the concentration of pollutants, benefiting the environment (Wu et al. 2022). The advancement of environmentally sustainable technology aids in the reduction of carbon emissions (Wahab et al. 2021).

The expansion in using RE resources is facing several obstacles. As a consequence, it is critical to solve such hurdles in order to build RE resources. Although costs have declined significantly in recent years, several studies have concluded that prices are the most significant impediments to RE growth, and entrepreneurs confront various problems and hindrances. Promoting entrepreneurship has been hailed as a critical tool for increasing energy for long-term growth. In some ways, becoming an entrepreneur in a developing nation is much more difficult. They face numerous difficulties in starting and operating their business organization (Gabriel 2016). The constraints that prevent these systems from being implemented have previously been intensively investigated. Generally speaking, the barriers can be divided into four main groups: institutional and regulatory barriers, economic and financial impediments, technical and infrastructure fences, and public awareness and information difficulties.

In recent years, countries have become more aware of the need to expand the potential of RE sources, and they now regard them as a step to address energy security while also achieving environmental intentions (Hassan et al. 2018; Naseer et al. 2021). Pakistan's government needs to include renewables in its solution to fulfill its energy needs because various geographic characteristics make the country well-suited for deploying RE generating plants (Usman et al. 2020). There are plenty of primary resources in the country, and demand is rising, making it ideal for renewable energy developers. Many barriers remain to further expansion of renewable energy projects despite favorable conditions and government objectives. It is thus crucial to comprehend why RE is not taking off in the country as expected, and there must be some roadblocks delaying or preventing renewables' progress.

The roadblocks to the progression of RE technologies faced by entrepreneurs are contextual. As a result, their implications vary based on the country's technical capabilities, socio-economic status, political, and geographical situation. The insufficiency of such studies causes a lag in the implementation and utilization of RE sources. It is indeed critical to understand the nature of the hurdles before developing policies to address them (Oryani et al. 2021; Kumar et al. 2022). As evidenced by the literature, the AHP technique has often been employed for investigations involving minimal outlay costs, social acceptability, land use, energy costs, maintenance costs, and so on (Xu 2020). The technique used in this study could be useful for future research on ecopreneurs' hurdles to RE technology in other nations. However, the number of impediments and consequences varies. This research helps to reduce or eliminate ecopreneur's hurdles to RE sources, clearing the road for their implementation in Pakistan and other developing countries.

The present study aims to identify and prioritize the obstacles that entrepreneurs face in developing RE projects in Pakistan. The implementation of RE is a tough decision to make. It demands a thorough evaluation based on multi-criteria (Solangi et al. 2019). The current investigation pays to prevailing inquiry in numerous ways:

(1) This research will help governments and policymakers concentrate future efforts on installing RE resources for long-term energy planning and development in Pakistan.
(2) It outlines the constraints and sub-barriers entrepreneurs face in promoting RE sources.
(3) The parameters for the application are established by reviewing articles in the literature, taking into consideration expert views and existing systems in use.
(4) The study utilizes a Pythagorean fuzzy analytical hierarchy process (PF-AHP) to offer detailed insights into an ecopreneur's hurdles to RE development and implementation constraints in Pakistan.

(5) Finally, it proposes workable strategies for overcoming such obstacles to achieve the Paris Agreement's long-term development goals and objectives.

The remainder of this work is as follows: Sect. 2 discusses the literature review. Section 3 describes the challenges to RE promotion that entrepreneurs confront. Section 4 explains the technique used in the research. Sections 5, 6, and 7 detail the method's application, the findings and discussion, and finally, the conclusions.

Literature review

Renewable sources have gained a lot of attention from academics and policymakers in recent times as a viable solution to the growing energy demand problem and the climate change associated with fossil fuels. Electricity usage has been increasing rapidly as a result of an overreliance on ICT-related equipment in both offices and homes (Zhao and Hafeez 2022). Photovoltaic technology is one of the most important RE technologies for long-term power generation. Nevertheless, there is a scarcity of extensive research in this field to fill in the many gaps between accomplishments and objectives. More significantly, the implications of technical, social, and economic restrictions on RE sources' development have not been thoroughly researched, and these obstacles must be explored in order to find appropriate solutions (Ali et al. 2021). Energy conversion by many aspects of the economy is among the difficulties of achieving sustainability. RE sources have been regarded as among the most important aspects for the future of society and the global economy for decades, with investments in clean energy increasing from approximately $9.9 billion in 2010 to $18.6 billion in 2016 (Bortoluzzi et al. 2021).

Entrepreneurship is regarded as one of the leading factors in economic development (Sendra-pons et al. 2022). There is widespread agreement that entrepreneurs are often motivated by proper motivations and act at a conducive time (Miller 2003). According to the initial viewpoint, the entrepreneur is a representative of change, creator, or innovator (Schumpeter 1947), and it is an individual who holds risks and establishes unpredictable enterprises (Thornton 2020), opportunity vigilance (Shane and Venkataraman 2000). According to the second point of view, the entrepreneur possesses a collection of characteristics including a drive for success, an internal center of control, a tolerance for ambiguity, and a risk-taking proclivity. Growing energy use and the degradation of ecosystems have been two important challenges for the global community in recent decades (Lei et al. 2021). Environmental challenges such as climate change and carbon emissions have boosted environmental consciousness, and many individuals now prefer to buy with ecological considerations in mind (Anderson 1998). One of the main strategies for achieving this goal is to use RE sources such as wind, solar photovoltaic, small hydro, biomass, and geothermal, although these alternate energy sources will indeed meet rising energy demand while also improving environmental quality (Gómez-navarro and Ribó-pérez 2018).

The increase in ecopreneurs might be attributed in part to increased market prospects for sustainable products and services. Customers are getting more concerned about the environment (Laroche et al. 2001). The concept "ecopreneurship" is often stated to as "green entrepreneurship" (Schaper 2002), "entrepreneurship" (Keogh and Polonsky 1998). Berle (1993) coined the term "Green Entrepreneurship" in his book "The Green Entrepreneur: Business opportunities that can save the earth and make you money." Green entrepreneurs take advantage of possibilities and build a firm for long-term development that is structure-changing, socially committed, and technologically sophisticated and is based on environmentally friendly processes and products (Walley and Taylor 2002). Schaper (2002) has discussed numerous facets of environmental entrepreneurship in his study "The Essence of Ecopreneurship." According to the researcher, green entrepreneurship is an extremely new area that offers various prospects for long-term sustainable growth through innovation. However, administration regulations, legislation, and industry support organizations must all show an essential part in ensuring the success of this endeavor. Non-governmental organizations (NGOs), venture capital firms, and local communities might play crucial roles in assuring the success of green entrepreneurship. Dean and McMullen (2007) discuss the significance of environmentally relevant market failures as a hindrance to successful entrepreneurship. They identify several market failures—externalities, monopoly power, and inappropriate government intervention as appropriate to environmental entrepreneurs. If an industry is monopolistic, entrepreneurs must overcome entry barriers to acquire market share from incumbents who tend to be sclerotic and resistant to innovation (Dean and McMullen 2007). As for the obstacles to the demand for the eco-innovations of environmental entrepreneurs, another principal factor is consumer resistance. Tanaka et al. (2014) lament the slow pace of change in consumer behavior toward more sustainable consumption and call for urgent action to mobilize the public to protect the environment.

Renewables are seen as a significant prospect for improving the situation of society, particularly in rural places where access to contemporary sources of energy is limited (Painuly 2001). Adoption of eco-innovation in renewable generation technologies may also depend on consumers' willingness to pay for the conservancy of legitimate reserves. This is likely to be based on their environmental values (Kowalska-Pyzalska 2019). Consumer resistance to eco-innovation in

the energy industry is a significant obstacle to the success of new ventures (Claudy et al. 2015). There is also political uncertainty surrounding policy and government behavior (Meijer et al. 2007). Political uncertainty is a particular problem in a sector where governmental activity is essential, such as energy. In essence, in order to alleviate entry barriers for environmental entrepreneurs to the energy industry, innovation in grid infrastructures will be necessary. In order to achieve this, the governance of electricity networks is crucial—the government and the regulator must find market-based ways of stimulating network innovation in a privatized energy market (Bolton and Foxon 2011). Indeed Meijer et al. (2007) highlight the adverse effects of political uncertainty on new ventures in the Dutch energy industry. Lüthi and Wüstenhagen (2012) stress the importance of the long-term stability of policy frameworks, such as subsidy mechanisms like the feed-in tariff, to minimize policy risk. In contrast, Bürer and Wüstenhagen (2008) and Lüthi and Wüstenhagen (2012) discuss the importance of environmental regulations and policies for other stakeholders in environmental entrepreneurship, namely venture capitalists whose investment is a green start-up, which is, in part, contingent on the policy and regulatory context.

Identification of entrepreneur's barriers to renewable energy promotion

Entrepreneur barriers overcame in RE promotion are accurate and show a significant impact on the development. Ghimire and Kim (2018) suggested that literature, spot inspections, and conversations with relevant associations (sellers, installers, experts, and development firms) might identify impediments; subsequently, this research endorsed the same technique. First, a thorough literature review was conducted, including keywords such as entrepreneurs, green business, barriers, challenges, and RE development in developing nations. The online search engines Google, Google Scholar, and Science Direct were used for the literature review. Second, consultations with experts and green businesses in Pakistan were held to confirm existing obstacles and introduce new ones. Using this approach, the obstacles were identified and categorized into four main hurdles: inadequate access to institutional finance, social culture and behavioral, legal and regulatory framework, and technical aspects. Besides the obstacles placed in this research work, there may be other entrepreneurs' hurdles to RE promotion in Pakistan that have not been examined in the literature and future difficulties. Figure 1 summarizes and categorizes barriers, with concise descriptions of each obstacle as follows.

Inadequate access to institutional finance

In several developing nations, including Pakistan, economic and financial constraints are a key hindrance to the development of RE initiatives. The most significant impediments might be identified as low private and public investor intention to participate in REs, lack of credit and pay-back duration, costly initial investment, high cost of RE technologies, and higher subsidy for conventional energy sources linked to RE. The pay-back periods and investment costs of RE systems are both higher. These technologies are not only more expensive to develop, but they are also viewed as higher-risk investments. Entrepreneurs face numerous obstacles to promoting renewable energy, including a lack of available capital and difficulty obtaining credit (Bianchi 2010; Loock 2012; Gabriel 2016; Pueyo 2018; Shithila et al. 2018; Cheraghi et al. 2019), securing investors (Shithila et al. 2018), and accessing credit (Bianchi 2010; Gabriel 2016; Ouedraogo 2019).

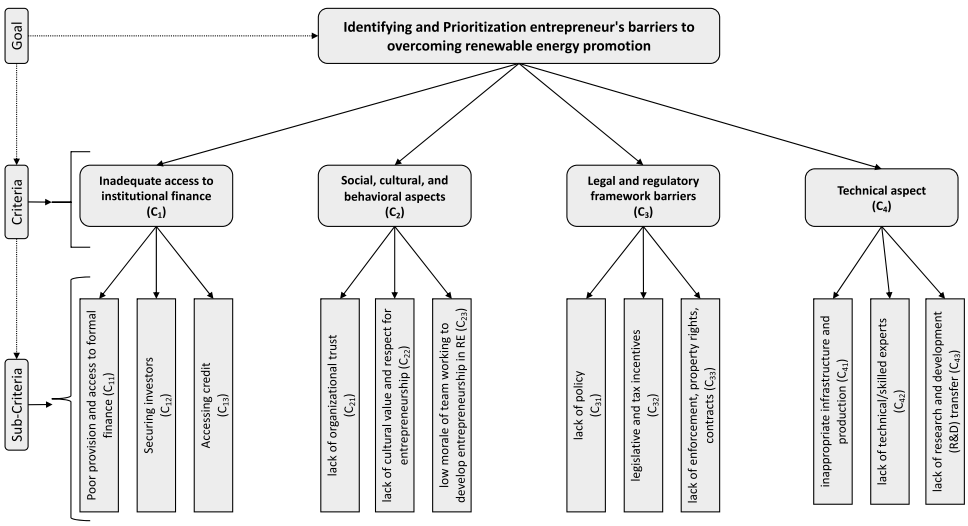

Fig. 1 The hierarchy structure of barriers and sub-barriers

Social, cultural, and behavioral aspects

A primary impediment to the implementation of RE technology in Pakistan has been identified as a lack of public awareness. This situation is associated with a lack of public understanding of the benefits of RE sources and a lack of societal acceptability. The most serious issues with public consciousness may be described as a lack of understanding of current technology such as RE technologies and uncertainties about the economic viability of developing renewable sources. The critical barriers in Pakistan under the social, cultural, and behavioral category include lack of organizational trust, cultural value and respect for entrepreneurship, and low morale of team working to develop entrepreneurship in RE.

Legal and regulatory framework barriers

The absence of a fully legal and regulatory framework is a major hindrance to the expansion of RE. Indeed, due to the essence of RE systems, increasing investor interest in the inexhaustible energy market demands the formulation of clear laws and appropriate strategies. Another issue that generally arises in the installation of RE sources is the lack of grid access regulation. The advancement of RE technology compels accurate, accessible, and non-discriminatory grid access standards. Meanwhile, it seems that many municipal electrical networks continue to restrict the connection of these smaller-scale devices. The deployment of RE technologies faces tremendous difficulty in terms of open transmission access. A practical regulatory framework in the energy industry is critical for attaining sustainable development goals and might help resolve the incoherence between traditional and contemporary energy sources.

The most critical barriers encountered are the legal and regulatory framework. These challenges are categories as lack of policy (Stel 2013; Nasirov et al. 2015; Gabriel et al. 2016; Shithila et al. 2018), legislative and tax incentives (Stel 2013), lack of enforcement, property rights, contracts (Stel 2013).

Technical aspect

One of the most significant hurdles to expanding modern RE technology in Pakistan is the lack of essential infrastructure. Indeed, RE technologies' effective administration and operation need trained and qualified staff, as evidenced by inappropriate infrastructure and production, a lack of technical/skilled experts, and a lack of R&D transfer (Shah et al. 2019).

Research methodology

Multi-criteria decision-making (MCDM) procedures are presumed to be suitable for multi-perspective appraisal of problematic decision dilemmas. MCDM is likewise pertinent for contradictory interpretations that incorporate several aspects, and it supports decision-makers in accomplishment reasonable solutions. MCDM is a branch of operations analysis that promotes a variety of methods. The MCDM approach consists of determining criteria, sub-criteria, and alternatives connected to a goal, determining computational measures to evaluate the relevance of the criteria and substitutes, and ordering and positioning the alternatives. These methods have the potential to enhance decision quality by making them more coherent, cohesive, and competent. This study proposes a PF-AHP and an application of PF-AHP to assess barriers to RE promotion for entrepreneurs. Figure 2 depicts the adopted technique for the committed analysis.

Pythagorean fuzzy set (PFS)

Yager (2013) proposed PFS and its basic set operations. Further research found a connection between Pythagorean membership (MB) degrees and complex numbers by Yager and Abbasov (2013). PFSs, unlike intuitionistic fuzzy sets, permit total MB degree and non-MB degrees to exceed 1, but not their sum of squares. It is described as follows:

(1) Let "X" be a fixed set. A PFS $\tilde{P}$ is an object having the form (Yager, 2016):

$$P \cong \left\{ \langle x, \mu_p(x), v_p(x) \rangle ; x \in X \rangle \right\} \tag{1}$$

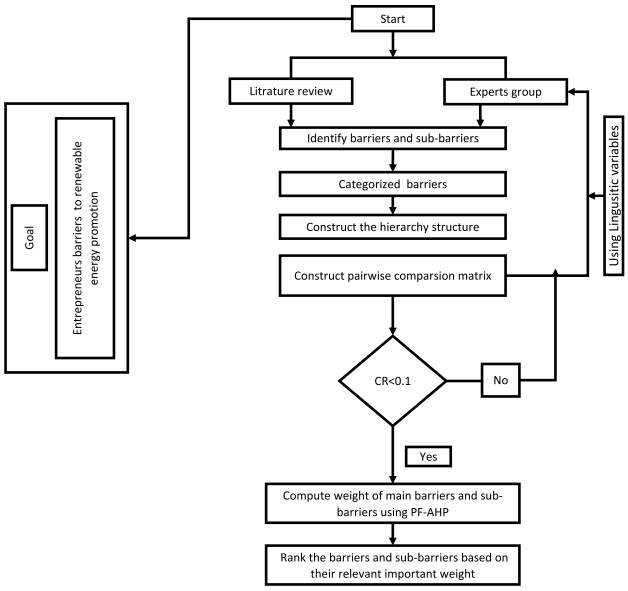

Fig. 2 Outline of the research framework

where the function $\mu_p(x)X \rightarrow [01]$ defines the MB degree and $v_p(x)X \rightarrow [01]$ determine the non-MB degree of the element to $x\ \epsilon\ X$ to P, respectively, and for every $x\ \epsilon\ X$ it holds,

$$0 \leq \mu_A(x)^2 + v_A(x)^2 \leq 1 \tag{2}$$

Here, the degree of hesitancy condition is as follows:

$$\pi_A(x) = \sqrt{1 - \mu_p(x)^2 - v_p(x)^2} \tag{3}$$

(2) Let $N = \langle \mu, v_1 \rangle M = \langle \mu_2 v_2 \rangle$ be two PFNs, and $\lambda > 0$, then the operation on these two numbers is defined as follows (Zhang & Xu, 2014):

$$N \oplus M = \left(\sqrt{\mu_1 + \mu_2 - \mu_1\mu_2, v_1 v_2} \right) \tag{4}$$

$$N \otimes M = \left(\mu_1\mu_2, \sqrt{v_{1+}v_2 - v_1 v_2} \right) \tag{5}$$

$$\lambda N = \left(\sqrt{1 - \left(1 - \mu^2\right)^{\lambda}, v^{\lambda}} \right) \tag{6}$$

$$N^{\lambda} = \left(\mu^{\lambda} \sqrt{1 - \left(1 - v^2\right)^{\lambda}} \right) \tag{7}$$

Pythagorean fuzzy AHP (PF-AHP) and its steps

In 1980, T.L. Saaty established the AHP technique (Saaty 1987). The AHP technique is widely applicable on a global scale. It is among the most commonly used MCDM approaches for analyzing multidimensional and complex decision scenarios. The AHP is an effective technique for coping with difficult decision-making circumstances, such as subjective judgments (Lin 2010). The AHP method has been applied in various situations, ranging from daily problems to the more complicated challenges of planning possible alternative outcomes for a developing country, allocating energy resources, assessing political candidates, and so on (Özdağoğlu 2007). AHP is the most regularly utilized decision-making method for cases with multiple criteria. This investigation adopted PF-AHP as a decision-making method to treat the vagueness in the expert judgment data. The stages for PF-AHP are as follows:

(1) Pairwise comparison matrix construct based on the expert panel's inputs using the LTs listed in Table 1.

$$X = \left(x_{ik}\right)_{m \times n} \tag{8}$$

(2) Calculate $D = \left(d_{ik}\right)_{m \times n}$ the differences matrix using the lower and upper values of the MB and non-MB functions by using Eqs. (9) and (10):

Table 1 Weighing scale for the PF-AHP technique (Shete et al. 2020)

Linguistic terms (LT)	PF-AHP			
	μ_L	μ_U	ν_L	ν_U
CLI (Surely low position)	(0)	(0)	(0.9)	(1)
VLI (Actual low position)	(0.1)	(0.2)	(0.8)	(0.9)
LI (Low position)	(0.2)	(0.35)	(0.65)	(0.8)
BAI (Below average position)	(0.35)	(0.45)	(0.55)	(0.65)
AI (Average position)	(0.45)	(0.55)	(0.45)	(0.55)
AAI (Above average position)	(0.55)	(0.65)	(0.35)	(0.45)
HI (High position)	(0.65)	(0.8)	(0.2)	(0.35)
VHI (Very high position)	(0.8)	(0.9)	(0.1)	(0.2)
CHI (Certainly, high position)	(0.9)	(1)	(0)	(0)
EE (Accurately equal)	(0.1965)	(0.1965)	(0.1965)	(0.1965)

$$d_{ikL} = \mu_{ikU}^2 - v_{ikU}^2 \tag{9}$$

$$d_{ikU} = \mu_{ikU}^2 - v_{ikL}^2 \tag{10}$$

(3) Determine the interval multiplicative matrix $S = \left(S_{ik}\right)_{m \times n}$ applying Eq. (11) and Eq. (12):

$$s_{ikL} = \sqrt{1000^{d_L}} \tag{11}$$

$$S_{ikU} = \sqrt{1000^{d_U}} \tag{12}$$

(4) Find the determinacy value $\tau = \left(\tau_{ik}\right)_{m \times n}$ of the x_{ik} using Eq. (13):

$$\tau_{ik} = 1 - \left(\mu_{ikU}^2 - \mu_{ikL}^2\right) - \left(v_{ikL}^2 - v_{ikL}^2\right) \tag{13}$$

(5) Before normalization, calculate the matrix of weights, $T = \left(t_{ik}\right)_{m \times n}$, by multiplying the τ_{ik} with $S = \left(s_{ik}\right)_{m \times n}$ with matrix using Eq. (14):

$$t_{ik} = \left(\frac{S_{ikL} + S_{ikU}}{2} \right) \tau_{ik} \tag{14}$$

(6) Compute the normalized prioritized "W_i" by Eq. (15):

$$W_i = \frac{\sum_{k=1}^{m} t_{ik}}{\sum_{i=1}^{m} \sum_{k=1}^{m} t_{ik}} \tag{15}$$

Consistency ratio (CR) check

The CR measure is used to analyze the consistency of evaluations. A slew of new CR computing algorithms has arisen since the advent of AHP extensions with fuzzy sets in the

literature. Here, we employ Saaty's traditional consistency ratio technique. The CR is computed by comparing LTs to Saaty's scale and using the conventional framework.

Decision-maker for PF-AHP method

It is essential to assign specialized individuals whenever resolving out a complicated case because experienced experts perceive how to carry out and determine the decision-making dilemma (Table 2). As feedback, qualified and skillful experts were approached in the research to assign weights and evaluate the PF-AHP technique outputs. A questionnaire on the 9-Likert scale is developed using the conventional AHP survey format. We collected the evaluation of each expert via a mail platform. The expert's essential information is presented in Table 3.

Application of Pythagorean fuzzy AHP

The use of the PF-AHP approach to assessing entrepreneur hurdles to RE promotion in Pakistan is described below.

The pairwise comparison matrix $X = \left(x_{ik}\right)_{m\times n}$ is generated using the decision-makers' opinions from Table 4. The final decision matrix is taken from Table 4 adopting the scale provided in Table 1, and the outcome is disclosed in Table 5. The difference matrix $D = \left(d_{ik}\right)_{m\times n}$ between the upper and bottom values of the MB and non-MB functions is then calculated using Eqs. (9) and (10) (see Table 6). Next to the interval multiplicative matrix $S = \left(s_{ik}\right)_{m\times n}$ provided in Table 7 is formed using Eqs. (11)–(12). The determinacy values are used to create the matrix of un-normalized weights $T = \left(t_{ik}\right)_{m\times n}$ shown in Table 2. Finally, Eq. (15) is used to generate the priority weights and ranking shown in Table 8. The same procedure was adopted for the sub-barriers. The results of each sub-barriers are discussed in the next section, and the detailed computation process is provided in the supplementary section. In contrast, the overall ranking and global weight of sub-barriers are obtained by multiplying each weight with their main category barriers weight. The outcome is presented in Table 9.

Table 3 Pairwise comparison matrix by decision-makers

Decision-maker (D_{M1})				
Criteria	(C_1)	(C_2)	(C_3)	(C_4)
(C_1)	EI	CHI	AI	AAI
(C_2)		EI	VLI	BAI
(C_3)			EI	AI
(C_4)				EI
D_{M2}				
(C_1)	EI	AAI	AAI	AAI
(C_2)		EI	AI	BAI
(C_3)			EI	AI
(C_4)				EI
D_{M3}				
(C_1)	EI	AI	BAI	VLI
(C_2)		EI	AI	BAI
(C_3)			EI	VLI
(C_4)				EI
D_{M4}				
(C_1)	EI	AAI	BAI	HI
(C_2)		EI	BAI	AAI
(C_3)			EI	HI
(C_4)				EI
D_{M5}				
(C_1)	EI	HI	AI	AAI
(C_2)		EI	VLI	LI
(C_3)			EI	HI
(C_4)				EI
CR D_{M1} (0.0553), CR D_{M2} (0.0529), CR D_{M3} (0.0608), CR D_{M4} (0.0629), CR D_{M5} = (0.0540)				

Results and discussion

Figure 3 depicts the weight and ranking of the key hurdles to entrepreneurship in Pakistan based on the relative and final weights calculated in Table 8. It is determined that the experts perceive the legal and regulatory framework (C_3) obstacles as the priority and follow the inadequate access to institutional finance (C_1), technical (C_4), and social, cultural, and behavioral (C_2) hurdles stance the second to fourth, respectively. The assigned weight for the essential barrier legal and regulatory framework is equal to (0.3134). In

Table 2 Experts' demographic information

Designation	Qualification	Department
Chief technical officer	MBA	8.2 RE Experts Hamburg GmbH
CEO	BS, Mechanical Engineering	Target Energy (Pvt) Ltd Islamabad
Deputy director	Ph.D	KFW
Director (renewable energy)	Master in Project management	DHA Karachi city
Energy expert	Master	MOE

Table 4 Importance of main criteria concerning the goal

	(C_1)				(C_2)				(C_3)				(C_4)			
(C_1)	0.1965	0.1965	0.1965	0.1965	0.6200	0.7300	0.2700	0.3600	0.4300	0.5300	0.4700	0.5700	0.4800	0.5900	0.4100	0.5200
(C_2)	0.2700	0.3600	0.6200	0.7300	0.1965	0.1965	0.1965	0.1965	0.2900	0.3900	0.6100	0.7100	0.3600	0.4700	0.5300	0.6400
(C_3)	0.4700	0.5700	0.4300	0.5300	0.6100	0.7100	0.2900	0.3900	0.1965	0.1965	0.1965	0.1965	0.4600	0.5800	0.4200	0.5400
(C_4)	0.4100	0.5200	0.4800	0.5900	0.5300	0.6400	0.3600	0.4700	0.4200	0.5400	0.4600	0.5800	0.1965	0.1965	0.1965	0.1965

Table 5 Matrix of variance between upper and bottom values of the MB and non-NB functions

	(C_1)		(C_2)		(C_3)		(C_4)	
(C_1)	(0.0000	0.0000)	(0.2548	0.4600)	(−0.1400	0.0600)	(−0.0400	0.1800)
(C_2)	(−0.4600	−0.2548)	(0.0000	0.0000)	(−0.4200	−0.2200)	(−0.2800	−0.0600)
(C_3)	(−0.0600	0.1400)	(0.2200	0.4200)	(0.0000	0.0000)	(−0.0800	0.1600)
(C_4)	(−0.1800	0.0400)	(0.0600	0.2800)	(−0.1600	0.0800)	(0.0000	0.0000)

Table 6 Interval multiplicative matrix

	(C_1)		(C_2)		(C_3)		(C_4)	
(C_1)	(1.0000	1.0000)	(2.4110	4.8978)	(0.6166	1.2303)	(0.8710	1.8621)
(C_2)	(0.2042	0.4148)	(1.0000	1.0000)	(0.2344	0.4677)	(0.3802	0.8128)
(C_3)	(0.8128	1.6218)	(2.1380	4.2658)	(1.0000	1.0000)	(0.7586	1.7378)
(C_4)	(0.5370	1.1482)	(1.2303	2.6303)	(0.5754	1.3183)	(1.0000	1.0000)

Table 7 Matrix of un-normalized weights

	(C_1)	(C_2)	(C_3)	(C_4)
(C_1)	(1.0772)	(1.0540)	(1.4498)	(1.3208)
(C_2)	(1.8606)	(1.0772)	(1.8082)	(1.5992)
(C_3)	(1.3618)	(1.1042)	(1.0772)	(1.3432)
(C_4)	(1.4762)	(1.2218)	(1.4328)	(1.0772)

Table 8 Priority weights and rank

	Weight	Rank
(C_1)	(0.2907)	2nd
(C_2)	(0.1422)	4th
(C_3)	(0.3134)	1st
(C_4)	(0.2537)	3rd

Table 9 Overall global weight and ranking

Main barriers	Weight	Sub-barriers	Weight	Global weight	Rank
(C_1)	0.2907	(C_{11})	0.4199	0.1221	2nd
		(C_{12})	0.1947	0.0566	9th
		(C_{13})	0.3854	0.1121	4th
(C_2)	0.1422	(C_{21})	0.4284	0.0609	8th
		(C_{22})	0.3160	0.0449	11th
		(C_{23})	0.2555	0.0363	12th
(C_3)	0.3134	(C_{31})	0.4240	0.1329	1st
		(C_{32})	0.2617	0.0820	7th
		(C_{33})	0.3142	0.0985	5th
(C_4)	0.2537	(C_{41})	0.4505	0.1143	3rd
		(C_{42})	0.1950	0.0495	10th
		(C_{43})	0.3545	0.0900	6th

contrast, the social, cultural, and behavioral, whose assigned weight is (0.1422), have accomplished the least devotion by experts. Figure 3 reveals an immense deal of consideration to the legal and regulatory framework issues by experts.

As shown in Fig. 3, the criteria of insufficient access to institutional funding are rated second, behind one of the legal and regulatory frameworks. The C_3 and C_1 final weights (0.3124) and (0.2907) indicate that these two barriers are among the most significant perceived problems entrepreneurs encounter when promoting RE in Pakistan. According to some researchers, businesses in emerging economies experience difficulties due to a lack of regulatory integrity and direct support (Herrera-Echeverri et al. 2014). However, it is stated that government policy is critical in encouraging entrepreneurs and general growth (Guerrero and Urbano 2019). On the other side, strict regulation has been claimed to undermine entrepreneurs, particularly in emerging markets (Brown et al. 2020).

The Paris Agreement's goal cannot be accomplished appropriately in Pakistan without enough finance and assistance for entrepreneurs. One of the primary aims for achieving the Sustainable Development Goals is to ensure clean

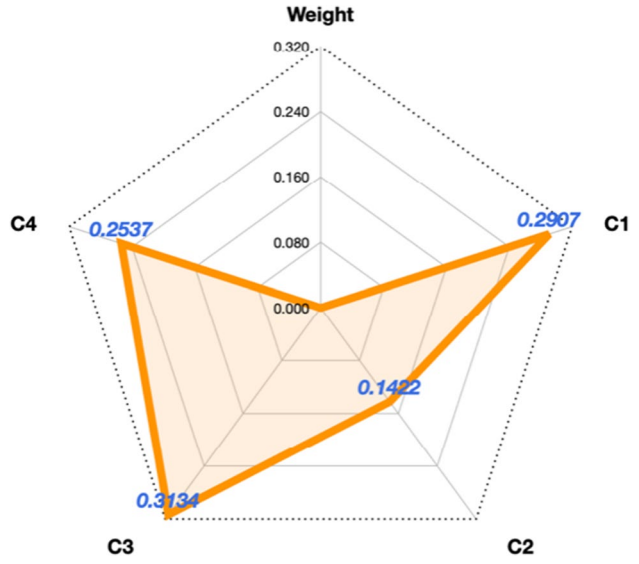

Fig. 3 Main barriers final weights concerning the goal

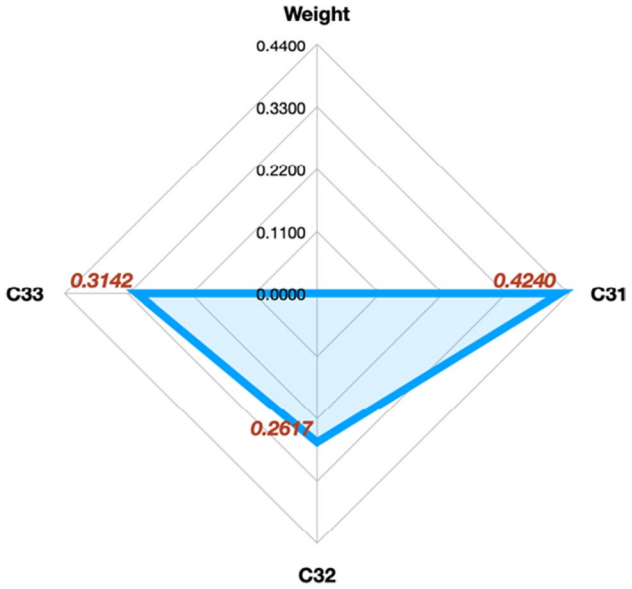

Fig. 4 Legal and regulatory framework sub-barriers weight

and inexpensive power sources by switching to RE usage in the power mix, which increases green jobs, facilitates green GDP, and enhances the quality of life. Solar, wind, hydropower, biomass, tides, geothermal, and biofuels are examples of alternative power consumption resources that are deemed natural, safe, and ecofriendly. As prices continue to fall, RE is becoming a feasible choice for meeting the energy demands of various sectors. Although RE technologies in Pakistan are still in the early stages of development and face numerous economic, societal, and market obstacles, Pakistan is steadily increasing its installed RE capacity. As a result, Pakistan will surpass many wealthy countries as one of the world's leading green energy producers. The COVID-19 outbreak has hindered the development and commissioning of RE installations.

Entrepreneurship and its application suffer as a result. In addition, due to numerous concerns and restricted access to bank credit resources, low foreign investment in Pakistan has posed several hurdles for enterprises looking to grow their RE use and activities. Several developed economies have formed green investment banks to support green growth in response to such entrepreneurs and environmental concerns. A "green investment bank's" principal goal is to provide financial competence. Endeavors in developed economies, such as Austria's CEFC (Clean Energy Finance Corporation) and the UK's GIB (Green Investment Bank) (Ikram et al. 2021), have proved successful. As a result, Pakistan has a chance to create financial institutions that encourage RE sources and support green entrepreneurship for long-term growth.

It was also stated that the technical obstacle to RE enlargement is of comparative importance, as younger professionals require a significant amount of time and expenditure to become experienced (Ali et al. 2021). Furthermore, a scarcity of sophisticated domestic materials has been identified as a significant issue. The absence of local amenities not only causes a rise in the cost of appliances due to the obligation to import them, but it further decreases the trot of indigenous industrial growth (Shah et al. 2019).

Figure 4 concentrates on legal and regulatory framework barriers as the most serious criterion. The "Lack of policy (C_{31})" has been assigned in the first rank with a final weight of (0.4240) among legal and regulatory framework criteria. This is mostly due to a lack of policies in Pakistan to improve entrepreneur circumstances. As predicted, suitable policies are critical in the development of RE sources. Lack of policies assistance causes linked entrepreneurs to alter their attitudes and actions, and they may abandon their ventures.

As the most critical factor, Fig. 4 focuses on legal and regulatory framework obstacles. Among this category barriers, "Lack of policy (C_{31})" has been given the highest ranking, with a final weight of (0.4240). This is due mainly to the lack of legislation in Pakistan that supports businesses. As predicted, effective policies are critical in the development of RE sources. Due to a lack of policy support, connected entrepreneurs' views and behaviors change, and they may quit their businesses.

Figure 5 shows the overall global weight and ranking of all sub-barriers. As can be seen, "C_{31} (Lack of policy)" is placed first among the 12 sub-groups of entrepreneurial hurdles, followed by "C_{11} (Poor provision and access to formal finance)," which is ranked second. The relative global weights of these two barriers are (0.1329) and (0.1221), respectively.

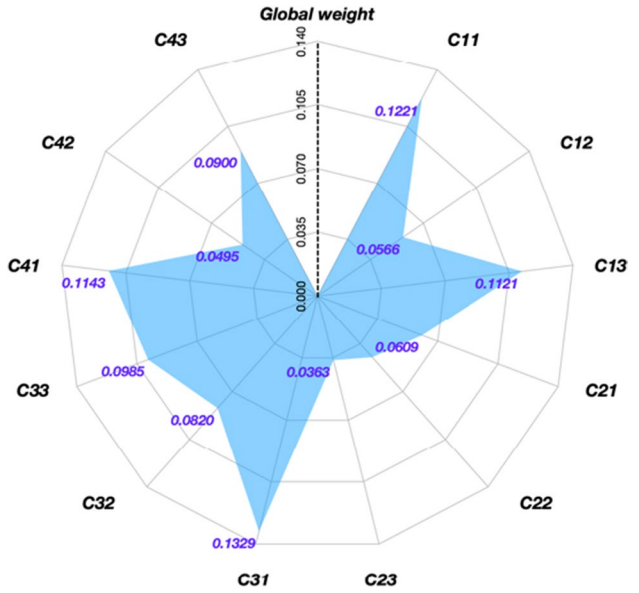

Fig. 5 Global weight of sub-barriers

Pakistan's power generation is still mainly based on traditional sources, such as oil, coal, and natural gas, which damage the environment severely. As the world economy focuses on renewable generation technologies, the government should encourage the enterpenurship and facilitate them to invest in renewable sources of energy to reduce the effects of climate change. For long-term growth, Pakistan's government and decision-makers in the energy industry should solve these concerns promptly. This research will be critical in raising knowledge of various obstacles and how categorizing them will assist Pakistan in becoming more viable and effective in utilizing RE technologies.

The fundamental goal of this research is to help the government and businesses in Pakistan promote RE sources for electricity generation since they are cost-effective and reduce the use of fossil fuels. The hurdles to the growth of RE in Pakistan are highlighted in this report. Understanding technological and economic issues also leads to significant lessons in establishing country institutions, such as Pakistan, in developing RE legislation and in implementing more sustainable energy projects in Pakistan. Because RE sources are both cost-effective and environmentally friendly, it will also provide us with new knowledge on RE development and support its long-term development.

As a result, this investigation offers a conceptual and analytic foundation for various decision-makers, regulators, and investors to help comprehend the entrepreneurial hurdles to RE deployment. It opens up new avenues for overcoming the effects of restrictions that impede the potential of RE technology in Pakistan. So, let us all strive together to set a precedent and act as role models by integrating RE technology across the country in order to realize the vision of "Clean Pakistan, Green Pakistan."

Conclusion

In this research work, an MCDM strategy has been adopted, which will assist decision-making attempts to prioritize entrepreneur hurdles. As previously stated, utilizing statistical-managerial methodologies, there is a probe gap in the literature to the entrepreneurs' hurdles to the implementation of RE sources in Pakistan. This research attempted to address this gap by rating the hurdles faced by entrepreneurs in developing RE sources using an MCDM technique based on Pythagorean fuzzy AHP methods. Twelve barriers were finalized under four major categories, "Inadequate access to institutional finance," "Social, cultural, and behavioral aspects," "Legal and regulatory framework barriers," and "technical." To determine the weights and ranks of each barrier, Pythagorean fuzzy AHP was employed. The findings and discussions reveal that the legal and regulatory framework constraints are the most significant barrier, evident in the current status quo. The results also indicate that the legal and regulatory framework hurdles are crucial due to a lack of policy, the most critical sub-barriers. Furthermore, the most significant "Inadequate access to institutional finance" obstacle is "poor provision and access to formal finance."

Policy and recommendation

Based on the research findings of Pythagorean fuzzy AHP, it is recommended that a significant authority be established to manage and encourage RE by enabling them to request consent and adopt new legislation or modify current ones. Both technology developers and end-users should be given financial assistance in the form of simple access to credits or funds. Furthermore, the government must create a match between renewable and conventional energy sources by providing RE subsidies. Technical vocational courses and training are being offered in Pakistan to help create qualified human resources and raise standards. It will lead to the formation of a public enlightenment system that must be adaptable enough to cope with any unforeseen challenges that may arise in the future. Furthermore, the state must level the ground for RE by offering financial incentives for the RE energy equipment. All levels of stakeholders should have easy access to favorable loans. It is essential to raise awareness about the benefits of RE.

Limitation and future direction

It must be emphasized that the employed approach has some limitations, like the proposed framework being constructed

using expert opinions that may be prejudiced, affecting the structural model's dependability and accuracy. The proposed approach is exclusive to the case of entrepreneurship in Pakistan, and it cannot be easily applied to other economies because each has its own distinct set of laws and regulation. In addition, the entrepreneurial challenges for RE promotion and expert viewpoints differ from one region to another. For future research, the suggested technique, along with other MCDM models such as fuzzy AHP, spherical fuzzy logic, and entropy, can be utilized to investigate and rank the hurdles encountered by entrepreneurs in other nations, especially in developing countries, who are deciding to support RE technologies in the energy market.

Author contribution KS: complete writing, software working, data analysis, methodology. BL: supervision, conceptualization, review, editing. DA: writing, proofreading, references verification. BL, the author's research supervisor, as well as the author's parents, teachers, and friends, all contributed to the completion of this work.

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Declarations

Ethics approval It has been ascertained that the document has been submitted entirely in ESPR. The submitted article is one-of-a-kind and has never been published before.

Consent to participate A final version of the article has been approved by all the authors. No author is obligated to complete the work. The entire content was written with the help of the contributors.

Competing interests The authors declare no competing interests.

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