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Modeling energy governance index for the adequacy of policy, legal, and institutional response measures for climate compatible development

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Climate compatible and sustainable expansion of energy resources is a major global challenge. Developing countries, with inadequate resources and incoherent policies, and legal and institutional frameworks must strive hard to achieve targets set by the Sustainable Development Goals (SDGs) while keeping track of Nationally Determined Contributions for Greenhouse Gas (GHG) emissions abatement. Inclusive governance is quite complex due to the interplay of informal and formal systems, rules-based to rights-based approaches, and arrangements in national to local scenarios *vis-à-vis* methodological limitations. In this context, this study aims at developing a governance index for assessing climate compatible development (CCD) by taking case of the energy sector in Pakistan. The study adopted a two-step approach to develop and validate a methodological framework for assessing the adequacy of governance. In the first step, a multivariate analysis model was developed using principle (CP-1), criteria (09), and 43 indicators (PCIs) through stakeholder involvement. In the second step, the model was deployed by combining the Multi Criteria Decision Analysis method with statistical analysis of the dataset. Data were collected from federal and provincial capitals as well as ten districts through a structured scoring matrix consisting of all 43 indicators. The sample population was based on key informant interviews (340), and experts (17) who were engaged through focus group discussion at federal, provincial, and district levels. Respondents were asked to score against each indicator on a ratio scale, which was then aggregated to develop a governance index score. The findings reveal the dearth of a preemptive and comprehensive governance to address climate compatible development in the energy sector in all tiers of constituencies in Pakistan. There is a need for coherent and inclusive policy, and a legal and institutional framework. This study's outcome authenticates the findings of United Nations SDGs Report 2020 that efforts to achieve sustainable energy targets are not up to scale and stresses the need to speed up the efforts and development of the associated governance framework for renewable energy to achieve climate compatible and SDGs.

KEYWORDS

energy sector, climate compatible development (CCD), sustainable development, governance index, principles, criteria and indicators, MCDA

Introduction

The cascading effects of the climatic phenomenon are attributed to all sectoral economies through its convergent evidences and manifestation in everyday life (Carvalho and Peterson 2009; Höök and Tang 2013; Reser, Bradley, and Ellul 2014; IPCC 2018; Iqbal and Khan 2018; Blunden and Arndt 2019; WMO 2019). The energy sector is no exception, where a strong interplay of fossil fuel consumption, lifestyle changes, and growing concerns about environmental security and sustainable development makes the development of this sector more challenging (Ali and Iqbal 2017; Eleftheriadis and Anagnostopoulou 2017; Iqbal et al., 2020; Hassan et al., 2021). The United Nations' SDGs Report of 2020 highlighted the unsustainable use of energy resources worldwide, as the anticipated target (3%) of energy efficiency is not yet achieved. Consequently, the global temperature is anticipated to rise (3.2°C) by 2100. Annual global GHG emissions reduction targets are lagging behind (about 7.6%), mainly due to an injudicious use of energy resources (UN Statistics Division, United Nations, 2020). Sustainable and climate compatible energy development is among the major global challenges, particularly in the governance context of countries with a lack of adequate and coherent policies, and legal and institutional arrangements (Jiang et al., 2017; López-Ballesteros et al., 2020; Naseer, Iqbal, and Khan 2020; Nwedu 2020; Waheed, Fischer, and Khan 2021).

In order to address policy, and legal and institutional arrangements for energy security and sustainability, conformance between SDGs 7 and 13 is a prerequisite and foremost important element. SDG-7 aims at ensuring clean, affordable, accessible, and modern energy for all, while SDG-13 calls for climate action (Kaygusuz 2012; Armin Razmjoo, Sumper, and Davarpanah 2020; Swain and Amin 2020; Elavarasan et al., 2021). In theory, these two goals go hand in hand and form a synergistic relationship. Understanding the linkages between various aspects of SDGs may aid in developing a cross-sectoral program and policies that could lead to a synergistic functioning for developing and promoting renewables (Xu et al., 2019; Wei et al., 2020). However, the developing countries are facing challenges in shifting towards effective, sustainable, and climate compatible renewable energy (RE) solutions while fulfilling their rapidly growing energy demand. A lack of understanding of the linkages, flexible behavior about trade-offs, and poorly designed sectoral synergies have resulted in incoherent policies, adverse impacts of development on different sectors, lost opportunities for sustainable solutions, and a delayed outcome to progress. Overall, major challenges include high financing costs; insufficient infrastructure; inadequate skills for production and transmission; policy, legal, and regulatory barriers; lack of political will and institutional effectiveness; ownership problems; and poor understanding (Galera 2017; Liu et al., 2019; Asante et al., 2020; Mahama, Derkyi, and Nwabue 2020; Usman, Khalid, and Mehdi 2021).

Most important among the aforementioned factors is the issue of an ineffective policy and institutional framework to adapt to clean energy sources (Galera 2017; Sen and Ganguly 2017; Zafar et al., 2018; Erdiwansyah et al., 2019). The highly centralized system that depends on few actors often becomes hostile and non-hospitable for innovative technologies and suppliers. Many countries in the world still have their policies designed around the interests and monopoly of these giant inhospitable suppliers, acting as a policy barrier (Eleftheriadis and Anagnostopoulou 2015; Hu et al., 2018). Thus, modification of the existing laws is an imperative priority to make the industry and the stakeholders open to the idea of a clean energy mix. Overcoming inconsistent standards, compliance requirements, and regulations regarding RE buy-back schemes and feed-in tariffs could help in mainstreaming the RE forms in the developing world (Qazi et al., 2017; Seetharaman et al., 2019; Kamran, Fazal, and Mudassar 2020). This complex interplay of energy markets, technology, policies, social norms, and consumer preferences has affected, and will continue to affect, energy production and consumption and low carbon development, which ultimately links with a climate compatible and sustainable development (Ike et al., 2020). Besides, a lack of clarity and priorities with the crosscutting and rather conflicting nature of institutions also impede the progress on climate compatible energy sector development.

As of 2019, the global installed capacity of RE reached more than 200 GW, with a significant share by the developing countries (IAEA 2020). At present, 17% of the total energy share is RE and this needs a boost, as 789 million people around the globe still lack access to electricity (Armin Razmjoo et al., 2020; UN Statistics Division, United Nations, 2020), provision of which raises serious concerns about its compatibility with climate mitigation targets. In the current scenario, SDGs serve as the primary driving instruments for the international community to set their policies and practices in line with the set and agreed targets. However, under the current policy arrangement status, many countries are lagging behind. For the Association of Southeast Asian Nations (ASEAN), the target (23%) for renewables seems ambitious unless comprehensive reforms in strategies are ensured (Khuong, McKenna, and Fichtner 2019). Similarly, the Nationally Determined Contribution (NDC) Statement (2016) of Pakistan also provided an ambitious commitment of reducing

GHG emissions (26%) which will cost 40 billion US$ (UNFCCC 2016). Like Pakistan, many nations are still far behind in achieving SDG targets due to policy gaps and an ineffective implementation mechanism (Khuong et al., 2019; UN Statistics Division, United Nations 2020).

The sustainability goals for CCD require realizing the milestones of SDG-7 and SDG-13 together, which necessitates an inclusive governance mechanism. The mechanism should be able to put into practice a set of coherent and widely accepted policies, and legal and institutional arrangements with cross-sectoral integrations at all levels. However, the matter of inclusive energy governance is quite complex. It encompasses informal to formal systems and rules-based to rights-based approaches for policies. It will also require rearrangements in national, sub-national, and local institutional setups *vis-à-vis* methodological procedures to assess and review the policies systematically and periodically. The informal governance concept is based on practices and processes without observing formal rules and procedures, and does not provide voting rights to the weak actors. The "formal governance" concept normally revolves around rules. Rules-based approaches are linked with the application of a top-down model, which raises concerns pertaining to stakeholders' participation. Right-based approaches revolve around the rights, participation, and active engagement of all kind of relevant actors and the political economy (Follesdal, Christiansen, and Piattoni 2004; Visseren-Hamakers and Glasbergen 2007; Saunders and Reeve 2010; Stone 2011; Kleine 2014; Pierre and Peters 2020). Besides, the "triple-win" notion of CCD is participatory in nature and involves multi-sector and multi-actor approaches (Mitchell and Maxwell 2010). Thus, adopting traditional governance frameworks is unable to address the challenges faced by the energy sector. These challenges necessitate a proper methodological framework for periodic review about the adequacy, performance, and decision-making process at all levels of the energy governance mechanism in a country. However, a widely acknowledged model for analysis of governance framework for CCD is tenuous in the literature (Pyone, Smith, and van den Broek 2017). The frameworks proposed in the past have limitations and ambiguities due to a lack of clarity about the subject, principles, criteria, and indicators (Douxchamps et al., 2017; FAO 2017; Ha et al., 2018; Oliveira and Hersperger 2018). The concept of CCD is still evolving, and there are no specified principles, criteria, and indicators for sectoral governance for national, sub-national, and local reference scenarios.

As aforesaid, this study aims at evolving a framework based on a governance index for assessing the compatibility of the government's policies, legal instruments, institutional strategies, and management of CCD by taking the case of the energy sector in Pakistan. It comes under the scope of a basic response mechanism which is the first component of overall governance framework (i.e., GC-1). It is extracted from an extensive study regarding the development of a climate governance assessment framework based on mixed-method modeling of PCIs for CCD in different sectors of the economy (Iqbal et al., 2022). In this study, the assessment of energy governance for CCD was done against the first climate response principle, that is, "respect climate policies, processes, strategies, law and the institution." It provides a methodological framework for periodic assessment of the efficacy of energy governance for CCD in terms of the contents of the policies, legal instruments, and institutional setup to promote a state's sustainable and climate compatible energy initiatives.

The research query undertaken for GC-1 was "whether the existing architecture of policies, legal instruments and institutional setup has essential ingredients for emerging CCD needs in energy sector, and is inclusive for national, sub-national and local reference scenarios." The null hypothesis of this research query revolved around the absence of an inclusive governance mechanism.

Methodological framework

The study employed a PCI-based methodological framework for developing a governance index, employing six climate principles which were formulated by the first author as part of his PhD study in relation to six governance components (see Table 1) of the published article in Iqbal et al. (2022). A similar framework was previously used to study the actor's capacity in the energy sector, which was also extracted from the same major study as applicable for this article (Iqbal et al., 2022). The research design for the board study is reflected in the Supplementary Appendix SI. The methodological framework for the limited scope of the present research to the first governance component (GC-1) and Climate Principle (CP-1) is shown in Table 1 and Figure 1. The analysis is based on mixed-method modeling by combining various quantitative and qualitative tools and techniques including the application of MCDA (Multi Criteria Decision Analysis) along with SMART (Simple Multi Attribute Rating Technique) scoring, and clumping the rules and rights-oriented model approaches of the governance (Daim et al., 2009; Amer and Daim 2011; Costa, Gomes, and de Barros 2017; Ishtiaque et al., 2019; McIntosh and Austin 2020). During the course of developing and finalizing the methodological framework for CCD, three consultative sessions with climate change and energy sector experts were conducted, by following the previous practices as reported in the literature (Wellman 1983; Borgatti et al., 2009; Ingie Hovland 2005). The model was logically organized for CCD and the energy sector. The framework provides flexibility to be applied as unabridged or sectional for a governance component and/or climate response principles. Its architecture is simple, and application is easy. The present study used the framework in partial form by using CP-1 and GC-1 (Iqbal et al., 2022) for developing a governance index to gauge the adequacy of the

TABLE 1 Climate response principles and components of the basic governance mechanism (Iqbal et al., 2022).

Code	Climate response principle	Corresponding governance component
CP1	Respect climate policies, processes, strategies, law, and the institution	Policy, legal, and institutional arrangements (GC1)
CP2	Ensure climate competence, capacity, and active role of the line government departments	Role and capacities of the line government departments (GC2)
CP3	Promote vibrant and influential role of the civil society stakeholders with climate competence and capacity	Role and capacities of CSOs and academia (GC3)
CP4	Maintain active engagement of the community-based stakeholders towards climate endeavors	Role and capacities of community-based organizations (GC4)
CP5	Dynamic role of the private sector stakeholders for best climate solutions	Role and capacities of corporate/private sector stakeholders (GC5)
CP6	Achieve and maintain participatory sustainable climate compatible performance	Practice and performance system (GC6)

Source: PhD dissertation of the first author.

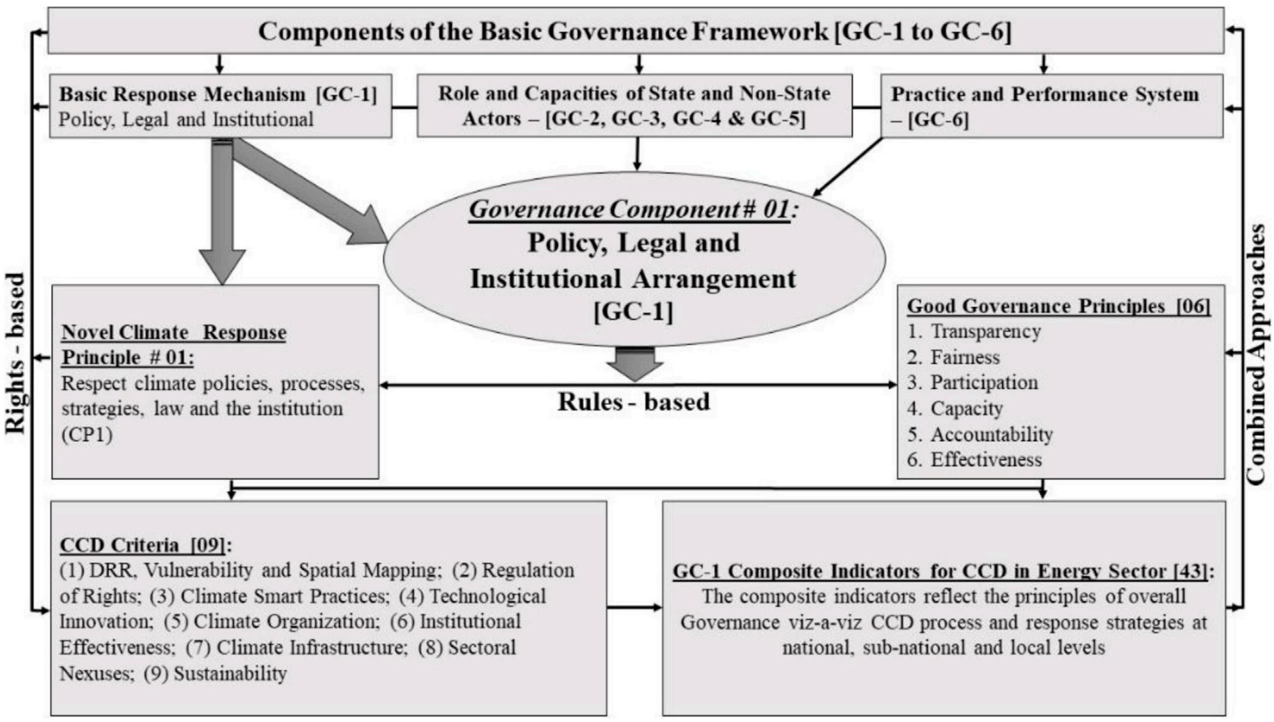

FIGURE 1
GC1 CCD assessment model for energy governance.

government's policies, and legal and institutional strategies and management for CCD. The logical structure adopted for the multivariate governance model is portrayed in Figure 1. The analysis was carried out through a two-step procedure, that is, the first step involved the formulation of a measuring tool, while the second step was a practical application for the determination of a governance index for a basic response mechanism through a case study of the energy sector in Pakistan.

Determination of key variables and primary data collection

The study demands diverse sets of variables to address the newly developed governance model by integrating PCIs. A careful narrowing-down procedure was followed in determining the set of 43 composite indicators against 9 CCD criteria, governance component 1 (GC1), that is, basic response mechanism, CP1, and

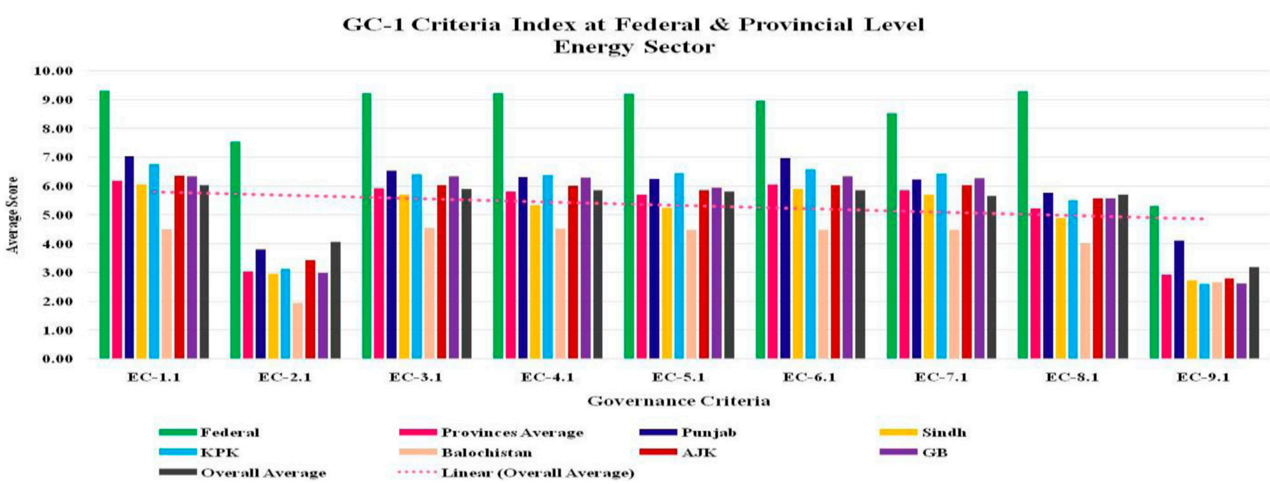

FIGURE 2
Criteria wise governance index for Governance Component-1 at provincial and federal level.

6 World Bank good governance principles (Kartodihardjo et al., 2013), as illustrated in Figure 2. For the purpose, a widely practiced scenario-based learning and situational analysis technique (Dey 2012; Hovland 2005; Norris et al., 2012; Serrat 2017) was employed, using flip charts in three consultative meetings with experts in Islamabad. The consultative meetings concluded a set of nine criteria (i.e., Energy C-1.1 = Disaster Risk Reduction, Vulnerability and Spatial Mapping; Energy C-2.1 = Regulation of Rights; Energy C-3.1 = Climate Smart Practices; Energy C-4.1 = Technological Innovation; Energy C-5.1 = Climate Organization; Energy C-6.1 = Institutional Effectiveness; Energy C-7.1 = Climate Infrastructure; Energy C-8.1 = Agriculture, Water, and Energy Nexus; and Energy C-9.1 = Sustainability) and 43 indicators (see Supplementary Appendix SII). The indicators focused on established and in-practice policies, strategies, legal and institutional mechanism targeting climate vulnerability assessment, renewable energy proliferation, and grievance redressal mechanisms against nine criteria.

MCDA's SMART was employed with a ratio scale presented as 0 = not applicable or no response for CCD yet; 0.01 to 1.99 = very poor response for CCD; 2.00 to 3.99 = poor response for CCD; 4.00 to 4.99 = considerable response for CCD; 5.00 to 5.99 = fair response for CCD; 6.00 to 7.49 = good response for CCD; 7.50 to 8.99 = very good response for CCD; and 9.00 to 10.0 = excellent response for CCD. The responses against each indicator were aggregated for scoring and weighting (Edwards 1977; Leskinen and Kangas 2005; Gärtner et al., 2008; Heinrich et al., 2011) the CCD criteria. For SMART scoring, a structured questionnaire-cum-scoring matrix comprising 9 criteria and 43 indicators of energy governance was used. To validate and normalize the tool, pilot testing was carried out in Islamabad. A purposive sampling plan was designed by keeping in view the geographical requirement and attaining a representative size of the sample from each jurisdiction, including federal and provincial capitals and 10 districts throughout the country (i.e., Khuzdar and Jhal Magsi from the Balochistan province, Rajanpur and Bahawalpur from the Punjab province, Badin and Sanghar from the Sindh province, Ghizer from Gilgit-Baltistan, and Muzaffarabad from Azad Jammu and Kashmir). The existence of climate-related initiatives was duly considered during the selection of the geographical locations under the scope of this study. Data were collected through interviews of key experts/informants (KIIs) and FGD (focus group discussion) sessions. For each location, data through one FGD and 20 KIIs were collected, resulting in a purposive sample of a total of 357 responses. For FGDs and KIIs, experts were selected from energy departments including power generation, transmission, distribution, regulating authorities, as well as allied organizations like National Energy Efficiency and Conservation Authority (NEECA), Provincial Energy Efficiency and Conservation Authority (PEECA), Alternative Energy Development Board (AEDB), and Pakistan Council for Renewable Energy Technology (PCRET). Besides that, for FGD, experts from climate change-related departments including the Ministry of Climate Change, provincial environmental departments, and the Global Change Impact Studies Center (GCISC) were also invited. Flashcards were used to keep the discussion interactive and focused. Besides responses, the discussion of experts was also recorded, which helped in understanding different aspects of the findings.

Analysis of data

MS Excel 2016 was used for tabulating, cleaning, and processing the data and calculating the governance index of GC1 for the energy sector. The results were validated using IBM SPSS Statistics 25 by employing three statistical tests: linear regression, the non-

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TABLE 2 Governance index for Governance Component-1 for the energy sector of Pakistan.

Constituency level	CCD criteria									
	Energy C-1.1	Energy C-2.1	Energy C-3.1	Energy C-4.1	Energy C-5.1	Energy C-6.1	Energy C-7.1	Energy C-8.1	Energy C-C9.1	Average score	Ranking
National	9.31	7.53	9.22	9.21	9.19	8.95	8.52	9.28	5.30	**8.50**	Very Good
Sub-national (all provinces)	6.16	3.02	5.91	5.79	5.69	6.04	5.85	5.21	2.90	**5.17**	Fair
Local level (all districts)	2.60	1.59	2.55	2.55	2.54	2.55	2.55	2.54	1.30	**2.31**	Poor
Average score	**6.02**	**4.05**	**5.90**	**5.85**	**5.81**	**5.85**	**5.64**	**5.68**	**3.17**	**5.33**	Fair
Ranking	Good	Considerable	Fair	Fair	Fair	Fair	Fair	Fair	Poor	Fair	-

Bold indicates that the average values.

parametric H-test, that is, Kruskal–Wallis (KW) hypothesis testing, and 1-tailed Pearson Correlation. The H- test helped in understanding and characterizing the sample groups from district, provincial, and federal levels. The tests were preordained to ensure the originality of the sample and to understand the association of the different interlocking variables.

Results

The present study analyzed the adequacy of the current governance framework for the energy sector in relation to the CCD principles at the vertical levels with the constituencies at national (federal), sub-national (all provinces), and local (districts) levels. The responses were collected from the key informants using a structured questionnaire as well as through FGD with the experts in the energy and climate change sectors. The GC-I index was calculated by averaging the individual rating scores against each criterion. Table 2 shows the criteria-wise itemization of the GC-1 index for CCD in relation to the energy sector in Pakistan. The overall results depict the highest score (6.02) for EC-1.1. For other criteria, the score was variable: the EC-2.1 index score of 4.05; EC-3.1 index score 5.90; EC-4.1 score 5.85; EC-5.1 index score 5.81; EC-6.1 index scores 5.85; EC-7.1 index score 5.64; and EC-8.1 index score 5.68. The lowest score is reported for EC-9.1 (average score 3.17). Constituency-wise index scores were highest for the federal (8.50), then the provincial (5.17), and lowest (2.31) for the district levels, signifying poor governance in districts. The overall GC-1 index remained 5.33. With reference to the constituency-wise GC-1 index, the federal area scored (8.50) good (see Figure 2). Figure 3 portrays the constituency-wise index score in the form of a radar to show constituency-wise comparison of the index scores. Figure 4 shows the GC-1 index at district level. The lowest GC-1 index score was from the district of Balochistan—Jhal Magsi and Khuzdar, while the highest score was from Muzaffarbad.

The inferential statistics, that is, KW Hypothesis Test, was performed to test the null hypothesis; that is, *the distribution of governance index score is the same across all nine criteria, constituency- and gender-wise.* It rejects the null hypothesis with an asymptotic significance level 0.05 (against N = 357) for the overall sample of GC-1 in the energy sector. The Pearson correlations (1-tailed) significantly indicate a strong co-relation among all CCD criteria (Table 3), whereas for the multivariate regression analysis (see Tables 4–7), the CCD criteria "Energy C-9.1, that is, Sustainability for GC-1," was taken as the dependent variable. The retrieved R and R Square values were 0.936 and 0.876 respectively. The results of the T-test (values above ±2) inferred a significant relationship of sustainability criteria with other criteria, except EC-1.1, EC-4.1, and EC-5.1. However, the collinearity diagnostics for all correlations (tolerance <0.10, VIF >10) is not indicative of significance, though all criteria showed zero-order correlation with the sustainability criteria.

The normal P-P plot (Figure 5) illustrates relatively low deviation, and upward and downward variations. Figure 6 (scatter plot) indicates four clusters, of which two clusters are submerged to each other while the remaining two are trivial with overall results within the (±3) boundaries. The inferential statistics determine that all nine criteria of the GC-1 index impact each other. Thus, convincingly the null hypothesis cannot be rejected, suggesting the absence of a preemptive and comprehensive response mechanism to govern CCD in the energy sector for its environmental security at federal, provincial, and district levels in Pakistan.

Discussion

Pakistan, with a population (213 million) growing at the rate of 2%, ranks the sixth-most populous country of the world. With a growing population, the energy demand is also increasing from 5% to 7% per year (Irfan et al., 2020; Qiu et al., 2022a; Qiu et al.,

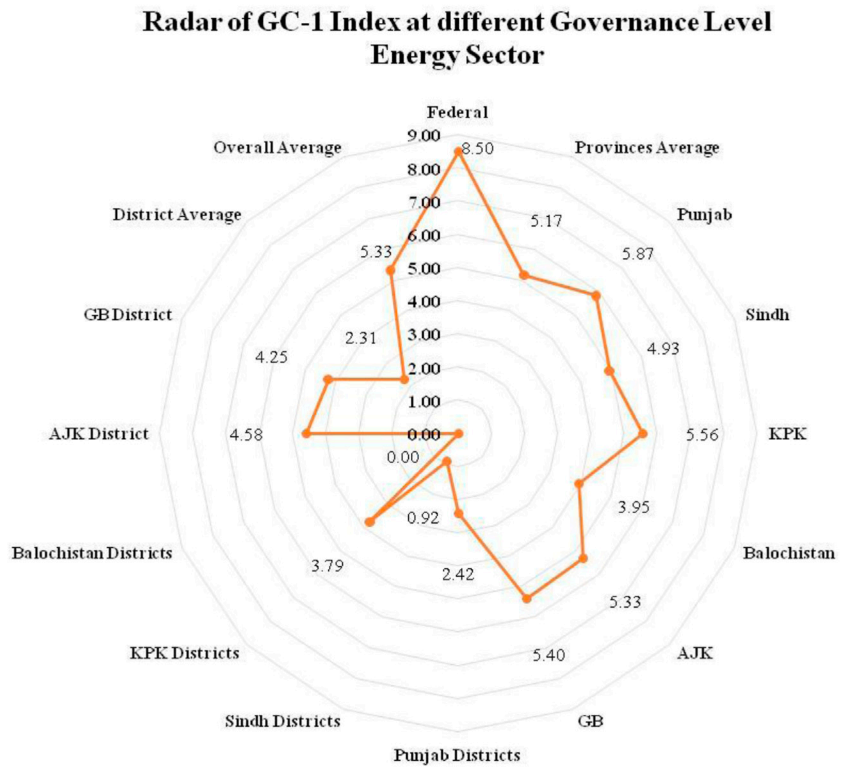

FIGURE 3
Radar graph of governance index for Governance Component-1 in the energy sector.

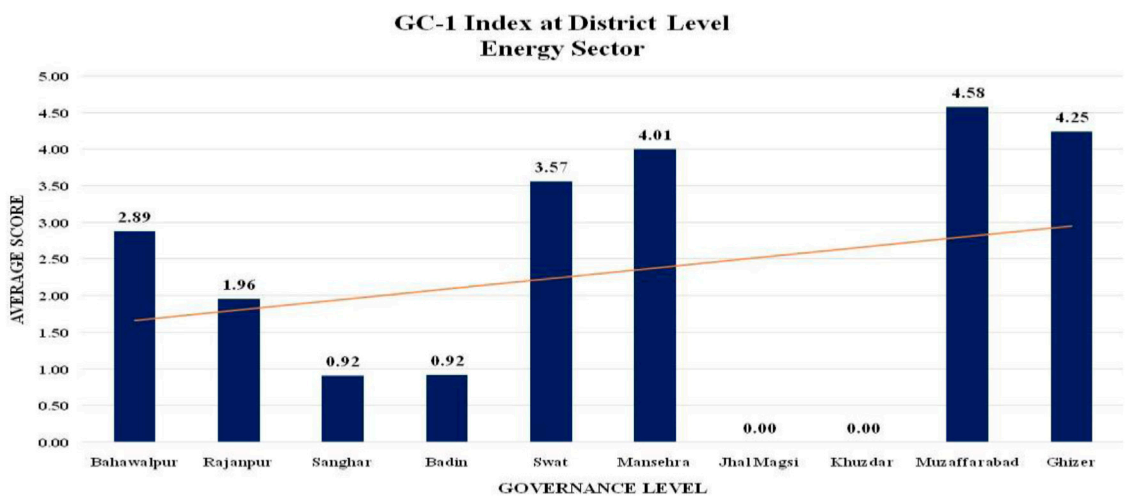

FIGURE 4
GC-1 index at district level.

2022b). As a result, the annual total GHG emissions reached 408 million tons of CO_2 in 2015, with the major share (45.5%) from the energy sector. Zhang et al. (2021a), Zhang et al. (2021b), and Zhang et al. (2021c) demonstrated that the major reason is reliance on fossil fuels as the major energy source. Among the major contributors of GHG emissions from the energy sector,

TABLE 3 Correlation between energy sector GC-1's CCD criteria (EC1.1-EC9.1).

Pearson correlations

CCD criteria	Energy C-1.1	Energy C-2.1	Energy C-3.1	Energy C-4.1	Energy C-5.1	Energy C-6.1	Energy C-7.1	Energy C-8.1	Energy C-C9.1
Energy C-1.1	1								
Energy C-2.1	0.914**	1							
Energy C-3.1	0.994**	0.924**	1						
Energy C-4.1	0.993**	0.927**	0.997**	1					
Energy C-5.1	0.992**	0.931**	0.996**	0.996**	1				
Energy C-6.1	0.995**	0.911**	0.995**	0.994**	0.993**	1			
Energy C-7.1	0.993**	0.906**	0.996**	0.995**	0.993**	0.995**	1		
Energy C-8.1	0.982**	0.951**	0.988**	0.990**	0.991**	0.982**	0.983**	1	
Energy C-9.1	0.893**	0.911**	0.897**	0.895**	0.894**	0.895**	0.882**	0.893**	1

**1-tailed significance level of correlation = 0.01.

TABLE 4 Summary of regression model for GC-1 in the energy sector.

Model summary[b]

Model	R	R square	Adjusted R square	Std. eror of the estimate
1	0.936[a]	0.876	0.873	0.47057

[a]Predictors: (Constant), Agriculture, Water, and Energy Nexus, Climate Infrastructure, Institutional Effectiveness, Regulation of Rights, DRR, Vulnerability and Spatial Mapping, Climate Smart Practices, Technological Innovation, and Climate Organization.
[b]Dependent variable: Sustainability.

TABLE 5 Summary of ANOVA for GC-1 in the energy sector.

ANOVA[a]

Model		Sum of squares	Df	Mean square	F	Sig
1	Regression	543.019	8	67.877	306.535	0.000[b]
	Residual	77.059	348	0.221		
	Total	620.078	356			

[a]Dependent variable: Sustainability.
[b]Predictors: (Constant), Agriculture, Water, and Energy Nexus, Climate Infrastructure, Institutional Effectiveness, Regulation of Rights, DRR, Vulnerability and Spatial Mapping, Climate Smart Practices, Technological Innovation, and Climate Organization.

electricity generation adds 49.065 Gg of CO_2 annually (GoP 2018). The current energy reliance is still on thermal power generation (61%), with renewables contributing only 1% in the total energy mix (Irfan et al., 2020). However, the government targeted to increase reliance on renewables (solar, wind, waste to energy) to 5% of the total energy by 2030 (Iqbal et al., 2018).

TABLE 6 Criteria wise summary of regression coefficients for GC-1 in the energy sector.

Coefficients[a]

	Model	Unstandardized coefficients		Standardized coefficients	t	Sig	Correlations zero-order	Collinearity statistics	
		B	Std. error	Beta				Tolerance	VIF
1	(Constant)	0.340	0.050		6.763	0.000			
	DRR, Vulnerability, and Spatial Mapping	0.094	0.103	0.189	0.916	0.360	0.893	0.008	118.671
	Regulation of Rights	0.605	0.056	0.799	10.904	0.000	0.911	0.067	15.037
	Climate Smart Practices	0.417	0.166	0.800	2.518	0.012	0.897	0.004	282.546
	Technological Innovation	0.208	0.155	0.394	1.345	0.180	0.895	0.004	240.670
	Climate Organization	−0.259	0.142	-0.486	−1.824	0.069	0.894	0.005	198.697
	Institutional Effectiveness	0.487	0.131	0.940	3.725	0.000	0.895	0.006	178.443
	Climate Infrastructure	−0.411	0.148	−0.759	−2.776	0.006	0.882	0.005	209.529
	Agriculture, Water, and Energy Nexus	−0.514	0.102	−0.928	−5.056	0.000	0.893	0.011	94.366

[a]Dependent variable: Sustainability.

TABLE 7 Regression's residual statistics for GC-1 in the energy sector.

Residuals statistics[a]

	Minimum	Maximum	Mean	Std. deviation	N
Predicted value	0.2587	5.7091	2.1038	1.23504	357
Residual	−1.16587	1.35976	0.00000	0.46525	357
Std. predicted value	−1.494	2.919	0.000	1.000	357
Std. residual	−2.478	2.890	0.000	0.989	357

[a]Dependent variable: Sustainability.

Chen et al. (2022) indicated that the current electricity production in Pakistan is less than demand, with a supply–demand gap of more than 3,000 MW. The resultant pressure forced the government to encourage short-term energy supply projects, including importing oil for thermal power generation (Miao et al., 2018; Yin et al., 2022a; Miao et al., 2022).

Pakistan's geographical location provides opportunities to harness 2900 GW of solar energy (Rafique et al., 2020). Similarly, Pakistan's multifarious terrain includes coastal and hill areas that provide excellent potential for wind energy (Shami et al., 2016). Being an agricultural country, Pakistan also has the potential to utilize agricultural biomass as fuel. Sixty percent of the population reside in rural areas. An estimated 230 billion tons of biomass, 652 M kg of manure, and 230 thousand tons of agricultural residues are produced every year. Besides that, an estimated 60,000 tons of solid waste per day is produced (Irfan et al., 2020). However, all these researches emphasized the need to adapt a comprehensive governance framework to tap the potential of renewable resources to achieve the low-carbon development goals for CCD (Iqbal et al., 2018; Irfan et al., 2019, 2020).

The global installed capacity of RE reached more than 200 GW in 2019, with a significant share by the developing countries (IAEA 2020). Fang et al. (2022), Rahman and Islam (2020), and Fofack and Derick (2020) indicated that the largest share of renewables is contributed in the electricity sector; however, the heat and transportation sectors are still far from the desired goals. The heat and transportation sector contributes 80% of the total energy consumption. Similarly, the United Nations SDG Report 2020 also stressed the need for additional efforts to achieve the energy efficiency targets. An enhancement in installation capacity and the spread of RE systems provided clean electricity and cooking fuel to the areas that lacked access to energy resources, especially in many developing nations. The actions helped to achieve

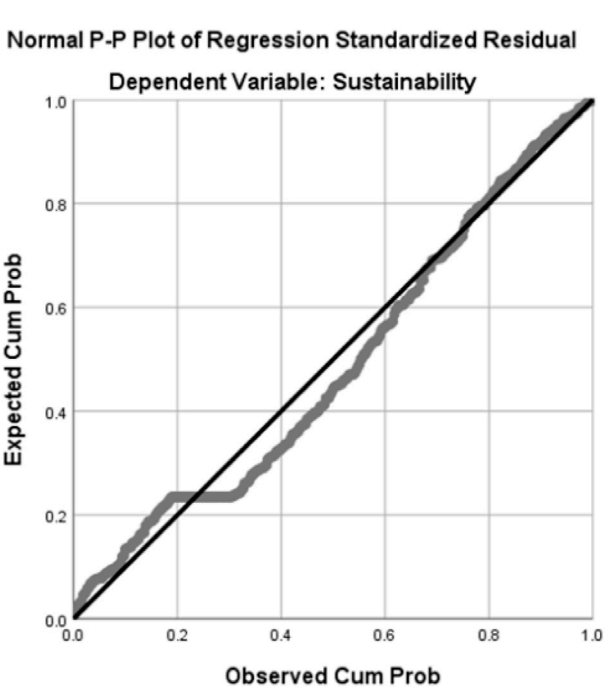

FIGURE 5
Regression's P-P plot for CCD index under GC1 in the energy sector.

access to the energy targets, while ensuring commitment pertaining to the global drive to diversify and shift to cleaner energy sources. However, progress is not the same across the nations; many nations are far behind in achieving a sustainable level of energy production and in meeting the SDG requirements, mainly due to policy gaps and effective implementation. ASEAN nations also lag behind in achieving the 23% renewable energy target by 2025, unless drastic adjustments in strategies are guaranteed (Khuong et al., 2019).

Pakistan is no exception. The renewable energy targets were set as a 20% share of renewables in energy generation by the year 2025 and further enhancement to 30% by the year 2030, while reducing GHG emissions seems ambitious in absence of an inclusive governance mechanism. The emission reduction targets become more challenging, particularly in the case of increasing energy demands under the "China Pakistan Economic Corridor (CPEC)"-related expansion needs and scope of activities (UNFCCC 2016; Iqbal and Haider 2020). At the same time, the United Nations SDGs Report 2020 reflects that international financing in renewable energy has accelerated, reaching up to $21.4 billion in 2017.

The findings revealed gaps in governance for the GC-1 related energy sector's CCD response measures at federal, provincial, and district level in Pakistan. The preparedness of federal level developments for CCD is better than that at the provincial and district levels (Table 1). When comparing the province and district levels, the provinces were rated "fair," but scores for the district level context are not promising transversely in Pakistan (Table 2). The findings corroborate that the energy sector had a strong foundation in the federal region for being a federal subject till the year 2010. Late in 2010, the 18th Amendment in the Constitution of Pakistan, 1973 devolved its powers, by giving autonomy to the provinces for the progression of energy sources. Subsequently, diversification in

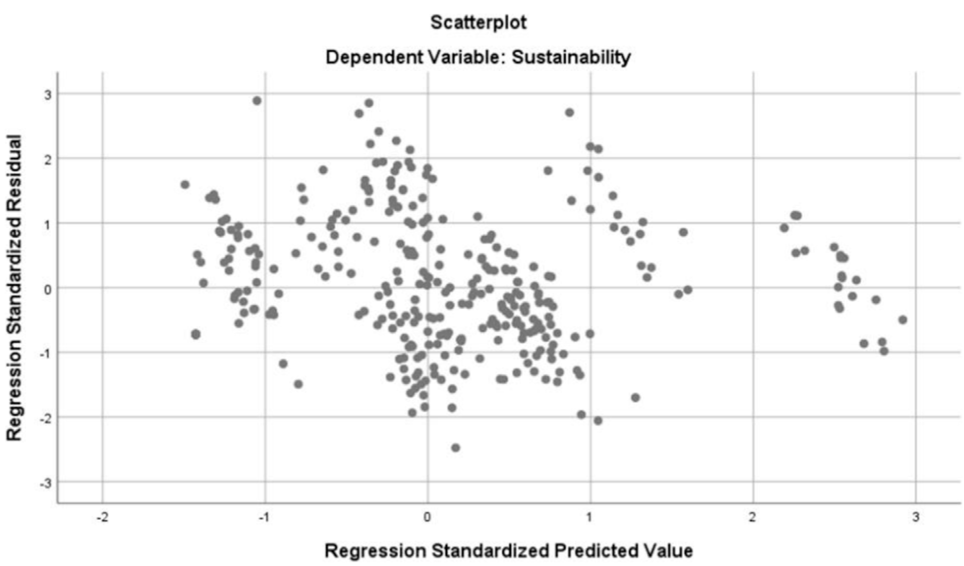

FIGURE 6
Regression's scatter plot for CCD index under GC1 in the energy sector.

the energy resources started targeting wind, solar, and waste to energy projects. The private sector was invigorated to invest in an independent power producer (IPP). The system was restructured to provide a net-metering facility that created prospects for harnessing solar energy at a domestic as well as a commercial scale in Pakistan. Accordingly, the relevant energy sector policies and strategies at the federal level were aligned to have all the mandatory provisions to fulfill the NDCs. However, the findings revealed that the progress in the provincial and local contexts sits far behind the national level development, due to the governance gaps.

Some of the key steps taken at the federal level include the launching of the Clean Development Mechanism (CDM) in August 2005. The CDM cell (Ghumman 2007) promoted clean energy and energy efficiency projects which aimed at reducing GHG emissions. The Local Adaptation Plan for Action (LAPA) started in 2012 as part of a 5-year project without any linkage to policies in the context of nexus of energy, water, and agriculture. During the project, six LAPAs for six districts were initiated, but the mechanism remained informal. So far, there is absence of concrete measures to link up LAPAs for the nexus of energy, water, and agriculture, which is critically important for CCD in the energy sector. Similarly, the Alternative Energy Development Board (AEDB) was established which in 2006 formulated a Renewable Energy Policy to diversify energy sources, stimulate renewable energy projects, and shun dependence on fossil fuels (GoP 2006). The Renewable Energy Policy 2006 was the first policy that intended to increase to a 10% share of renewables in the energy generation mix by the year 2015. Particular attention was given to micro-hydel, solar, and wind power projects. Consequently, renewable energy-based IPPs for selling the produced electricity were given incentives. Later on, the Power Generation Policy 2015 (GoP 2015) also announced incentives and a simplified *modus operandi* for approval and installation of power generation projects to meet the demand-supply gap for the socioeconomic lift of the economy. Vision 2025 of Pakistan also envisages the promotion of RE technologies in the goals to curtail the future upsurge of GHG emissions proportionately to growing energy demands. Later on, the Alternative and Renewable Energy Policy of Pakistan 2019 (ARE Policy 2019) augmented the target (AEDB 2019) to 20% of renewable mix by the year 2025 and 30% by the year 2030 in overall energy generation. It is anticipated that the targeted energy mix will provide environmentally sound, accessible, and affordable solution at the grassroots level while encouraging the stakeholders (AEDB 2019).

Among other important steps at the federal level, the establishment of the National Energy Efficiency and Conservation Authority (NEECA) is a major milestone. NEECA initially started as a project of USAID in 1985 which later become an authority after promulgation of NEECA Act in 2016 (GoP 2016b). Since its inception, NEECA has initiated projects to ensure energy efficiency and conservation in transport, manufacturing, and domestic sectors including energy auditing, building codes, and energy labeling of products (GoP 2016a).

Similarly, the National Climate Change Policy of Pakistan (GoP 2012) also stipulates commitment to GHG emission abatement as targeted in the NDCs. However, the policy also envisions that provisions related to the growth of RE technologies such as the promotion of distributed grid solutions, deployment of hydropower generation, utilizing rooftops for solar power generation, and installation of more waste to energy projects need to be in line with energy sector planning. Subsequently, the Framework for Implementation of Climate Change Policy (FICCP) further elaborates strategies and engagements for the advancement of RE-based energy diversification to control GHG emissions (GoP 2014). The strategies comprise the preferment of hydel power projects, the installation of more power plants based on municipal waste, and provision of incentives for desirable projects to gear progress towards low-carbon energy sources. However, all these steps also require institutional reforms for the transmission and distribution of the energy produced, tariff setting, and other fiscal reforms to promote RE technologies.

The role of the government in the progression of RE is crucial in any nation. RE brings opportunities such as the creation of a large number of jobs, energy security, and improved quality of life. Globally, governments are implementing policies to stimulate the utilization of RE sources and technologies (Sweetnam et al., 2013). Currently, the feed-in tariff (FIT) mechanisms are widely practiced across the globe, particularly in the developing nations (REN21, 2011). Pakistan adopted the FIT mechanism to promote renewable energy in connection with net-metering policies in 2015. The scheme set remuneration for a solar power project of up to 10 MW for 25 years in accordance with capacity and region. Ostensibly, 19 solar power generation projects with more than 50 MW of capacity gained licenses during 2020–21. Besides that, 8,417 net metering licenses of above 145 MW capacity were issued during the same year. However, Pakistan is facing deterrence pertaining to insecurity for FITs in relation to high capital investment, and investors' and consumers' interests (Sweetnam et al., 2013). Other challenges include financial obstacles, a dearth of competition, institutional obstructions, and a lack of access to technology (Yazdanie and Rutherford 2010). Consequently, setting FITs high by the National Electric Power Regulatory Authority (NEPRA) will maximize the profits of the investors. In such case, the consumers will suffer from high costs of RE. Likewise, setting FITs to a lower rate will result in benefitting consumers while investors bear high capital investment costs. These challenges compromise the desired results that can be achieved by implementing the FIT framework in Pakistan. The analysis of respondents' feedback reveals that sustainability under GC-1 is fair at the federal level, while in the range of very poor to poor at the provincial and district levels respectively. However, the vertical coherence of policies and legal instruments is necessary for the sustainability of the federal level commitments. In this context, the role of the provincial governments is critical to complement all the provincial policies and plans with the federal endeavors. The findings also reveal that the development of compulsory mechanisms to strengthen the institutional capabilities and capacities is important. However, such a roadmap is non-existent in strategies, policies, and planning documents resulting in the low governance index score.

The energy sector requires intensive investment which is necessary to boost the economy, ensure social well-being, and strengthen the technology base and thus the overall development of a country. Awareness and the capacity building of relevant institutions remain a major hurdle in the inclusive development energy sector in the developing world. Most of the current initiatives are project based, temporary, and thus inadequate for capacity building and training of human resources (Lawonski et al., 2018). Consequently, gaps in innovation, management, analytical research base, and general awareness need to be overcome in order to achieve the 20–30% contribution of RE in the overall energy mix to achieve the NDCs (Lo et al., 2019). This can be achieved by decommissioning policies that revolve around conventional energy forms, and the promotion of RE-based initiatives adopting cross-sectoral approaches.

Awareness and relevant capacity-building remain a major hurdle in the inclusion of RE in the developing world, as the current efforts have project-based orientation rather than context-dependent and long-term efforts envisaged (Lawonski et al., 2018). Perspective gaps in innovation, management, analytical research base, and general awareness need to be understood well in order to assess the effectiveness and demand of RE from the bottom up (Lo et al., 2019), by rationalizing and decommissioning the shortcomings of the policies that revolve around conventional energy forms and their promotion in the business-as-usual scenario. This is greatly needed in the context of Pakistan where policy coherence and overlaps have created great confusion, particularly for the trickle-down effect from federal to the provincial and local contexts.

Conclusion

Study of the Governance Component-1 (the basic response mechanism for policy, legal, and institutional arrangements), intended for first climate response principle 1 in the energy sector at federal, provincial, and district levels, showed that the model proved well in developing, validating, and interpreting the governance index against the basic research query. The developing countries including Pakistan have great potential and prospects for renewable and sustainable energy development. However, they have several challenges due to the lack of an adequate and coherent policy, and legal and institutional arrangements which are necessary for devising strategies as well as planning and execution processes. This occurs due to the complex governance mechanism. The results of this study reveal that climate response is more visible at the federal level. The relevant sectoral policies and strategies have all the essential provisions that are obligatory for CCD in the energy sector. However, the provincial and local contexts sit far behind the national level development, due to governance gaps, thus it shows a very strong disconnect and does not appeal to the audience. After the 18th Amendment in the Constitution of Pakistan, 1973, provinces were given autonomy to develop their energy resources. Private sector companies were given the choice to become independent power producer (IPP); particularly, the net-metering facility created the opportunity to tap the solar energy potential in Pakistan. A poor uptake was found in provinces. However, all nine criteria of GC-1 influence each other; in totality, the null hypothesis could not be excluded for the case of GC-1 in the energy sector. So, GC-1 index scores are indicative of the lack of a preemptive and inclusive governance framework to ensure climate compatible development in the energy sector at the federal, provincial, and district levels in Pakistan. The study reveals that the governance mechanisms pertaining to energy generation, distribution and regulation of the consumption, and efficiency lack clarity in their objectives as well as in their execution. Due to the energy crises in the past few years, the predominant goal of the energy sector was to bridge the gap between supply and demand, irrespective of the commitments made under climate change policy and action plan. Consequently, Pakistan's energy mix skewed towards thermal power generation from imported fuel, posing a risk for climate as well as energy security and accessibility issues. The study also revealed a lack of coordination among the vertical hierarchy of governance, that is, federal, provincial, and district level departments.

The findings of the study pave the way to restructure the energy sector policies, strategies, and institutions in line with the principle, criteria, and indicators stipulated in the study to ensure environmental security and sustainable development. The study recommends aligning the energy sector development objectives in line with climate change and SDGs. This reflects rethinking the agreements of imported fuels as well as the diversification of existing energy resources. For this purpose, policies and strategies should support technological innovation in all segments of the energy sector.

As far as the limitation of the study is concerned, all aspects related to the basic response mechanism comprising policy, legal, and institutional measure to feature CCD in the energy sector have been covered well. However, it has been carried out by involving a large dataset based on indictors and constituencies, due to which it required more time and resource input. Data recording from the respondents was a difficult process, due to poor understanding of the subject, particularly at provincial and district levels. The outcome of the study could have been even better if adequate financial resources had been available for 1) increasing the number of districts and 2) having a comparative analysis by adding a few more developing countries under the scope of this study (Yin et al., 2022b).

10.3389/fenvs.2022.985340

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material. Further inquiries can be directed to the corresponding authors.

Ethics statement

Ethics review and approval/written informed consent were not required as per local legislation and institutional requirements.

Author contributions

All the authors contributed substantially to the entire work reported in this article. They read and approved the final manuscript, which was extracted from a novel and original research dissertation of the first author submitted to the International Islamic University, Islamabad, for partial fulfillment of his PhD degree. KI extracted and shaped the basic idea, methodology, results, discussion, and conclusion. MK supervised the work by reviewing and editing the overall paper, technically and academically. NA helped in drafting the introduction, discussion, and abstract sections. FW complemented in discussion, logical conclusion, proofreading, and processing the paper with Frontiers in Environmental Science. UA assisted in referencing and formatting.

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Conflicts of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fenvs.2022.985340/full#supplementary-material

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