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RESEARCH ARTICLE

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Mix-method modelling of actors' capacity for environmental sustainability and climate compatible development in energy sector

Kanwar Muhammad Javed Iqbal[1] · Nadia Akhtar[2] · Muhammad Owais Khan[3] · Muhammad Irfan Khan[2]

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Abstract

The development of the energy sector has played a major role in greenhouse gas (GHG) emissions and pollution. The situation thus necessitates rigorous actions for climate compatible development (CCD). The energy sector is context-dependent, due to which response strategies for CCD are quite challenging particularly in the context of energy crises and the actors' capacity issue in developing countries. This study was aimed at exploring the role of government actors involved in governing the energy sector, with the objective to assess their capacity using a set of principles, criteria, and indicators (PCIs). The study attempted to answer the question: is the capacity of the line departments involved in energy governance adequate to achieve the targets set under SDG-7 and SDG-13? For this purpose, the study employed a combination of "Rules-based" and "Rights-based" governance approaches at all tiers of governance, i.e., federal, provincial, and district levels. Actors' capacity was assessed by developing a governance index based on the scoring of PCIs. Three hundred forty key informant interviews (KIIs) and 17 focus group discussions (FGD) were conducted at federal, provincial, and district levels where respondents were asked to score each of the indicators. Responses were then statistically analyzed and validated. The findings revealed that departments at the federal level are playing an effective role and are adequately equipped to align SDG-7 and SDG-13 with energy sector development. However, departments at the provincial and district levels are still lagging behind to achieve the desired objectives, which demonstrate the need to enhance the capacities of provincial and district line departments.

Keywords Mix-method modeling · Governance index · Climate compatible development · Low-carbon strategies · Air pollution control · Energy

Introduction

Due to its calamitous social, environmental, and economic impacts, climate change is on top of the global environmental agenda (Iqbal and Khan 2018; Zheng et al. 2019; Wang et al. 2020; Fekete et al. 2021). Industrial revolution is considered the main driver behind climate change. In the past, industrial growth relied on non-renewable energy to run the system, which resulted in financial development and high levels of carbon emissions. However, at later stages, financial development helped to reduce carbon emissions (Khan et al. 2021). The reason behind this is greater awareness about climate change and its impact, and limits set for industrialized countries after United Nation Framework Convention (UNFCCC) in 1992 and the Kyoto Protocol in 1997. Initially, the targets were set for 37 industrialized countries to reduce their greenhouse gas (GHG) emissions by 5% compared to the level in 1990. Later, during the Conference of Parties (COP21) in 2015, 196 countries committed

Responsible Editor: Ilhan Ozturk

✉ Muhammad Owais Khan
owaisk@aup.edu.pk

Kanwar Muhammad Javed Iqbal
kanwar.javediqbal@gmail.com

Nadia Akhtar
nadia@iiu.edu.pk

Muhammad Irfan Khan
drirfan@iiu.edu.pk

1 National Institute of Maritime Affairs, Bahria University, Sector E-8, Islamabad 44000, Pakistan

2 Department of Environmental Science, International Islamic University, Sector H-10, Islamabad 44000, Pakistan

3 Department of Soil & Environmental Sciences, The University of Agriculture, Peshawar, Pakistan

to set national targets known as the Intended Nationally Determined Contribution (INDC) to reduce greenhouse gas (GHG) emissions and maintain the temperature less than 2 °C above the pre-industrial level till 2030 (UNFCCC 2016; Fekete et al. 2021).

Future projections of GHG emission for many countries suggest that INDCs will not be achievable unless rigorous policies to control GHG emissions are implemented (United Nation Environment Program 2017; Statistics Division 2020; Fekete et al. 2021). Among major challenges faced by the countries to achieve set targets are synchronization of political commitments and technical implementation (Herrmann 2020; Teng et al. 2021; Zhang et al. 2021). This will require the establishment of institutional structures comprised of state and non-state actors, increasing capacities of the existing institutions to effectively coordinate with the whole governance process, integrating climate change priorities in different sectoral and cross sectoral programs, training relevant staff, engaging all stakeholders, streamlining the regulatory framework, and monitoring and reporting progress (Van Asselt and Hale 2016; Kuramochi et al. 2020). An effective institutional structure is essential for implementation of climate-related strategies and other activities at different levels of governance with the involvement of multiple actors including donors and stakeholders from other relevant departments. However, only a few countries have established institutional structures beyond ministry levels, while the rest have too weak actors' capacity to fulfill the requirement within the set time period.

Consequently, global GHG emissions have continued to increase at the rate of 2% reaching 51.8 Gt of CO_2 equivalent in 2018. This level is 57% higher than the level in the 1990s, and 43% higher than the level in 2000. In the same time period, global energy consumption increased by 2.1%, with a major share coming from fossil fuels and construing a strong interplay between energy and climate change. On average, global energy reliance is still on non-renewables (75%), including oil (29%), coal (25%), and natural gas (21%) while renewables account for only 25% (Zheng et al. 2019; Kuramochi et al. 2020; Olivier and Peters 2020; Chishti et al. 2021). The trends of global CO_2 emissions commensurate with global energy consumption trends representing a contribution of 89%, with share of coal (39%), oil (31%), and gas (18%). However, this increasing trend is not uniformly distributed, with 62% of the share coming from the five largest emitters: China (26%), USA (13%), European Union (8%), India (7%), Russian Federation (5%), and Japan (3%). In 2018, due to a shift towards renewables, GHG emissions declined in the European Union (− 1.5%) and Japan (− 1.2%), while at the same time, the share of the rest of the world increased, which is attributed to an increase in coal consumption in Pakistan (+ 63%), Vietnam (+ 22.9%), Kazakhstan (+ 12.2%), India (+ 8.7%), Indonesia (+ 7.7%), Turkey (+ 7.2%), Russia (+ 4.9%), and China (+ 0.9%) (Olivier and Peters 2020).

The situation is alarming which needs dedicated efforts from the line government departments for effective policies and capacities for a shift from carbon-based fuels to renewables and bring energy efficiencies (Baral and Guha 2004; Yuan and Zuo 2011; Georgilakis 2011; Heinrich Blechinger and Shah 2011; Songolzadeh et al. 2014; Ali and Iqbal 2017; Mondal et al. 2018; Liu et al. 2019). Many countries are already on the path to developing policy actions for a climate compatible and low-carbon development (Yuan and Zuo 2011; Anwar 2016; Swain and Karimu 2020; Wang et al. 2020; Fekete et al. 2021). Sustainable Development Goals 7 and 13 also require rigorous action from countries to achieve set targets (Munro et al. 2017; Swain and Karimu 2020). Climate compatible development (CCD) requires a shift towards low-carbon pathways particularly in sectors with high GHG emissions (Olivier and Peters 2020). Among the highest contributors, the energy sector plays a critical role in controlling GHG emissions but at the same time have social, economic, and environmental impacts and concerns, especially in developing economies (Shah 1999; Yuan and Zuo 2011; Anwar 2016; al Irsyad et al. 2019; Swain and Karimu 2020).

As a result, climate policies in relation to the energy sector are facing challenges in sustaining development and the execution of massive transition policies. The cost of reshaping infrastructure, investing in the renewable energy sector, eliminating fossil-energy infrastructure, increasing access to technology, and facilitating the involvement of multiple actors makes the transition towards low-carbon energy more challenging. Fekete et al. (2021) recommended that to achieve the Paris goals, quick actions are required to develop a comprehensive policy package, supported by financial incentives to address user preferences and reduce administrative barriers. In this context, Fekete et al. (2021) emphasized the need to strengthen the role of regional, national, and sub-national actors in order to fulfill climate commitments. The role of key actors (state and non-state) becomes more crucial after the Paris Agreement. While discussing global GHG emissions, renewable energy solutions, and low carbon pathways, several researchers like Andonova et al. (2017), Khuong et al. (2019), and Hassan et al. (2021) identified key actors like government departments, academia, industry, and users (Aized et al. 2018; Wang et al. 2020). Contrary to that, research to determine the role and capacities of state and non-state actors in aligning energy and climate change policy remained less studied and limited to a contextual setting. Many countries failed to mention the roles and capabilities of these actors in the first round of the NDC review cycle; thus, the situation demands an insight analysis (Lin and Ahmad 2017; Kuramochi et al. 2020).

In this backdrop, this study was conceived to develop a methodological framework based on some principles, criteria, and indicators to assess actors' capacity in the energy sector to control air pollution for low-carbon emission-based CCD by taking the case of a developing economy, i.e., Pakistan. Hence, criteria and indicators in consultation with stakeholders were developed and applied to the contextual setting of the energy sector in Pakistan.

Energy sector in Pakistan

Pakistan is among the countries most heavily dependent on fossil fuels (87%) to meet its energy demand. The share of renewables is just 4% of its total energy supplies (Aziz and Abdulaziz 2010; Anwar 2016; Zafar et al. 2018; Aized et al. 2018; He et al. 2020). Despite a < 1% share in global GHG emissions, Pakistan is among the countries most vulnerable to climate change, which makes the country's achievement of sustainable development goals more challenging. After facing a decade of severe energy shortages, Pakistan is now striving to fulfill its energy demand from indigenous coal reserves. Consequently, Pakistan's coal-based energy emissions increased up to 63% in 2018 (Olivier and Peters 2020). Moreover, Pakistan has joined the Belt and Road Initiative (BRI) of China under which US$ 62 billion is being invested through the China-Pakistan Economic Corridor (CPEC) Plan- 2017–2030. Energy projects, mostly coal-based are a 75% component of CPEC (Bilgen 2016; Verma et al. 2017) and are expected to increase GHG emission up to 371 MtCO_2 by 2030 (Janjua et al. 2018). Pakistan faced a severe energy crisis because of the complex dynamics of its energy sector in the last two decades and still is in the recovery process (Qudrat-Ullah 2015; Qazi et al. 2017; Shah et al. 2019; Hassan et al. 2021; Hu et al. 2018). This pressure has led the government to focus on short-term energy generation projects like independent power plants and utilization of coal reserves (Valasai et al. 2017). Pakistan's energy sector contributes significantly to GHG emissions. With the current energy mix in Pakistan, 100 years of global warming potential from electricity generation is expected to increase from 22.2 Mt CO_2e in 2012 to 55.2 Mt CO_2e in 2030 (Aized et al. 2018) while a business-as-usual scenario and the additional impact of energy projects under CPEC may increase the level up to 4621 Mt CO_2e (GoP 2011) by the middle of the century in 2050, which would be 60% of total GHG emission (Khan et al. 2016). Hence, the impact of projects under CPEC must also be given serious consideration as this is the largest investment program ever in Pakistan but with 75% energy projects, mostly coal-based, 13% road infrastructure development, 8% train, and 4% transport; all are contributors to GHG emissions and numerous environmental and climate change impacts (Zubedi et al. 2018; Kouser et al. 2020).

At the same time, due to its geographical location and topography, Pakistan has an enormous potential to develop renewable energy resources including solar, wind, biomass, hydro, and geothermal. Among these, solar, wind, and biomass energy have an ample potential to generate electricity to meet the current energy demand (Harijan et al. 2008; Farooq and Kumar 2013; Wang et al. 2020). Developing renewable energy has an enormous potential, particularly in terms of eliminating the energy crisis and ensuring sustainable economic growth, energy security, and reduction in GHG emissions (Shah et al. 2019). Unfortunately, these natural RE resources have not been fully harnessed in the country. As a result, the country is facing a demand–supply gap, posing a challenge for future energy security while meeting the commitments for climate change (Valasai et al. 2017). The situation demands an effective institutional and governance system to promote renewable resources, in line with INDC commitment and climate vulnerabilities of Pakistan (Shah et al. 2019). Present study focused on assessing capacities of the line departments in energy sectors for CCD response, to complement the multi-criteria analysis of energy policies of Pakistan by Hassan et al. (Hassan et al. 2019) and alternate and renewable energy governance, barriers, and opportunities in Pakistan discussed by Hassan et al. (Hassan et al. 2018).

The situation thus necessitates a coherent energy governance framework (Waheed et al. 2021) for low carbon development. To address climate change, Pakistan has developed a governance framework in 2012 by launching a National Climate Change Policy (GoP 2012) and a framework for its implementation in 2013 followed by enactment of the Pakistan Climate Change Act in 2017 (GoP 2017) and establishment of the Pakistan Climate Change Council in 2018. The establishment of a national climate change authority is in process. Whereas for energy governance, the National Energy Efficiency and Conservation Authority (NEECA) was established through the National Energy Efficiency and Conservation Act of 2016. The NEECA helped in developing the NDC Statement 2016 (UNFCCC 2016) and the Alternate and Renewable Energy Policy of 2019 at the federal level (GoP 2016a, b; AEDB 2019). Based on their study, Hassan et al. (2019) concluded that energy policies in Pakistan lack the capacity to vouch for the SDGs and combat climate change and are devoid of indispensable criteria to strengthen energy governance for low carbon development.

A coherent and integrated energy governance system needs effective institutions beside policy and legal instruments. Hence actors' capacity assessment is of crucial importance. The government has been taking various measures including institutional restructuring (Valasai et al. 2017). In this context, this study aimed at exploring the role of actors involved in governing the energy sector with the objective to assess actors' capacity against specific principles, criteria, and indicators for climate response mechanism and implementation arrangements. The study attempted to determine whether capacity of the line departments involved in energy governance is adequate to achieve targets set under SDG-7 and SDG-13 for climate compatible development. In doing so, the study helped to determine areas where the actors' capacity is weak. The findings will help in improving coordinated performance of energy sector horizontally as well as vertically which will enhance the country's preparedness for developing robust energy governance frameworks for low-carbon development.

Methodology

Research design

The study employed the second climate principle "ensure climate competence, capacity and active role of the line government departments (CP2)," which was formulated during an umbrella study focusing on climate governance in Pakistan, aimed at developing the sectoral indices for assessing the adequacy and state of governance for CCD. The study employed a mix-method innovative research design by combining qualitative and quantitative analysis. Figure 1 portrays the research design for the broad study. The study employed a combination of "Rules-based" and "Rights-based" governance approaches along with application of the MCDA method on six components of the governance mechanism as mentioned in Table 1 (Daim et al. 2009; Amer and Daim 2011; Costa et al. 2017; Ishtiaque et al. 2019; McIntosh and Becker 2020). For developing the governance analysis framework, three sessions with experts were organized to get an insight of the existing situation (Wellman 1983; Hovland 2005b; Borgatti et al. 2009). In the light of these findings, the model was logically organized to develop CCD principles, criteria, and indicators (PCI). Being generic for sectoral indicators, the model is flexible with simple architect and easy application as a whole or in partial form for any of the six different governance components (GC) and climate response principles (CP) using cross-sectional primary data. Present study focuses on the second climate response principle (CP2) against governance component 2 (GC-2) (Table 1) for developing an index to assess the role and capacities of the line government departments for CCD in the energy sector. The logical sequence adopted for this study is portrayed in Fig. 1. It is basically extracted as the subset of governance analysis framework for the whole study which was completed in two steps, (i) formulation of PCI and (ii) practical application of PCI for governance index using a case study of Pakistan's energy sector.

Formulation of PCI and data collection

In light of the findings from three consecutive focus group discussions (FGDs) with experts, 58 composite indicators were determined against nine CCD criteria for GC-2 (capacity of the line government departments), CP2 (ensure climate competence, capacity and active role of the line government departments) and six of the World Bank's good governance

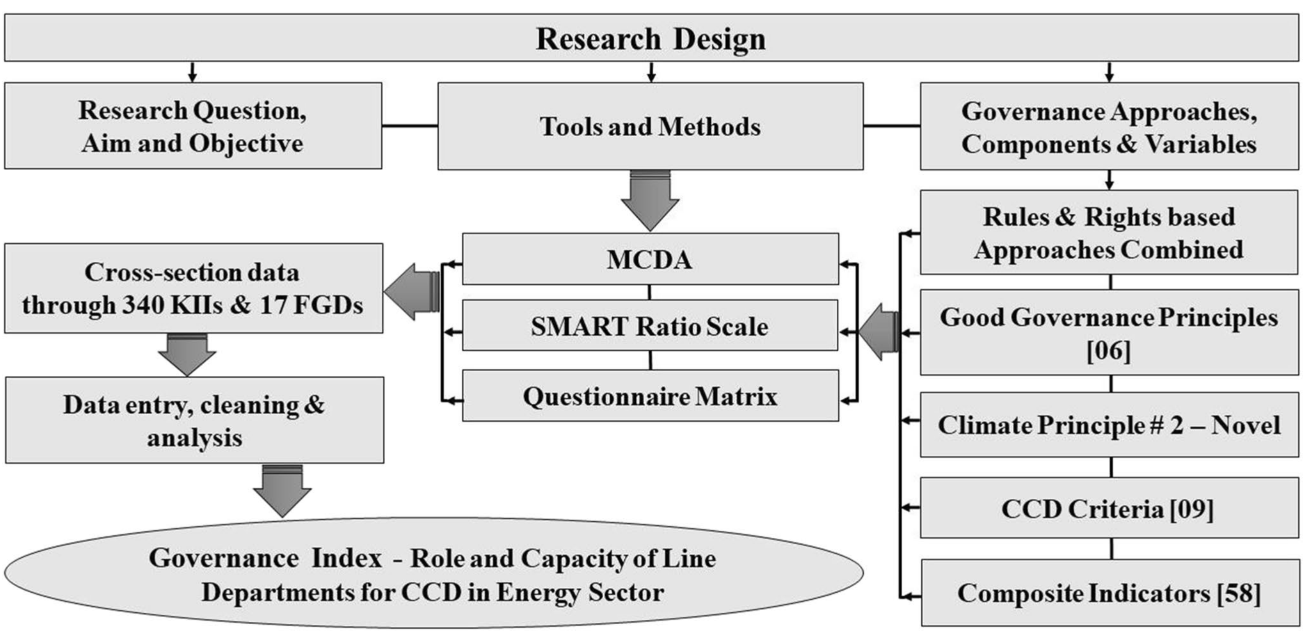

Fig. 1 Study design and methodological steps' process flow (source: PhD dissertation of first author)

Table 1 Climate response principles and components of basic governance mechanism

Code	Climate response principle	Corresponding governance component
CP1	Respect climate policies, processes, strategies, law, and the institution	Policy, legal, and institutional arrangements (GC-1)
CP2	Ensure climate competence, capacity, and active role of the line government departments	Role and capacities of the line government departments (GC-2)
CP3	Promote vibrant and influential role of the civil society stakeholders with climate competence and capacity	Role and capacities of CSOs and academia (GC-3)
CP4	Maintain active engagement of the community-based stakeholders towards climate endeavors	Role and capacities of community-based organizations (GC-4)
CP5	Dynamic role of the private sector stakeholders for best climate solutions	Role and capacities of corporate/private sector stakeholders (GC-5)
CP6	Achieve and maintain participatory sustainable climate compatible performance	Practice and performance system (GC-6)

Source: Principles and components adopted for governance analysis framework study (PhD dissertation of first author)

Table 2 Ratio scale for scoring and weighting the criteria

S. no	Ratio scale	Classes
1	0	Not applicable
2	0.01 to 1.99	Very poor
3	2.00 to 3.99	Poor
4	4.00 to 4.99	Considerable
5	5.00 to 5.99	Fair
6	6.00 to 7.49	Good
7	7.50 to 8.99	Very good
8	9.00 to 10.0	Excellent

principles (Kartodihardjo et al. 2013). During these meetings, scenario-based learning and situational analysis techniques using flip charts were employed (Hovland 2005a; Dey 2012; Norris et al. 2012; Serrat 2017). These three consecutive in-house consultation sessions with the experts' groups were held at Islamabad, with a group size of 13–15 persons, as per maximum provision under the standard protocol for a FGD session. The experts were from academia, civil society- led think tanks, and officials of relevant government departments. The present study advanced study conducted by the Indonesian government for the participatory assessment of REDD + Governance (Kartodihardjo et al. 2013) which used six components of the basic governance with only six criteria and good governance principles. This study is an advancement, as it employed a more comprehensive framework with nine criteria and six principles for CCD, which were never applied before in any study on CCD.

Data was collected using structured questionnaire cum scoring matrix with SMART ratio scale (Table 2) and by utilizing the applicable set of 58 composite indicators of energy governance for GC-2. Responses were collected through focus group discussion (FGD) and key informant interviews (KII) from seven (07) federal and provincial capitals along with ten districts (Swat, Mansehra, Bahawalpur, Rajanpur, Sanghar, Badin, Jhal Magsi, Khuzdar, Muzaffarabad, and Ghizer). The sampling locations were selected by giving due consideration to the existing climate-related projects and programs by the government and other stakeholder groups including academia, civil society organizations, and private sector actors. The target respondents were from academia, civil society- led think tanks or initiatives, and officials of relevant government departments at all selected locations. A total of 357 responses were collected by employing a purposive sampling technique, i.e., one FGD and 20 KIIs per location, keeping in mind two important factors: (1) geographical boundaries and (2) the size of the sample against which key informant interviews (KIIs) and focus group discussion (FGD) sessions were conducted.

A widely practiced MCDA's simple multi-attribute rating technique (SMART) (Edwards 1977; Leskinen and Kangas 2005; Gärtner et al. 2008; Heinrich Blechinger and Shah 2011) was used with ratio scale (Table 2) for scoring and weighting the criteria against the indicators for data analysis.

A pre-test exercise was carried out at Islamabad for weighting, normalization, and validation of the composite indicators.

Primary data management and analysis

For compiling, cleaning, processing the data, and developing the GC-2 governance index, MS Excel-2016 was used. For validation of results, three statistical tests were carried out, i.e., non-parametric Kruskal–Wallis (KW) hypothesis or H-test, Pearson correlation, and regression using "IBM SPSS Statistics 25". KW test helped in authenticating the originality of the sample data with the existence of diverse trends on a ratio scale. The test was applied for understanding and characterizing the sample groups, variables constituency, and gender wise prior to indicate whether the samples are dominating one way or another stochastically, at different levels of the governance arrangements (i.e., federal, provincial, and district levels). A one-tailed Pearson correlation helped in portraying relationship, impact, and interlocking of variables with each other, which provided clarity on complex interdependence for private sector capacity vis-a-vis CCD agenda in energy sector. Multivariate linear regression analysis helped in evaluating the mathematical relationship between different interlocking variables in order to decipher the basic research question.

Results

Criteria-wise breakdown of GC-2 index score for CCD response in energy sector of Pakistan at federal, provincial, and district levels are presented in Table 3. Figure 2 provides a graphical overview of governance index vis-a-vis nine criteria of CCD. Figure 3 shows criteria-wise GC-2 index on a clustered bar chart. Figure 4 forms a radar for the distances against governance index, and Fig. 5 shows the overall index for CCD response at federal and provincial levels. Figure 6 shows GC-2 index at district level. Overall results depict EC-1.2 index scores 7.93, 5.49, and 2.31 with an average score of 5.24; EC-2.2 index scores 4.66,

Table 3 The breakdown of the GC-2 index for CCD response in energy sector

CCD criteria	Criteria-wise index score			
	Federal	Provinces	Districts	Average
Disaster risk reduction, vulnerability, and spatial mapping (EC-1.2)	7.93	5.49	2.31	5.24
Regulation of rights (EC-2.2)	4.66	3.35	1.72	3.24
Climate smart practices (EC-3.2)	7.61	5.06	2.30	4.99
Technological innovation (EC-4.2)	7.49	4.99	2.32	4.94
Climate organization (EC-5.2)	7.48	4.94	2.31	4.91
Institutional effectiveness (EC-6.2)	7.80	5.17	2.31	5.09
Climate infrastructure (EC-7.2)	7.48	4.99	2.31	4.93
Agriculture, water, and energy nexus (EC-8.2)	6.09	4.37	2.32	4.26
Sustainability (EC-9.2)	4.43	3.07	1.66	3.05
Overall average	**6.78**	**4.60**	**2.17**	**4.52**

[Scale: 0 = Not applicable or no response yet, 0.01 to 1.99 = Very poor, 2.00 to 3.99 = Poor, 4.00 to 4.99 = Considerable, 5.00 to 5.99 = Fair, 6.00 to 7.49 = Good, 7.50 to 8.99 = Very good, 9.00 to 10.0 = Excellent]

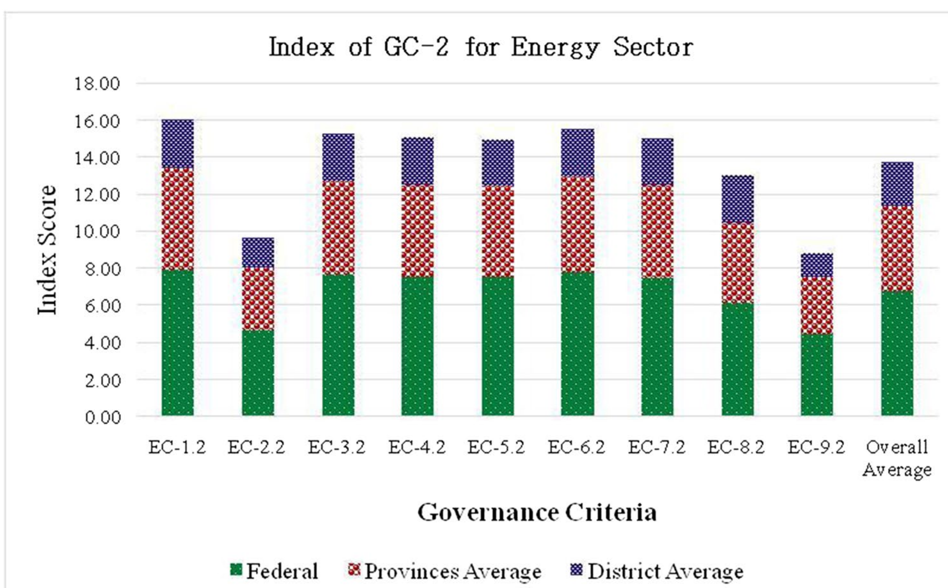

Fig. 2 Criteria-wise GC-2 index for CCD response in energy sector

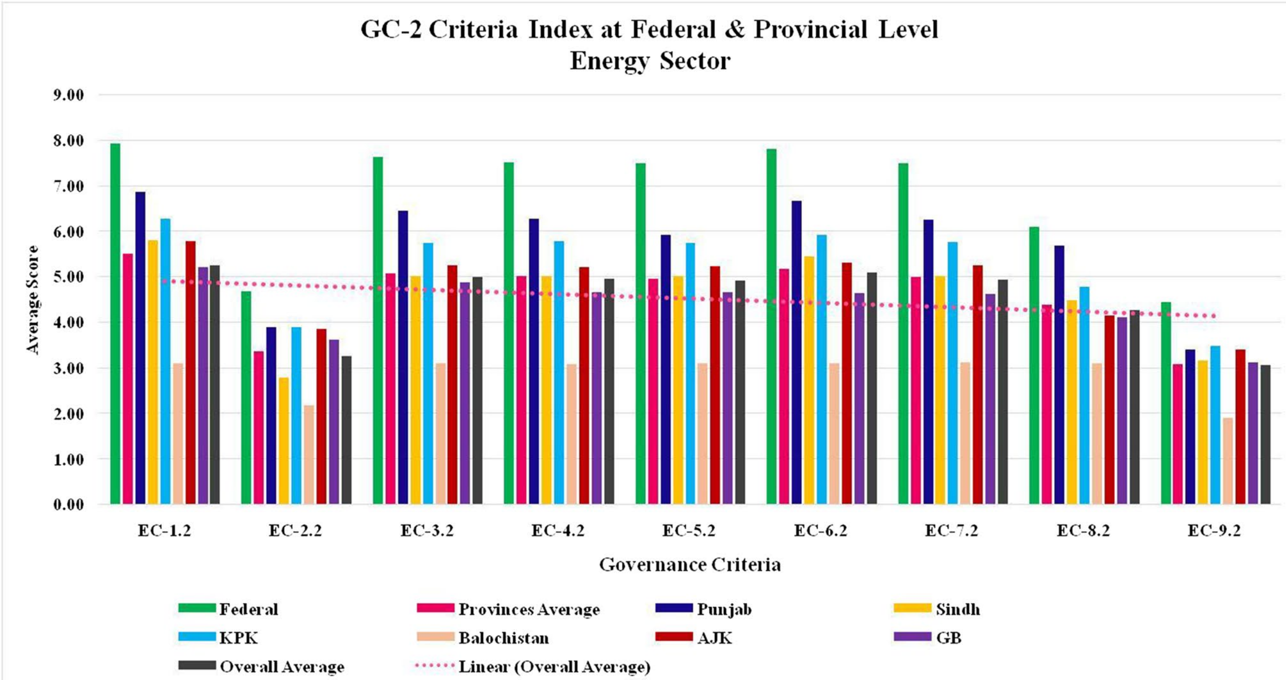

Fig. 3 Criteria-wise GC-2 index for CCD response at federal and provincial levels

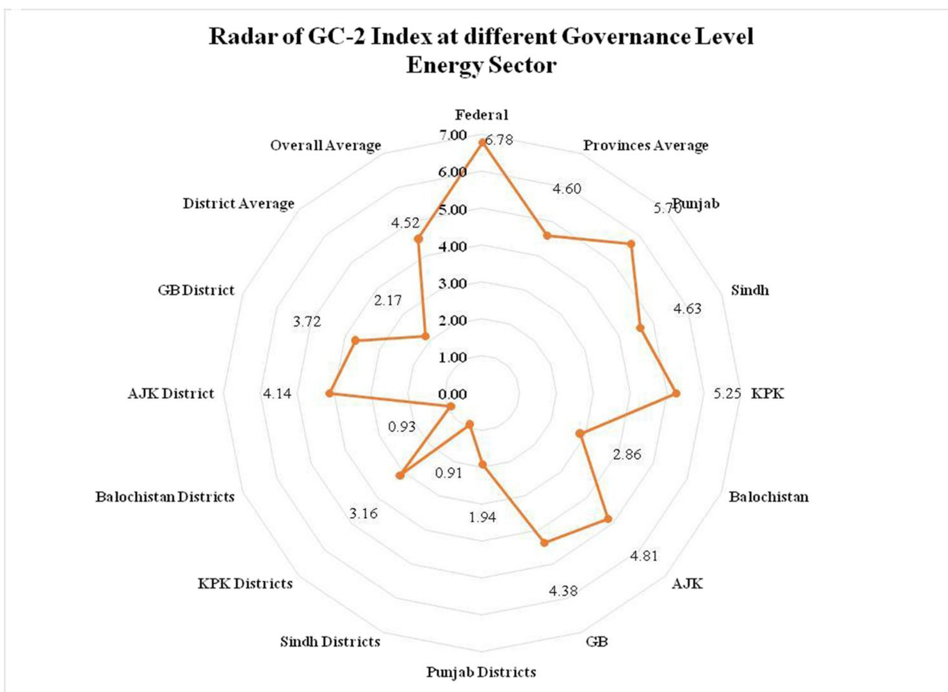

Fig. 4 GC-2 index radar for CCD response at different governance levels in energy

3.35, and 1.72 with an average score of 3.24; EC-3.2 index scores 7.61, 5.06, and 2.30 with an average score of 4.99; EC-4.2 index scores 7.49, 4.99, and 2.32 with an average score of 4.94; EC-5.2 index scores 7.48, 4.94, and 2.31 with an average score of 4.91; EC-6.2 index scores 7.80, 5.17, and 2.31 with an average score of 5.09; EC-7.2 index scores 7.48, 4.99, and 2.31 with an average score of 4.93; EC-8.2 index scores 6.09, 4.37, and 2.32 with an average score of 4.26; EC-9.2 index scores 4.43, 3.07, and 1.66 with an average score of 3.05; and constituency-wise average scores of

6.78, 4.60, and 2.17 at federal, provincial, and district levels respectively. The overall GC-2 index score is 4.52.

Regarding statistical validation, Tables 4 and 5 provide summaries of constituency and gender-based KW

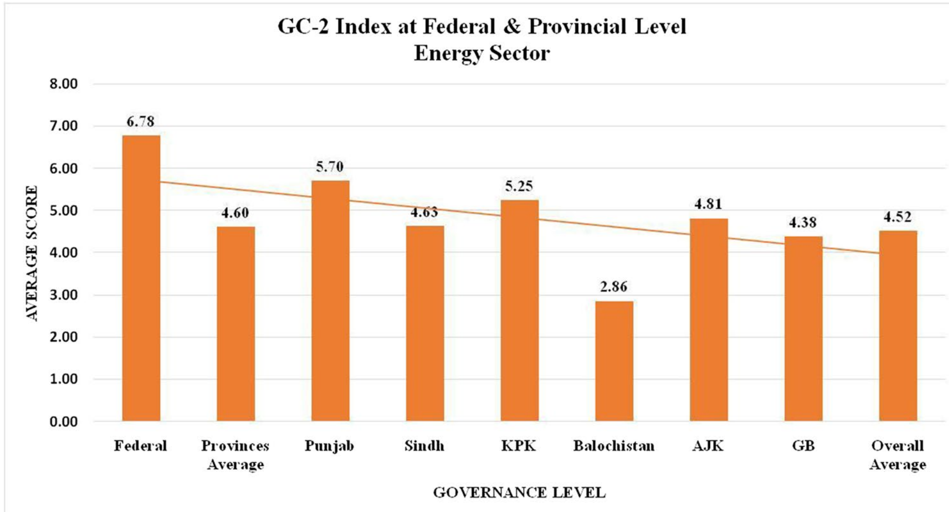

Fig. 5 GC-2 index for CCD response at federal and provincial levels in energy sector

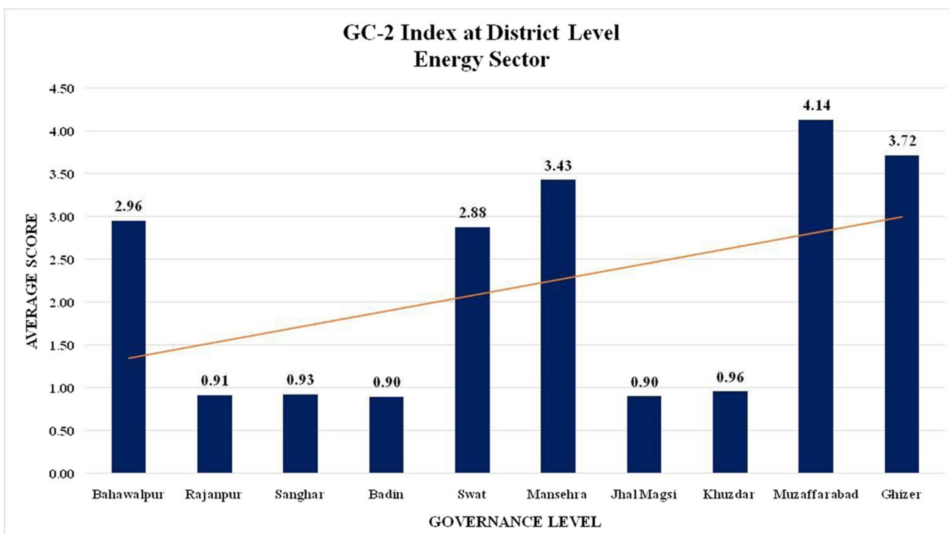

Fig. 6 GC-2 index for CCD response at district level in energy sector

Table 4 Constituency-based KW test summary for GC-2 sample

Independent-samples Kruskal–Wallis hypothesis test summary

No	Null hypothesis	Sig	Decision
1	EC-1.2 distribution is same across categories of constituency	.000	Reject the null hypothesis
2	EC-2.2 distribution is same across categories of constituency	.000	Reject the null hypothesis
3	EC-3.2 distribution is same across categories of constituency	.000	Reject the null hypothesis
4	EC-4.2 distribution is same across categories of constituency	.000	Reject the null hypothesis
5	EC-5.2 distribution is same across categories of constituency	.000	Reject the null hypothesis
6	EC-6.2 distribution is same across categories of constituency	.000	Reject the null hypothesis
7	EC-7.2 distribution is same across categories of constituency	.000	Reject the null hypothesis
8	EC-8.2 distribution is same across categories of constituency	.000	Reject the null hypothesis
9	EC-9.2 distribution is same across categories of constituency	.000	Reject the null hypothesis

Asymptotic significances are displayed. The significance level is .05. $N=357$

Table 5 Gender-based KW test summary for GC-2 sample

Independent-samples Kruskal–Wallis hypothesis test summary			
No	Null hypothesis	Sig	Decision
1	EC-1.2 distribution is same across categories of gender	.014	Reject the null hypothesis
2	EC-2.2 distribution is same across categories of gender	.018	Reject the null hypothesis
3	EC-3.2 distribution is same across categories of gender	.015	Reject the null hypothesis
4	EC-4.2 distribution is same across categories of gender	.014	Reject the null hypothesis
5	EC-5.2 distribution is same across categories of gender	.003	Reject the null hypothesis
6	EC-6.2 distribution is same across categories of gender	.018	Reject the null hypothesis
7	EC-7.2 distribution is same across categories of gender	.012	Reject the null hypothesis
8	EC-8.2 distribution is same across categories of gender	.017	Reject the null hypothesis
9	EC-9.2 distribution is same across categories of gender	.001	Reject the null hypothesis

Asymptotic significances are displayed. The significance level is .05. $N = 357$

hypothesis tests respectively for the overall sample of GC-2 in the energy sector, for which asymptotic significances are displayed with their respective significance level of 0.05 (against $N = 357$), where the null hypothesis is rejected for all cases. It authenticates the observations and depicts different responses from all respondents at federal, provincial, and district levels. Pearson correlations with significance at the 0.01 level (1-tailed) are shown in Table 6 and Fig. 7 which indicate a strong correlation among all CCD criteria of the governance under GC-2. Whereas, descriptive statistics of multivariate regression analysis for the overall sample of the energy sector are shown in Tables 7, 8, 9, and 10, while Fig. 8 shows normal P-P plot, and Fig. 9 shows scatter plot of regression standardized residual for the overall sample in the energy sector. EC-9.2, i.e., sustainability of GC2 was used as dependent variable. The values of R and R square are 0.972 and 0.944 respectively. Coefficients of T test show significant relationship of EC-9.2 with EC-2.2 and EC-5.2 (with values above ± 2), except all other criteria. However, collinearity diagnostics, i.e., tolerance below 0.10 and VIF above 10 creating interference for all of these relationships thus do not support their significance, despite all criteria having shown very good zero-order correlations with EC-9.2. The normal P-P plot shows very good results with low level of deviation to upward and downward fluctuations. The scatter plot shows three different groups, but overall shows very good results within the ± 3 boundaries. Although a majority of the criteria in the GC-2 index of governance impact each other, as a whole, the null hypothesis of the basic research question cannot be rejected for the case of GC-2. So, GC-2 results indicate, so far, the absence of a proactive and inclusive response mechanism vis-a-vis capacity of the line government departments to govern climate compatible development in the energy sector at federal, provincial, and districts levels in Pakistan for its environmental security.

Discussion

Findings revealed that the capacity of the line department is better at federal level (average index score = 6.78), but poor at district level (average index score = 2.17). The results convey that departments working at the grass-root levels do not have adequate capacities in terms of financial, technical, technological, and human resources to fulfill the criteria for

Table 6 GC-2 summary of Pearson correlations between CCD criteria

Pearson correlations									
Criteria	EC-1.2	EC-2.2	EC-3.2	EC-4.2	EC-5.2	EC-6.2	EC-7.2	EC-8.2	EC-9.2
EC-1.2	1								
EC-2.2	.936**	1							
EC-3.2	.991**	.950**	1						
EC-4.2	.990**	.952**	.995**	1					
EC-5.2	.990**	.954**	.994**	.996**	1				
EC-6.2	.992**	.941**	.994**	.995**	.994**	1			
EC-7.2	.992**	.952**	.997**	.997**	.997**	.996**	1		
EC-8.2	.966**	.950**	.978**	.979**	.979**	.977**	.980**	1	
EC-9.2	.946**	.960**	.956**	.958**	.961**	.952**	.957**	.951**	1

**Correlation is significant at the 0.01 level (1-tailed), $N = 357$

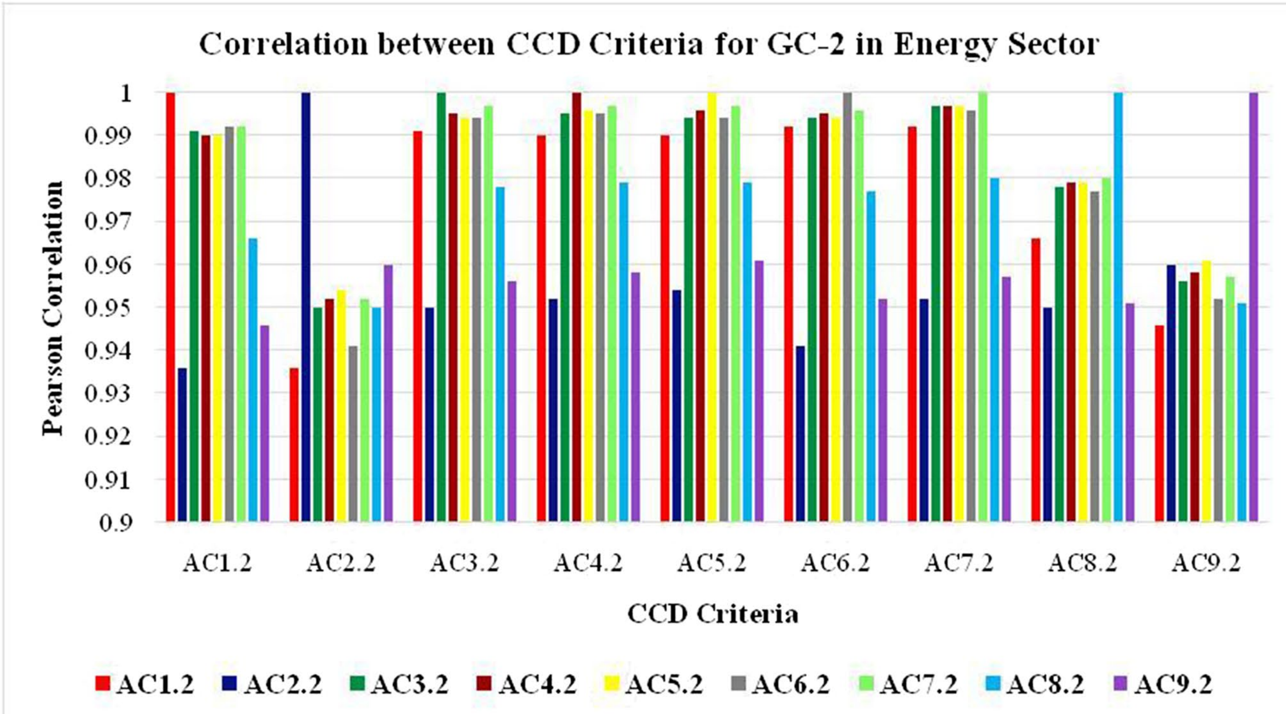

Fig. 7 CCD criteria-wise Pearson correlations for GC-2 in energy sector

Table 7 Regression model summary for GC-2 in energy sector

Model summary[b]				
Model	*R*	*R* square	Adjusted *R* square	Std. error of the estimate
1	.972[a]	.945	.944	.28332

[a]Predictors: (constant), agriculture, water and energy nexus, regulation of rights, DRR, vulnerability and spatial mapping, technological innovation, climate organization, climate infrastructure, institutional effectiveness, climate smart practices

[b]Dependent variable: sustainability

CCD. The findings commensurate with the fact that energy remained a federal subject until 2010. Devolution of powers to legislate in this sector occurred after the 18th Amendment to the 1973 Constitution of Pakistan. During the same time period, investment in the renewable energy sector grew all around the globe (Kamran et al. 2020). In Pakistan, institutional re-structuring was carried out after the 18th amendment to meet the need of the devolved governance structure. Provincial energy efficiency and conservation authorities were established after the National Energy Efficiency and Conservation Act, 2016, while, at the federal level, institutions to promote energy efficiency and determine renewable energy options were already in place. At federal level, NEECA is the focal agency with a mandate to initiate, catalyze, and coordinate all energy conservation activities in

Table 8 ANOVA summary for GC-2 in energy sector

ANOVA[a]						
Model		Sum of squares	Df	Mean square	*F*	Sig
1	Regression	480.725	8	60.091	748.618	.000[b]
	Residual	27.934	348	.080		
	Total	508.659	356			

[a]Dependent variable: sustainability

[b]Predictors: (constant), agriculture, water and energy nexus, regulation of rights, DRR, vulnerability and spatial mapping, technological innovation, climate organization, climate infrastructure, institutional effectiveness, climate smart practices

Table 9 Summary of regression coefficients for GC-2 in energy sector

Coefficients[a]									
Model		Unstandardized coefficients		Standardized coefficients	*t*	Sig	Correlations zero-order	Collinearity statistics	
		B	Std. error	Beta				Tolerance	VIF
1	(Constant)	.212	.037		5.756	.000			
	EC-1.2	−.001	.061	−.001	−.010	.992	.946	.012	82.557
	EC-2.2	.412	.040	.478	10.254	.000	.960	.073	13.785
	EC-3.2	−.019	.095	−.033	−.204	.839	.956	.006	166.483
	EC-4.2	.145	.109	.244	1.337	.182	.958	.005	210.516
	EC-5.2	.343	.104	.568	3.307	.001	.961	.005	187.077
	EC-6.2	.055	.098	.097	.559	.576	.952	.005	191.998
	EC-7.2	−.272	.156	−.454	−1.737	.083	.957	.002	433.298
	EC-8.2	.062	.050	.086	1.241	.215	.951	.033	30.098

[a]Dependent variable: sustainability (EC-9.2)

Table 10 Regression's residual statistics for GC-2 in energy sector

Residuals statistics[a]					
	Minimum	Maximum	Mean	Std. deviation	*N*
Predicted value	.5429	4.6263	2.3227	1.16205	357
Residual	−.64372	.70438	.00000	.28012	357
Std. predicted value	−1.532	1.982	.000	1.000	357
Std. residual	−2.272	2.486	.000	.989	357

[a]Dependent variable: sustainability

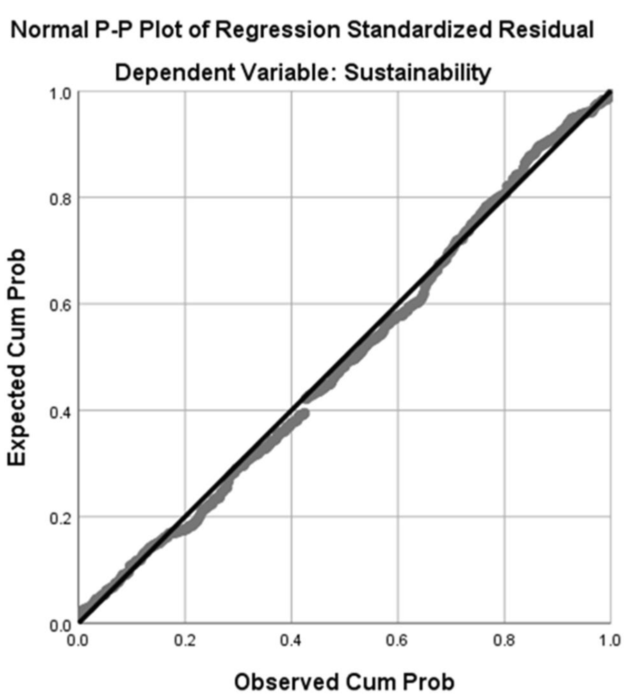

Fig. 8 Normal P-P plot of regression standardized residual for GC-2 in energy sector

different sectors of the economy. NEECA (formerly known as ENERCON) started its journey as an autonomous agency under the Ministry of Planning and Development in 1986 and had its Act approved in 2016. With a major mandate focusing on the area of energy conservation, NEECA projects always focused on this area in different sectors. Two other institutions at federal level that have focused on alternate energy resources are the Alternative Energy Development Board (AEDB) and the Pakistan Council for Research in Renewable Technologies (PCRET), established in 2003 and 2001 respectively. These institutions are better aligned with the Ministry of Climate Change (federal) by participating in decision-making and execution of different plans and projects in mutual collaboration. Criteria-wise scoring (Table 2) commensurate well with this fact. Energy, being the most contributing sector for GHG emissions, plays a crucial role in fulfilling the INDCs. Keeping this in view, the Ministry of Climate Change engages these institutions in climate change-related projects. However, institutions at provincial levels are newly established organizations and currently did not play a proactive role in terms of response to climate-related issues. Consequently, progress in the energy sector after the 18th amendment remained slow.

Climate change response in the case of Pakistan is multi-sectoral and multidimensional in nature (Khan et al. 2016; Iqbal and Khan 2018). Pakistan is among the countries most highly impacted by climate-related stressors. Due to its high vulnerability and low resilience capacity, it needs a multi-faceted action plan involving actors from all relevant sectors (Iqbal and Khan 2012, 2018; Khan et al. 2016; Waheed et al. 2021). For this purpose, the study employed nine criteria (Table 2) that effectively cover different dimensions of climate change response in relation to the energy sector. Criteria-wise breakdown of governance index score reveals that actors' capacity against criteria 1, 3, 4, 5, 6, and 7 is

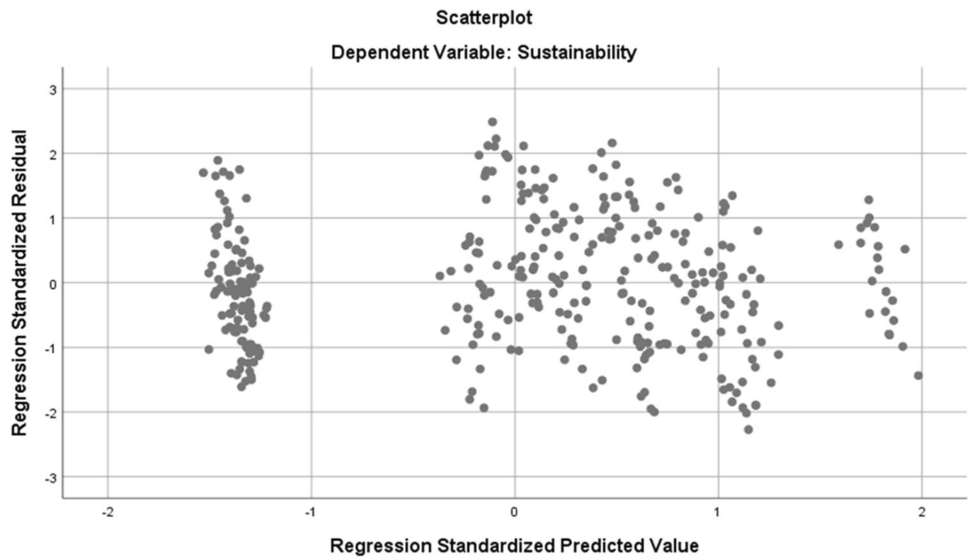

Fig. 9 Scatter plot of regression standardized residual for GC-2 in energy sector

satisfactory while line departments at federal level have to improve on criteria 2 and 9 (Table 2). During focus group discussions at the federal level, spatial mapping programs in universities, early warning systems for floods, and research on climatic vulnerabilities were the factors that resulted in an improved CCD response. Lower score (2.17) at district levels were correlated with inadequate capacities of line departments for disaster preparedness and rehabilitation work. For this purpose, there is a need to start awareness and training programs at the grass roots level (Hussain et al. 2018; Xu et al. 2019; Mahama et al. 2020; Kamran et al. 2020).

Almost two decades have passed since Pakistan acceded the United Nation Framework Convention on Climate Change in 1994 as a Non-Annex I party and Kyoto Protocol in 2005, and started receiving funding for identifying priority areas, need assessments, fulfilling reporting requirements, developing policies and action plans, and executing various projects. While there are many success stories in which relevant institutions tapped opportunities, such as the CDM National Operational Strategy which provided access to the carbon market, there are major failures in overall performance. Over two decades have passed, yet the government has not succeeded in effectively integrating climate change concerns in sectoral policies for energy, water, food, health, and agriculture. After the 18th constitutional amendment in 2010, the energy, health, and agriculture sectors have been devolved to provinces, which has made the integration of CCD response more challenging. At the same time, high demand for energy for increasing economic growth, inadequate resources, pollution from power generation, inconsistent oil prices, and fickle supplies triggered the government to develop long-term and secure energy sources.

Alternative and renewable energy sources are an anticipation of securing a long term, clean, and sustainable future of energy. Pakistan has potential for developing alternative and renewable energy and has set a target of a 5% share in the energy mix by 2030 (GoP 2006; Awan and Rashid 2012; Irfan et al. 2019, 2020; Kamran et al. 2020). However, responses during FGD and KII revealed a lack of collaborative mechanisms among departments, meager penetration of alternative and renewable energy technologies in masses (World Bank 2019; Shah et al. 2019), little to no incentives for domestic manufacturing, lack of standards for energy conservation and efficiency, lack of awareness, and the weak industry-academia research culture as major deficiencies for energy sector to respond to CCD (Hassan et al. 2021). Findings also reveal that uncertainty and a non-friendly institutional structure for investors are associated with a continuation of policies hindering large-scale investment in the RE sector.

It is pertinent to highlight that the findings of this study are applicable to the business- as-usual case and the state of climate response in other developing countries which have similar trends, as reported in United Nations SDG Report 2020 (Statistics Division 2020). The United Nations SDG Report 2020 links poor progress with issues of capacity and climate finance. At the same time, the state of climate response has no exception for the developed world in the context of their energy-driven scenario for global warming.

Conclusion

The innovative multivariate analysis model proved well in answering the research question through developed governance index of actor's capacity. On the basis of the findings of this study, it may be concluded that the capacity of government's line departments is relatively better at the federal level and considerably fair at the provincial level; and at the district level, it ranges from very poor to poor. Considering the index scores, there is a need for the development of required climate infrastructures. The effectiveness of institutions is relatively very good at federal level while the other constituencies are so far standing far behind the desired level of very good to excellent scales of the governance index. Although the majority of criteria in the GC-2 index of governance impact each other, as a whole, the null hypothesis of the basic research question cannot be rejected. It is deciphered that GC-2 results so far indicate the absence of a proactive and inclusive response mechanism vis-a-vis capacity of the line government departments to govern climate compatible development in the energy sector at federal, provincial, and district levels in Pakistan for its environmental security. There is a need to enhance the existing capacities of the provincial line departments along with mainstreaming their district arms. The district arms may be instrumental in harnessing the RE solutions along with energy efficiency and energy management best practices, which are important to control air pollution with low-carbon development strategies.

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Data availability Data is available from the corresponding author with a formal request.

Declarations

Ethics approval and consent to participate Not applicable.

Consent for publication All authors have read and approved this manuscript.

Competing interests The authors declare no competing interests.

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