INNOVATIVE MULTIVARIATE ENERGY GOVERNANCE MODEL FOR CLIMATE COMPATIBLE DEVELOPMENT: THE CASE OF PAKISTAN

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ABSTRACT

Energy sector has quite challenging path for sustainable and Climate Compatible Development (CCD) due to various governance issues worldwide. Pakistan's Nationally Determined Contribution (NDC) Statement 2016 committed to curtail its present 46% GHG emission which is likely to increase up to 56% by 2030 and the target is set to reduce it by 20% with estimated abatement cost of 40 billion US$. The sustainability agenda for a low carbon and resilient future under SDG-7 and SDG-13 requires inclusive governance mechanism to devise and implement energy sector specific holistic climate response strategies with cross-sectoral integrations at all constituencies' level in Pakistan. This paper resulted from a study aimed to produce governance indices for assessing adequacy of overall state of energy governance for CCD by employing an innovative mix-method analysis model, based on six governance components and MCDA method with SMART's Ratio Scale. Six novel principles of climate governance and good governance with 281 Indicators of 09 CCD Criteria were used for cross-section data collected through 340 KIIs and 17 FGDs. Empirical results provide baseline and decipher that country's climate response towards energy governance is in readiness phase and the null hypothesis of basic research question retained. Statistical validation of results was done by employing Non-parametric Kruskal-Wallis test, 1-tailed Pearson Correlation and Regression. It indicates lack of political will, inadequate fiscal resources, overlapping policy instruments and their implementation problem, coordination issues between constituencies after 18th amendment in national Constitution and actor's capacity gaps as key limiting factors, and suggests a way forward. Finally, it looks at implications of this model for open innovation concept.

Keywords: Innovative Multivariate Model, Climate Compatible Development, Energy Governance Index, Climate Governance Principles, Criteria and Indicators, MCDA

INTRODUCTION

Climate change is no more a distant reality or no longer a contested issue and it has emerged as biggest patent externality of 21st century (Eleftheriadis & Anagnostopoulou, 2017; Iqbal & Khan, 2018; Jiang et al., 2017; Ballesteros et al., 2020; Nwedu, 2020). It is attributed through its manifestation and convergent evidences across all sectors of economy (Blunden & Arndt, 2019; Höök & Tang, 2013; IPCC, 2018; Reser, Bradley & Ellul, 2014; WMO, 2019), with diverse dilemmas thus plaguing relations between the human and nature (Carvalho & Peterson, 2009; Iqbal, Rehman & Khan, 2020). Growing anxieties are connecting climatic catastrophes with apocalyptic dots for the future of our planet Earth and of humankind (Oegema, 2020). It is a big challenge to global sustainable development agenda for which risk perception has growing trends about hazards of climate change likely impact geographies, people and developing economies worldwide (Davies et al., 2020; JUNG & SONG, 2020; Leiserowitz, 2005; Mogomotsi, Sekelemani & Mogomotsi, 2020; Parry et al., 2008; Sanchez, 2000; Statistics Division, 2020). United Nations' SDGs Report (Sustainable Development Goals) highlighted that about 39 million people were the severe climate victim during 2018; while use of natural resources is unsustainable as the desired 3% target of energy efficiency has not achieved worldwide. A 3.2°C is an anticipated rise in global temperature by 2100 and annual global emissions reduction target is lagging behind about 7.6% for limiting the warming effect to 1.5°C (Statistics Division, 2020).

Anthropogenic flux of Green House Gases (GHGs) is a significant essential climate variable and among the key driving forces impacting the nexus of energy, water and agriculture for environmental security (Ali & Iqbal, 2017; Hassan, Afridi & Khan, 2018; WMO, 2019) for which response options are 'context-dependent' in order to have trade-offs for interlocking agenda of SDGs (Blanchard et al., 2017). The 'climate mitigation and adaptation strategies' have greater focus on energy conservation and efficiency, proliferation of renewables and reducing energy losses from all sectors of economy, clean air policies and sustainable natural resource management (Metz et al., 2002). Energy is the backbone of all human activities (Johansson, 2015; Wernet et al., 2011) having largest share towards GHG emissions among all sectors of the economy (Hassan, Khan Afridi & Irfan, 2019). The climate, energy, water, agriculture and land-use nexus has very strong interlocking between many SDGs (Sridharan et al., 2018) including SDG-13 dealing with climate action, SDG-12 dealing with sustainable consumption and production, SDG-7 dealing with affordable and clean energy, SDG-6 dealing with clean water and sanitation and SDG-2 aiming to finish hunger. There may be a paradigm shift due to energy and water insecurity (Hassan et al., 2021) and its crises as a result of gap in supply and demand (Bilal, Khan & Siwar, 2018). The negative impact would likely to aggravate further with business as usual scenario of economic growth and particularly important for mega transnational projects such as Belt and Road Initiative (BRI) of China which has global geo-economic endeavor (Iqbal & Haider, 2020; Waheed, Fischer & Khan, 2021).

There is a need to have necessary alignment for creating synergies between SDG-13 (UN, 2015) and the Paris Agreement (UNFCCC, 2015) to develop coherent climate response strategies towards energy, water, agriculture and food security, and poverty alleviation(Campbell et al., 2014). The energy and environmental security will need an integrated Climate Compatible Development (CCD) approach of 'triple-win strategies' (Mitchell & Maxwell, 2010) with adequate and inclusive governance mechanism for all sectors of economy (Iqbal & Khan, 2018). However, the energy sector has quite complex and challenging path for sustainable and Climate Compatible Development (CCD) due to largest share towards GHG emissions and cross-sectoral linkage amongst various governance issues worldwide. Pakistan's Nationally Determined Contribution (NDC) Statement 2016 committed to curtail its present 46% GHG to a target of 26 % with an estimated abatement cost of 40 billion US$, which otherwise would become 56% by 2030 in business as usual scenario(UNFCCC, 2016). The sustainability agenda for a low carbon and resilient future for achieving SDG-7 and SDG-13 will require inclusive governance mechanism to implement energy sector specific holistic climate response strategies with cross-sectoral integrations at all level in Pakistan.

The developing economies like Pakistan, have complex setups and lack of ownership at different tiers of governance mechanism thus having concerns about adequacy of energy governance for sustainable and climate compatible development philosophy. There is a need to examine the current state of energy governance by employing a widely accepted standard climate governance model that covers all related components in national, sub-national and local context. But, such a desired analysis framework model for case of CCD is non-existent in the literature (Pyone, Smith & Broek, 2017), though various frameworks were proposed in the past (Douxchamps et al., 2017; FAO, 2017; Ha et al., 2018; Oliveira & Hersperger, 2018). The propagation of the subject governance is reasonably good with abundant and diverse perspectives and dimensions (Sanchez & Roberts, 2014; Thornton et al., 2018). These showcase stand-alone application of principles (Aven & Renn, 2018; Chuku, 2010; Dasgupta & Roy, 2011; Lockwood et al., 2010), criteria (Wise et al., 2016; Wood et al., 2017), indicators (Dong & Hauschild, 2017; Emenanjo et al., 2015) for the governance assessment, along-with a diverse account of perspectives regarding effectiveness and shortcomings of methodological frameworks (Nakano et al., 2017; Ritchie et al., 2010). There is a lack of consensus in the literature about the use of existing methods due to involvement of various aspects and components of governance from informal to formal concepts (Follesdal, Christiansen & Piattoni, 2004; Kleine, 2014; Stone, 2011) and rules to rights based approaches involved (Pierre & Peters, 2020), which are quite complex to deal with the subject (Saunders & Reeve, 2010; Hamakers & Glasbergen, 2007). Since CCD involves multi-sectors, multi-actors and participatory approach, thus adopting a single conceptual framework or governance approach is unjustified and unsatisfactory that would likely to limit its actual scope in different sectoral economies.

The energy sector requires mitigation and low carbon development strategies and it interlocks with adaptation and resilience strategies that need to be implemented through an inclusive energy governance system. Therefore, the question arises whether the existing energy governance system is effective in implementing these strategies or some new model is required for CCD?

This empirical study aimed at developing a framework of analysis for energy governance for CCD, with a case study to assess its effective application in energy sector of Pakistan. The specific objectives were: (i) development of analysis model based on principles, Criteria and Indicators (PCIs) of governance for CCD; and (ii) validation of this model by application to energy sector at national, sub-national and local level.

RESEARCH METHODOLOGY

Steps, Governance Approaches and Formulation of Innovative Model

A two-step process was followed for the formulation and application of measuring tool for determination of governance indices for energy sector. Three different exercises were carried out through consultative workshops by using Problem Tree/Situational Analysis technique (Borgatti et al., 2009; Hovland, 2005; Wellman, 1983) and expert groups' consensus based decision was taken for adopting the combination of 'Rules-based' and 'Rights-based' governance approaches along-with application of MCDA method on six components of the basic governance mechanism (Amer & Daim, 2011; Costa, Gomes & de Barros, 2017; Daim et al., 2009; Ishtiaque et al., 2019; McIntosh & Becker, 2020), prior to develop governance analysis model framework for CCD. It integrated six (06) principles of climate and good governance, nine (09) criteria and two hundred eighty one (281) indicators for CCD in energy sector. Figure 1 describes the design and different steps involved in this study, while Figure 2 illustrates the logical sequence and arrangements for an innovative multivariable model for assessment and developing governance indices. This model is specific to the issue of climate compatible development, generic for the sectoral indicators and advanced form of the participatory assessment of REDD+ governance in Indonesia (Kartodihardjo et al., 2013). This logical and innovative model can be described easily and its applicability is equally good to all of sets of sectoral economy, by formulating and utilizing the slightly modified set of indicators for different sectors.

Determination of Key Variables

Six components of basic governance mechanism and their sets of key variables are logically arranged and described in Figures 1 & 2, which also provide breakdown of different components and sets of variables. Components of basic response mechanism include: (1) policy, legal and institutional arrangements; (2) role and capacities of state and non-state actors *i.e.*, (i) line departments of the government at federal, provincial and district levels; (ii) civil society organizations (CSOs) & academia, (iii) community based organizations (CBOs); (iv) Corporate/private sector stakeholders; (3) practice and performance system *i.e.,* implementation and compliance monitoring (Kartodihardjo et al., 2013). It was classified into six governance components (GCs) *i.e.*, GC-1 to GC-6 and a set of six (06) novel climate response principles (CPs) of governance (Figure 2) for CCD process and response strategies were formulated for these components. The climate response principles were set into the analysis model along-with World Bank's six principles of good governance (Figure 2); with their two hundred eighty one (281) composite indicators against nine (09) CCD criteria (Table 1 & Figure 2) for energy sector. Cause and effect analysis was done on flip charts for determining all the variables and their applicability as well as the cross-sectoral linkage through direct and indirect means and different scenarios related to CCD for energy sector. These tools (Dey, 2012; Norris et al., 2012; Serrat, 2017) are very widely and centrally practiced for scenario/situation based learning by all kind of stakeholders concerned with the agenda of policy governance and planning segments, and consultation session is a suitable way to effectively use them (Hovland, 2005). Table 1 illustrates the screening and evaluation process of nine criteria for their suitability and relevance to four different CCD segments. Simple multi-attribute rating technique (SMART) was used with ratio scale (*i.e.,* 0=Not applicable or no response yet, 0.01 to 1.95=Very Poor, 2.00 to 3.95=Poor, 4.00 to 4.95=Considerable, 5.00 to 5.95=Fair, 6.00 to 7.45=Good, 7.50 to 8.95=Very Good, 9.00 to 10.0=Excellent), for scoring and weighting the criteria against the indicators. SMART is widely practiced MCDA technique (Edwards, 1977; Gärtner et al., 2008; Blechinger & Shah, 2011; Leskinen & Kangas, 2005) and seemed very suitable for this model. A multi-variables coding system was developed and used to distinguish different sets of variables *viz*-a-*viz* governance components, principles, criteria and indicators. A pre-test exercise was carried out at Islamabad for weighting, normalization and validation of indicators.

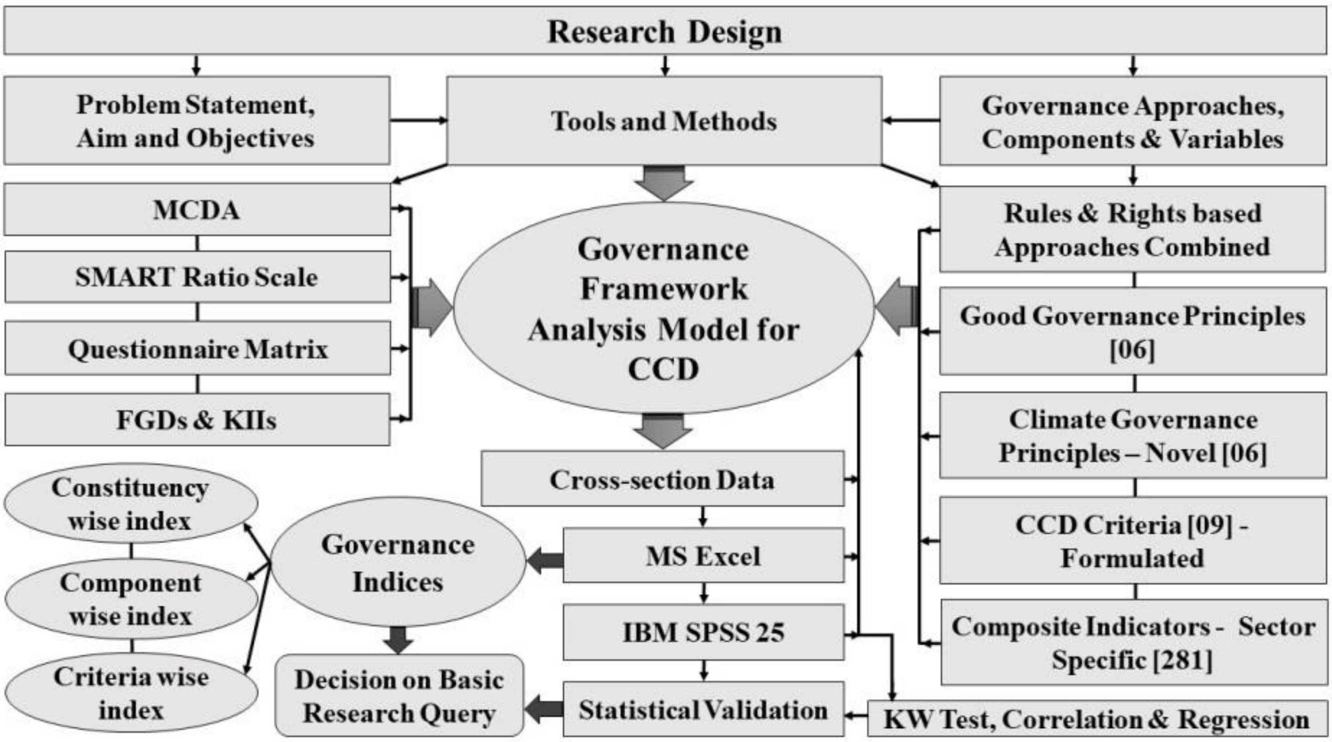

FIGURE 1
STUDY DESIGN AND METHODOLOGICAL STEPS (SOURCE: PHD DISSERTATION OF FIRST AUTHOR)

Table 1
SCREENED & EVALUATED CCD COMPONENTS (WITH DIRECT & INDIRECT LINKAGE)

#	Criteria at Federal, Provincial and District Levels for CCD	Screening of CCD Components			
		Adaptation	Mitigation	Low Carbon Development	Resilience
1	Disaster Risk Reduction (DRR), Vulnerability & Spatial Mapping (C-1)	√			√
2	Regulation of Rights (C-2)	√	√	√	√
3	Climate Smart Practices (C-3)	√	√	√	√
4	Technological Innovation (C-4)	√	√	√	√
5	Climate Organization (C-5)	√	√	√	√
6	Institutional Effectiveness (C-6)	√	√	√	√
7	Climate Infrastructure (C-7)	√	√	√	√
8	Sectoral Nexus (C-8)	√	√	√	√
9	Sustainability (C-9)	√	√	√	√

Source: PhD dissertation of first author

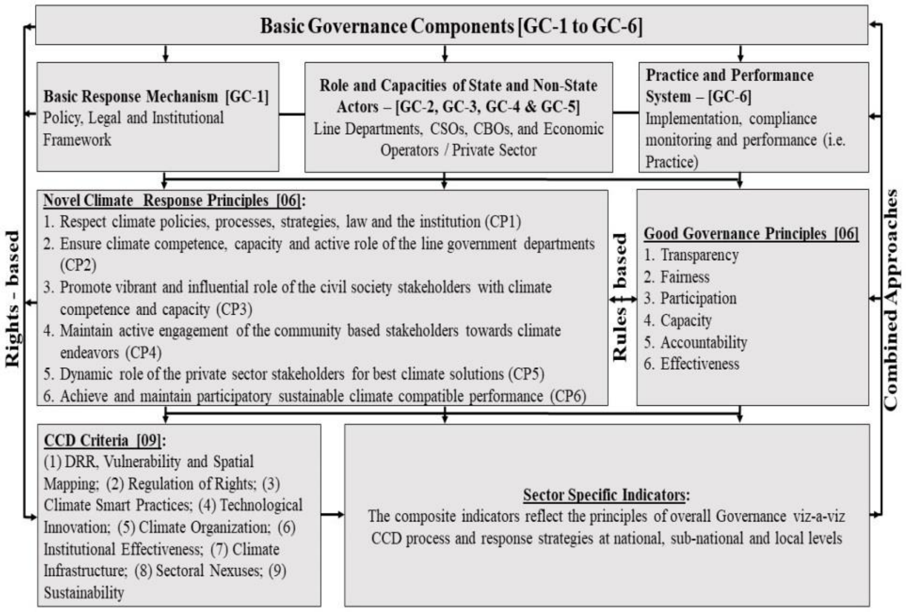

FIGURE 2
INNOVATIVE MULTIVARIATE GOVERNANCE MODEL FOR CCD (SOURCE: PHD DISSERTATION OF FIRST AUTHOR)

Primary Data Planning and Collection Procedure

A scoring matrix (Table 2) was prepared with a ratio scale (0 to 10) for Simple Multi-attribute Rating Technique (SMART) of Multi-criteria Decision Analysis (MCDA) Method and utilizing the applicable set of composite indicators of energy governance. SMART is a well-established technique used for MCDA in social and management sciences as well in decision sciences (Hassan et al., 2019). Sampling plan was consisted of two important segments *i.e.*, (1) geographical boundaries and (2) the size of the sample against which key informant interviews (KIIs) and focus group discussion sessions were conducted. Purposive sampling was done for different constituencies *i.e.*, at national (federal), sub-national (provincial) and local (district) level. Seven (07) federal and provincial capitals along-with 10 districts (Swat, Mansehra, Bahawalpur, Rajanpur, Sanghar, Badin, Jhal Magsi, Khuzdar, Muzaffarabad & Ghizer) were selected for taking the responses from relevant stakeholder's representatives. The selection of districts was carefully done by taking into account the existing climate related projects and programmes by the government and other stakeholder organizations. A total stock of 357 observations for energy sector was taken at federal, provincial and district level, for which one FGD and 20 KIIs per location were conducted.

Table 2
TEMPLATE FOR UTILIZING INDICATOR SETS AS QUESTIONNAIRE/SCORING MATRIX

Applicable Code	**Principle and CCD Criteria based Composite Indicators**	**Name of Respondent for KII:**							
		Gender: Male Female **Constituency:**							
		SMART Scoring with Ratio Scale							
		Not applicable or no response yet	Very Poor	Poor	Considerable	Fair	Good	Very Good	Excellent
		(Score 0)	(0.01 to 1.95)	(2.00 to 3.95)	(4.00 to 4.95)	(5.00 to 5.95)	(6.00 to 7.45)	(7.50 to 8.95)	(9.00 to 10.0)
		Corresponding Score in Percentage							
		0	**Jan-19**	**20-39**	**40-49**	**50-59**	**60-74**	**75-89**	**90-100**

Source: PhD dissertation of first author

Primary Data Handling and Analysis

Computer software 'IBM SPSS Statistics 25' and 'Microsoft Excel 2013' were utilized for data handling and analysis under the scope of this study. Excel was used effectively for entry, cleaning and classification of basic data, along-with data analysis for development of constituency, component and criteria wise governance indices and graphs for illustration purpose. 'IBM SPSS Statistics 25' was used for advanced statistical analysis, for which classified data sets in Excel 2013 were imported for the application of three different results validation tests with descriptive and graphical outputs. These tests included non-parametric Kruskal-Wallis (KW) hypothesis or H-test, Pearson Correlation and Regression. KW test was run with asymptotic significances against the significance level of '0.05', in order to characterize the sample groups variables constituency and gender wise prior to indicate whether the samples are dominating one way or the other way stochastically. It helped to cross-check differences in overall population responses at different level of the governance arrangements (*i.e.,* federal, provincial and district level) and authenticate the originality of the sample data with the existence of diverse trends on a ratio scale and at different level of the governance mechanism for climate compatible development in Pakistan. Earlier, a wider practice of KW test was found on datasets with ordinal scale (Atif et al., 2018). 1-tailed Pearson correlation analysis, by using 'IBM SPSS Statistics 25', helped in understanding the relationship, impact and interlocking of different governance variables on each other thus depicted a clear picture of complex interdependence for CCD agenda in energy sector of Pakistan. Multivariate Linear Regression, by using 'IBM SPSS Statistics 25' was intended to examine the mathematical relationship or association between the dependent and the grouping variables, and to validate the results of different parts of the study.

RESULTS

Tables 3 and 4 show overall and criteria wise governance indices respectively for CCD response in energy sector of Pakistan. Figure 3 provides a graphical overview of governance index *viz*-a-*viz* its components. Figure 4 shows component wise Governance Index on a clustered bar chart, Figure 5 forms radar for the distances against governance index and figure 6 shows overall index for CCD Response at federal and provincial level. Figure 7 shows overall index at district level.

Overall results depict GC1 index scores 8.50, 5.17, and 2.31 with an average score 5.33; GC2 index scores 6.78, 4.60, and 2.17 with an average score 4.52; GC3 index scores 6.55, 2.57, and 1.22 with an average score 3.45; GC4 index scores 2.06, 1.55, and 0.92 with an average score 1.51; GC5 index scores 4.89, 2.97, and 1.35 with an average score 3.07; GC6 index scores 6.24, 4.64, and 2.26 with an average score 4.38; and constituency wise average scores 5.84, 3.59, and 1.71 at federal, provinces and districts levels respectively. The overall average governance index score is 3.71 for energy sector in Pakistan.

Regarding statistical validation, Tables 5 and 6 provide summaries of constituency and gender based KW Hypothesis tests respectively for overall sample in energy sector, for which asymptotic significances are displayed with their respective significance level of 0.05 (against N=357) where null hypothesis is rejected for all the cases except of GC4 for gender based test. Null hypothesis is retained regarding the observations of the respondents for the capacity of community based stakeholders which is be due to poor capacity exists and reported on the same pattern particularly in Balochistan districts and also in other provinces' districts. However, the overall test result authenticates the observations and depicts different responses from majority of respondents at federal, provincial and district levels.

Pearson correlations with significance at the 0.01 level (1-tailed) are shown in Table 7 and Figure 8 that indicate a good correlation among various components of the governance.

Whereas; descriptive statistics of multivariate Regression analysis for overall sample of energy sector are shown in Tables 8 to 11 while Figure 9 shows normal P-P Plot and Figure 10 shows scatter plot of Regression standardized residual for overall sample in energy sector. GC6 was used as dependent variable. The values of R and R Square are 0.950 and 0.902 respectively. Coefficients of T-test show significant relationship of GC6 with GC1, GC2, GC4 and GC5 (with values below ±2). However, 0.043 and 0.057 tolerance (*i.e.*, below 0.10) and 23.320 and 17.619 VIF (*i.e.*, above 10) values are not supporting the significant relationships between GC6, GC1 and GC2; despite all components have shown a very good zero-order correlations with GC6.

The normal P-P plot shows a reasonably higher degree of deviations in its upward and downward fluctuations. The scatter plot also shows 14 different small groups but overall it is showing good results within the ±3 boundaries. These groups are indicative of different responses at federal, provincial and districts levels. Though all components of the governance are impacting each-other but as a whole the null hypothesis of the basic research question can't be rejected. So, it indicates so far the absence of a proactive and inclusive response mechanism to govern climate compatible development in energy sector at Federal, Provincial and Districts levels in Pakistan for its environmental security.

Table 3
OVERALL GOVERNANCE INDEX FOR CCD RESPONSE IN ENERGY SECTOR

#	Governance Component	Constituency wise Index Score			
		Federal	Provinces	Districts	Average
1	Policy, Legal and Institutional Arrangements (GC-1)	8.5	5.17	2.31	5.33
2	Capacity of Line Departments (GC-2)	6.78	4.6	2.17	4.52
3	Capacity of Civil Society Stakeholders (GC-3)	6.55	2.57	1.22	3.45
4	Capacity of Community Based Stakeholders (GC-4)	2.06	1.55	0.92	1.51
5	Capacity of Corporate Actors (GC-5)	4.89	2.97	1.35	3.07
6	Practice and Performance (GC-6)	6.24	4.64	2.26	4.38
	Overall Average	5.84	3.59	1.71	3.71

[**Scale:** 0=Not applicable or no response yet, 0.01 to 1.95=Very Poor, 2.00 to 3.95=Poor, 4.00 to 4.95=Considerable, 5.00 to 5.95=
Fair, 6.00 to 7.45=Good, 7.50 to 8.95=Very Good, 9.00 to 10.0=Excellent], (**Source:** PhD dissertation of first author)

Table 4
CRITERIA AND COMPONENT WISE GOVERNANCE INDEX FOR CCD RESPONSE IN ENERGY SECTOR

#	CCD Criteria	Criteria wise average Index Score					
		GC-1	GC-2	GC-3	GC-4	GC-5	GC-6
1	Disaster Risk Reduction, Vulnerability and Spatial Mapping (EC-1.1)	6.02	5.24	4	1.65	3.52	5.11
2	Regulation of Rights (EC-2.1)	4.05	3.24	2.21	1.4	1.49	2.61
3	Climate Smart Practices (EC-3.1)	5.9	4.99	3.83	1.58	3.53	4.96
4	Technological Innovation (EC-4.1)	5.85	4.94	3.82	1.59	3.51	4.9
5	Climate Organization (EC-5.1)	5.81	4.91	3.84	1.57	3.52	4.87
6	Institutional Effectiveness (EC-6.1)	5.85	5.09	3.83	1.59	3.52	5
7	Climate Infrastructure (EC-7.1)	5.64	4.93	3.83	1.56	3.52	4.9
8	Agriculture, Water and Energy Nexus (EC-8.1)	5.68	4.26	3.5	1.56	3.52	4.45
9	Sustainability (EC-9.1)	3.17	3.05	2.17	1.12	1.5	2.61
	Overall Average	5.33	4.52	3.45	1.51	3.07	4.38

Source: PhD dissertation of first author

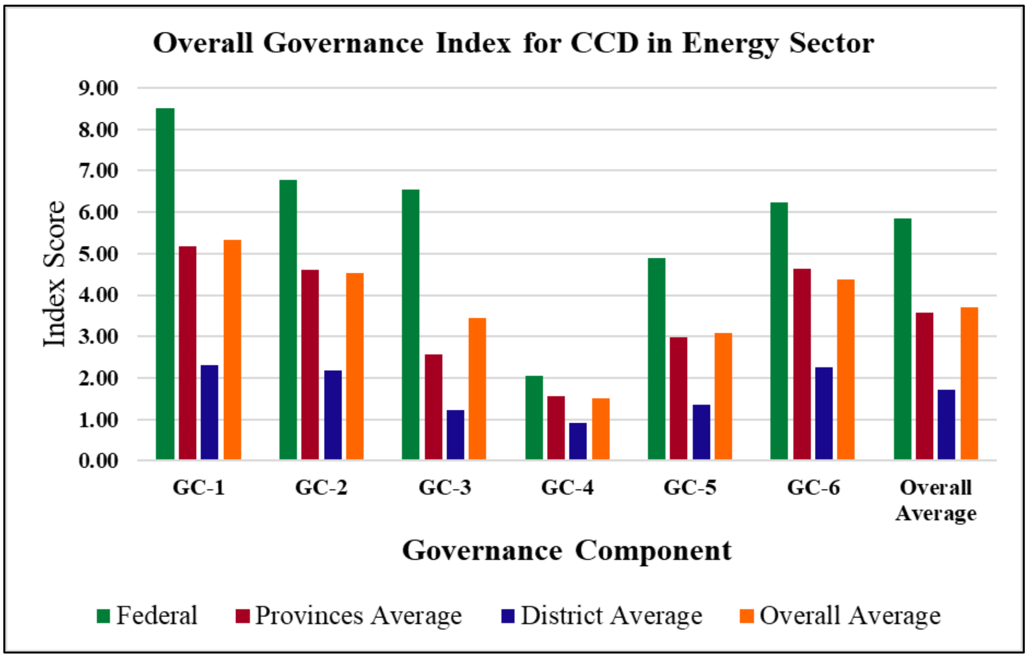

FIGURE 3
OVERALL GOVERNANCE INDEX FOR CCD RESPONSE IN ENERGY SECTOR

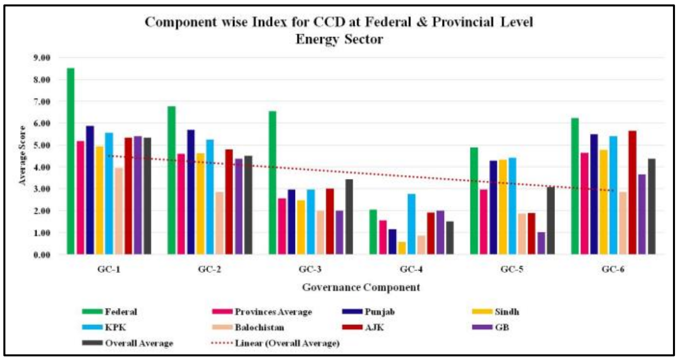

FIGURE 4
COMPONENT WISE GOVERNANCE INDEX FOR CCD RESPONSE AT FEDERAL & PROVINCE LEVEL

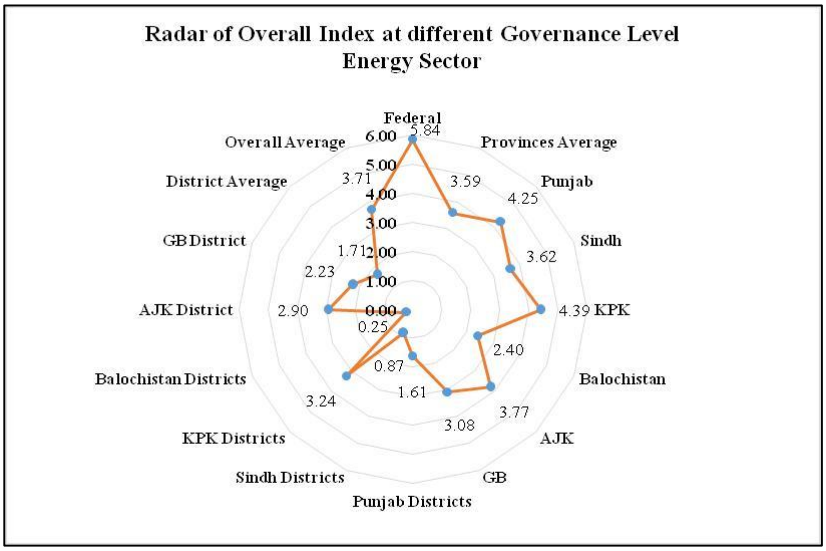

FIGURE 5
RADAR OF OVERALL INDEX FOR CCD RESPONSE AT DIFFERENT GOVERNANCE LEVEL

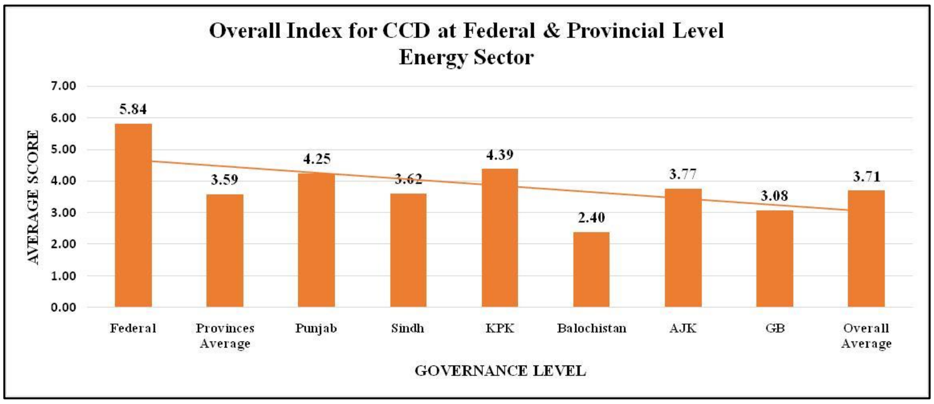

FIGURE 6
OVERALL GOVERNANCE INDEX FOR CCD RESPONSE AT FEDERAL & PROVINCIAL LEVEL

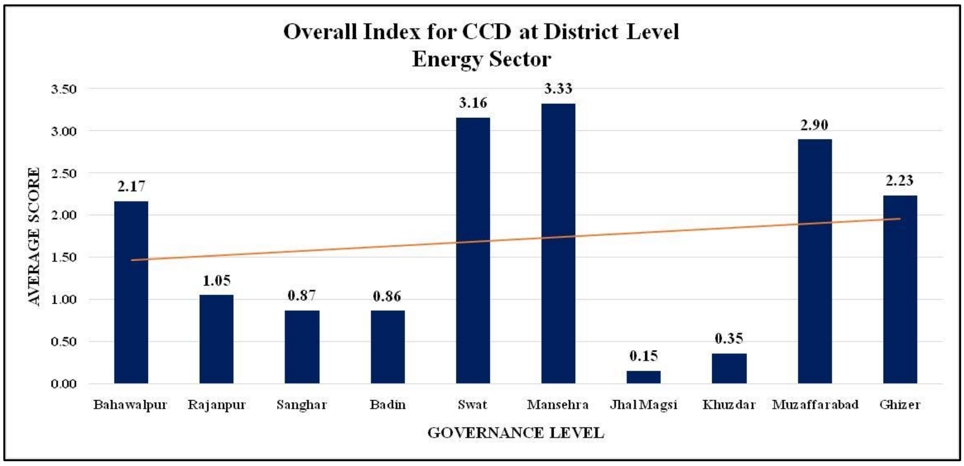

FIGURE 7
OVERALL GOVERNANCE INDEX FOR CCD RESPONSE AT DISTRICT LEVEL

Table 5
SUMMARY OF CONSTITUENCY BASED KW TEST FOR OVERALL SAMPLE IN ENERGY

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Policy, Legal and Institutional Arrangements is the same across categories of Constituency.	Independent-Samples Kruskal-Wallis Test	0.000	Reject the null hypothesis.
2	The distribution of Capacity of Line Departments is the same across categories of Constituency.	Independent-Samples Kruskal-Wallis Test	0.000	Reject the null hypothesis.
3	The distribution of Capacity of Civil Society Stakeholders is the same across categories of Constituency.	Independent-Samples Kruskal-Wallis Test	0.000	Reject the null hypothesis.
4	The distribution of Capacity of Community Based Stakeholders is the same across categories of Constituency.	Independent-Samples Kruskal-Wallis Test	0.000	Reject the null hypothesis.
5	The distribution of Capacity of Corporate Actors is the same across categories of Constituency.	Independent-Samples Kruskal-Wallis Test	0.000	Reject the null hypothesis.
6	The distribution of Practice and Performance is the same across categories of Constituency.	Independent-Samples Kruskal-Wallis Test	0.000	Reject the null hypothesis.
Asymptotic significances are displayed. The significance level is 0.05. N=357				

Table 6
SUMMARY OF GENDER BASED KW TEST FOR OVERALL SAMPLE IN ENERGY SECTOR

Hypothesis Test Summary

	Null Hypothesis	Test	Sig.	Decision
1	The distribution of Policy, Legal and Institutional Arrangements is the same across categories of Gender.	Independent-Samples Kruskal-Wallis Test	0.005	Reject the null hypothesis.
2	The distribution of Capacity of Line Departments is the same across categories of Gender.	Independent-Samples Kruskal-Wallis Test	0.010	Reject the null hypothesis.
3	The distribution of Capacity of Civil Society Stakeholders is the same across categories of Gender.	Independent-Samples Kruskal-Wallis Test	0.004	Reject the null hypothesis.
4	The distribution of Capacity of Community Based Stakeholders is the same across categories of Gender.	Independent-Samples Kruskal-Wallis Test	0.075	Retain the null hypothesis.
5	The distribution of Capacity of Corporate Actors is the same across categories of Gender.	Independent-Samples Kruskal-Wallis Test	0.005	Reject the null hypothesis.
6	The distribution of Practice and Performance is the same across categories of Gender.	Independent-Samples Kruskal-Wallis Test	0.002	Reject the null hypothesis.
Asymptotic significances are displayed. The significance level is 0.05. N=357				

Table 7
GOVERNANCE'S COMPONENT WISE CORRELATIONS FOR CCD IN ENERGY SECTOR

Correlations							
		GC1	**GC2**	**GC3**	**GC4**	**GC5**	**GC6**
GC1	Pearson Correlation	1					
GC2	Pearson Correlation	0.969**	1				
GC3	Pearson Correlation	0.868**	0.832**	1			
GC4	Pearson Correlation	0.706**	0.662**	0.626**	1		
GC5	Pearson Correlation	0.739**	0.740**	0.800**	0.558**	1	
GC6	Pearson Correlation	0.901**	0.926**	0.797**	0.741**	0.775**	1

**. Correlation is significant at the 0.01 level (1-tailed).

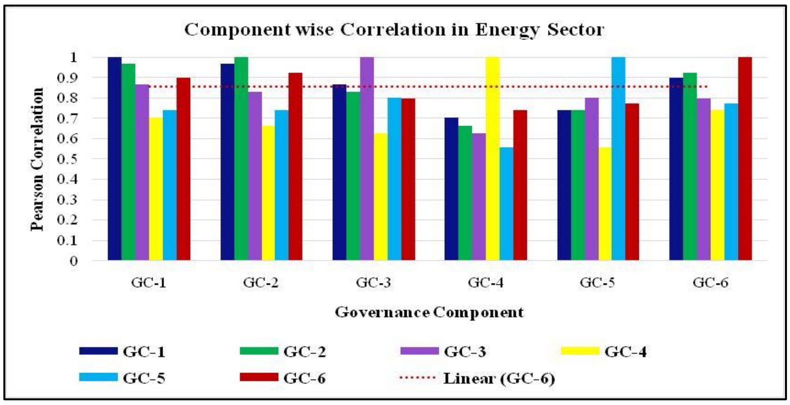

FIGURE 1
COMPONENT WISE PEARSON CORRELATIONS FOR CCD IN ENERGY SECTOR

Table 8
REGRESSION MODEL SUMMARY FOR OVERALL SAMPLE OF ENERGY SECTOR

Model Summary[b]				
Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**
1	0.950[a]	0.902	0.900	0.64510

a. Predictors: (Constant), Capacity of Corporate Actors, Capacity of Community Based Stakeholders, Capacity of Civil Society Stakeholders, Policy, Legal and Institutional Arrangements, Capacity of Line Departments

b. Dependent Variable: Practice and Performance

Table 9
ANOVA SUMMARY FOR OVERALL SAMPLE OF ENERGY SECTOR

ANOVA[a]						
Model		**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
1	Regression	1341.339	5	268.268	644.641	.000[b]
	Residual	146.069	351	.416		
	Total	1487.408	356			

a. Dependent Variable: Practice and Performance

b. Predictors: (Constant), Capacity of Corporate Actors, Capacity of Community Based Stakeholders, Capacity of Civil Society Stakeholders, Policy, Legal and Institutional Arrangements, Capacity of Line Departments

Table 10
SUMMARY OF REGRESSION COEFFICIENTS FOR OVERALL SAMPLE OF ENERGY SECTOR

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations	Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Tolerance	VIF
1	(Constant)	-0.267	0.074		-3.586	0.000			
	GC1	-0.184	0.073	-0.203	-2.511	0.012	0.901	0.043	23.320
	GC2	0.963	0.079	0.861	12.259	0.000	0.926	0.057	17.619
	GC3	-0.057	0.053	-0.042	-1.073	0.284	0.797	0.185	5.395
	GC4	0.548	0.056	0.234	9.764	0.000	0.741	0.488	2.048
	GC5	0.257	0.039	0.191	6.601	0.000	0.775	0.334	2.994

a. Dependent Variable: GC6

Table 11
REGRESSION'S RESIDUAL STATISTICS FOR OVERALL SAMPLE OF ENERGY SECTOR

Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	0.5215	6.8444	3.3325	1.94108	357
Residual	-1.06667	1.61972	0.00000	0.64055	357
Std. Predicted Value	-1.448	1.809	0.000	1.000	357
Std. Residual	-1.653	2.511	0.000	0.993	357

a. Dependent Variable: Practice and Performance

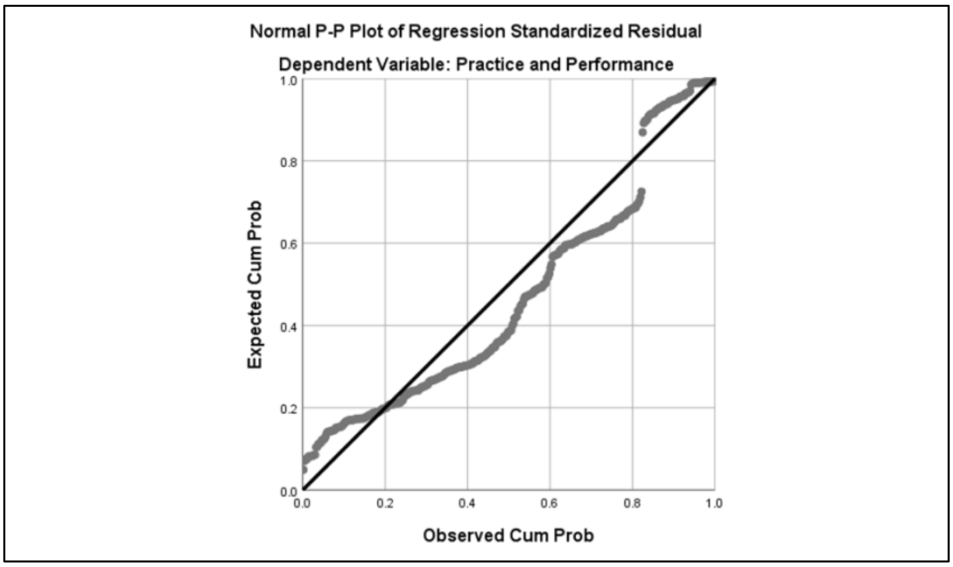

FIGURE 9
NORMAL P-P PLOT OF REGRESSION STANDARDIZED RESIDUAL FOR OVERALL SAMPLE IN ENERGY SECTOR

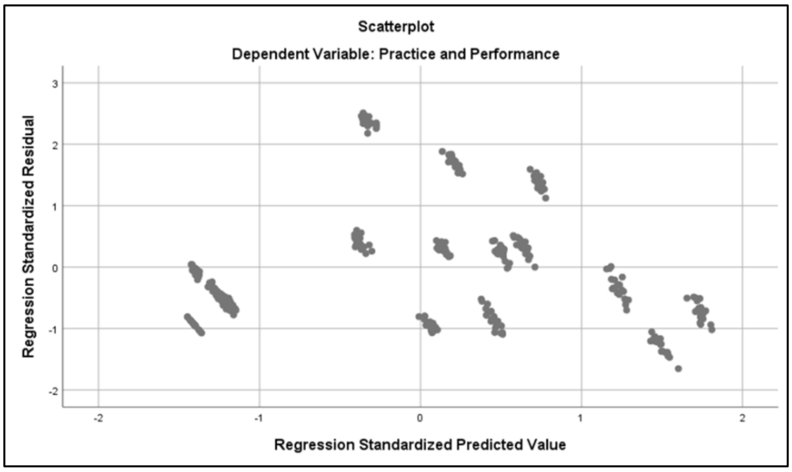

FIGURE 10
SCATTER PLOT OF REGRESSION STANDARDIZED RESIDUAL FOR OVERALL SAMPLE IN ENERGY SECTOR

The results also support the initial problem diagnosis according to which the policies, strategies and institutional arrangements are on advance stage at federal level. National level documents include National Climate Change Policy (GoP, 2012), Framework for Implementation of Climate Change Policy (FICCP) of Pakistan (GoP, 2014), energy related policies including renewables (AEDB, 2019; GoP, 2015) and work programme document for climate response actions (GoP, 2014a). But the majority of provincial cases are lagging far behind towards it. However, the stock-taking survey and analytical review of federal level documentation, legal instruments and climate response strategies depict a number of parallel developments and contents' overlap in among documents causing distortion, confusion and conflict. For example, the contents of 'Work Programme for Climate Change Adaptations and Mitigation in Pakistan: Priority Actions 2014' and FICCP documents by the Government of Pakistan have massive overlap regarding strategies and defined actions (GoP, 2014); thus, caused duplication of efforts by different stakeholders and utilization of available resources can be considered irrational. Whereas, sectoral ownership also remained a decades old major challenge in the governance system of Pakistan, for which capacity of the line department is an obvious and integral part of overall governance mechanism.

DISCUSSION

Innovative Multivariate Energy Governance Model and Open Innovation concept

Role of the Multivariate Model for Goevrnnance Analysis of Energy Sector

With the growing concern of the global warming due to substantial increase of CO2 concentrations in the Earth's atmosphere. The "climate mitigation and low carbon strategies" emphasize on energy efficiency and management. In the late 1980s, EU had contributed significant reduction in GHG emissions across the world. But, a dire need for the sustainable and renewable energy sources has been predicted for a long time. For SDG7, the SDG Report 2020 underlines the importance of scaling up sustainable energy on mass scale considering the fact that a worldwide population of 789 million human-being is living without electricity and 1 out of every 4 basic health facilities was not electrified in some developing countries in the year 2018. Efforts are needed to accelerate the use of modern renewables. This would help in increasing the share of renewable energy that reached to 17% in total energy consumptions in year 2017, up from 17% in year 2015 and 16.3% in year 2010. Whereas, the renewables are still lagging far behind the potential in order to complement towards the energy end-use in transportation and heat sectors which accounts for 80% of final consumption of the energy. Annual energy efficiency improvement rate felled down to 1.7% in 2017 against the SDG's target at the rate of 3% per annum from now to 2030. The SDG target is quite a challenging proposition but it is crucial to reduce GHG emissions to a certain limit. 1.7% in 2017 was a relatively improved figure from the year 2016 but the lowest since 2010. A 2.2% annual energy efficiency progress was observed from 2010 to 2017 which was the ever sustained trend in the history. The SDG Report 2020 also indicates that the rising level in fossil fuel subsidies, from US$ 318 billion in 2015 to US$427 billion in 2018, are contrary to the promotion of renewables and climate mitigation strategies. The costs of RE are still higher than already existing energy prices but competitive RE technologies are already competing (Statistics Division, 2020).

Pakistan is facing various energy supply challenges due to fast-growing energy demand, the high price of energy imports, poor grants on energy resources, rapid population growth & expanding industrialization. A large number of rural areas of Pakistan still lack electric supply thus depend upon conventional in-efficient methods of fire-wood, wastes of plants and animals to meet their day-to-day energy need. While, the climate change has cascading effect on energy security *viz*-a-*viz* water availability, agriculture and marine ecosystem services including the offshore and onshore RE development at a global, regional, sub-regional and national scale, and there is interplay between various segments of the land based and marine economy due to a very strong and complex interdependence between the two. This interplay is particularly important in the context of energy, water and agriculture sectors; particularly in responding climatic extreme events for disaster risk reduction, reducing GHG emissions and ensuring overall sustainability by employing the climate compatible development philosophy. CCD agenda for energy, water and agriculture sectors has very strong linkages due to complex interdependence among them, in the case of Pakistan.

According to Pakistan Economic Survey 2019-20, Pakistan is on way to overcome the crisis of energy, by increasing its capacity towards energy generation and supply system (GoP, 2020). Still, there is a gap between supply and demand for which energy-mix low cost solutions would be improved with priority measures. Renewables' share had shown a trend of steady increase in recent past years but the current progress year under PES 2019-20 have surprising decline in it. Whereas; the INDC statement of Pakistan (UNFCCC, 2016) has a commitment of reducing its 2030 projected emissions up to 20% against the baseline of year 2015 and also provided an estimated cost of abatement *i.e.*, approximately 40 billion US Dollars (at the time of submission of INDC). This INDC has significant linkage with the energy and agriculture sectors *viz*-a-*viz* GHS emissions factor, and was expected to be driven along-side the 'Pakistan's Vision 2025' which was conceived as a policy shift instrument with an ambitious development roadmap up to 'the year 2025'. As mentioned in the INDC statement document of Pakistan, energy sector is the leading contributor towards country's GHGs emissions. The INDC statement highlighted that 123% increase in emissions is observed during the period of 1994-2015, whereas a steady rise of 300% was anticipated during the projected trajectory during the period of 2015 to 2030, in the backdrop of Vision 2025 including the development agenda under Belt and Road Initiative (BRI) and China Pakistan Economic Corridor (CPEC).

In this context, the results of this study reveal major governance gaps at federal, provincial and districts level in response strategies for climate compatible development in energy sector of Pakistan; as the basic research question is validated through a statistical procedure. Observations gathered through FGDs are also supporting the overall quantitative governance index. So far, the overall climate response level in Pakistan is still in readiness phase *i.e.,* within the boundaries of initial governance arrangements, which means Pakistan's climate response is yet limited to initial stage of developing policies, strategies and implementation arrangements. The climate response trend in Pakistan is more or less same to the global trends for the status of climate governance in developing countries, as reflected on page 51 of the "SDG Report 2020".

The federal level developments for CCD response under GC1 are very good. While, provinces have shown a fair response but results for the local context are not encouraging at districts level across Pakistan. After the 18th amendment in the national constitution of Pakistan, provinces have the liberty to develop their energy sources. There is also a liberty available to everybody to become independent power producer (IPP), particularly the net-metering window has created doorstep opportunity for harnessing the real potential of solar energy in Pakistan. The relevant federal policies and strategies have all the requisite material for CCD in energy sector. In a series of climate response, the "Clean Development Mechanism" (CDM) was launched in Pakistan in August 2005 with the establishment of CDM cell (Ghumman, 2007), and promotion of clean energy projects and energy efficiency were among the key objectives to reduce GHG emissions. Alternate Energy Development Board (AEDB) of Pakistan formulated its "Renewable Energy Policy" in 2006 to promote alternative and renewable energy and avoid dependence on imported fossil fuels (GoP, 2006). Pakistan's 'Renewable Energy Policy 2006' was the first ever instrument that aimed precisely to promote the renewables with a target of 10 percent contribution towards overall energy generation by the year 2015. The major focus was given to solar power, micro-hydel and wind power initiatives, and also provided incentives to RE based IPPs for selling the generated electricity to the grid in order to promote RE technologies. In the document of (Power Generation Policy, 2015), Government of Pakistan has also announced to enhance incentives and easy processing to meet the demand-supply gap in less time by a generation of electricity for the socioeconomic boost of the economy (GoP, 2015). The Government of Pakistan in its Vision 2025 also include RE technologies in the goals to curb the rise of GHGs in the atmosphere. 'Alternative and Renewable Energy Policy of Pakistan 2019' (the 'ARE Policy 2019') is an improved version of "Renewable Energy Policy 2006". Pakistan has set two targets *i.e.*, 20% and 30% contribution of renewables by the years 2025 and 2030 respectively, towards overall energy generation. It is anticipated to be the environmental sound, affordable and easily accessible solution for the masses. It encourages both the investors and the consumers (AEDB, 2019).

The role of government in the growth of renewable energy technologies is very important in any state. Renewable energy has also created a large number of jobs in the world. The National Climate Change Policy of Pakistan (GoP, 2012) also provides a commitment to the climate change mitigation by giving preference to the Renewable Energy sources. It committed to promote the deployment of hydropower generation; stimulate the growth of renewable energy technologies; encourage installation of solar panels on rooftops of building and install more power plants for the power production from the municipal waste. Subsequently, Framework for Implementation of Climate Change Policy of Pakistan (FICCP) further provides strategies & actions for the promotion of RE technologies in order to curb the GHG emissions (GoP, 2014). These strategies include: preference to the promotion of hydropower projects; encourage more RE technologies; install more power plants to produce power from the municipal waste; provide incentives for the actions needed for the energy mix from fossil fuels to low carbon fuels. On the same trends, onshore and offshore energy resources come mostly under the scope of renewable and clean energy which is particularly important segment for climate compatible development and meeting the targets of clean and affordable energy for all (SDG7) under SDGs regime.

Governments are executing such policies which stimulate the utilization of renewable energy sources & technologies globally (Sweetnam et al., 2013). A number of policy instruments are widely practiced worldwide in order to promote RE development. These instruments include Net Metering, grants and rebates, 'Distributed Generation Measures and Disclosure', Tax credits, Feed-in-tariff (FIT), 'Renewables Portfolio Standards (RPS)', 'Green Marketing Measures', competitive tenders & auctions, tradable renewable energy credits, and other economics related tools etc. (UNEP, 2011). Currently, FIT instruments are observed on a wider scale *viz*-a-*viz* practice across the globe and are very particular in the developing nations (REN21, 2011). In addition to the introduction of net-metering policies, Pakistan has also adopted FITs in order to promote RE technologies. FITs in Pakistan could be one of the effective policy instrument to enhance the deployment of RE sources *i.e.*, solar, wind and micro-hydel energy. Although, Pakistan is striving hard to attain rapid growth in the renewable energy sources, but still facing some hindrance in achieving FIT policies in Pakistan. The insecurity elements for FITs revolves around high costs of capital investment, investors and consumers interests. The major challenges being faced by FITs in Pakistan include: financial barriers, lack of competition, institutional barriers, lack of technology access. If the FIT would be set high by NEPRA, it will benefit the investors but the consumers would be suffered from high costs of RE. Likewise, if the FIT would be set to lower rate, then the consumers will be deriving benefits but the investors would have to bear high capital investment cost. These challenges reduce the FIT framework applicability in Pakistan.

Overall, the method is very much effective but it has limitations of time consuming process due to large datasets and scoring required for a big set of indicators in national, sub-national and local context to develop comprehensive outlook of energy governance in a country. It can be overcome by undertaking partial studies for different governance components *i.e.*, GC1 to GC6, for which this model is equally beneficial.

In this context, this paper extracted from a comprehensive study aimed at developing governance indices for assessing adequacy of overall state of energy governance for CCD. Empirical results provide baseline and decipher that country's climate response towards energy governance is in readiness phase and the null hypothesis of basic research question retained. It indicates lack of political will, inadequate fiscal resources, overlapping policy instruments and their implementation problem, coordination issues between constituencies after 18th amendment in national Constitution and actor's capacity gaps as key limiting factors, and suggests a way forward.

It also discusses the implications for *n*-triple helix concept of open innovations to allow multi-sectors and multi-actors along-with different governance approaches for creating an ecosystem of climate compatible development.

Implications for the Open Innovation Concept

The detailed modification of the proposed model for energy governance on the basis of open innovation engineering fundamental approach could be a topic for a further research. Additionally, the approach of Christensen's determinants of the open innovation model (Christensen, Olesen & Kjær, 2005) should be taken into account. His approach is associated with the industrial dynamics of an industry segment undergoing a process of radical technological innovation and unravels the Chesbrough's Open Innovation concept which was initially studied by from the company-level perspective (in contrary to the closed innovation old model). The fundamental theory was created by JinHyo Joseph Yun considering the open innovation engineering model including both open-innovation engineering channels and determining ways of operating the channels through conceptual experiments (Yun, Kim & Yan, 2020). The effects of mechanism design (fundamental to the study of incentives and information (Vohra, 2011) can be expanded and implemented for developing new business models from open innovation and Schumpeterian new combinations (Smith, 2010; Williams, 1996) as well as being an open-innovation-based business model design compass (Yun, 2017).

One of the most important issues to be considered is the fact that open innovations allow interacting people and organizations to create ecosystems. Chesbrough notes that the main trend in the development of open innovation is with regard to digital transformation (Bogers et al., 2019). It involves business models—the logic of creating and capturing value—that dynamically transcend organizational boundaries within that innovation ecosystem (Bogers, Chesbrough & Moedas, 2018). Clayton M. Christensen examined the complexity and inconsistency of innovation (Christensen et al., 2018).

The complexity of knowledge can be investigated using the quadruple-helix model (Carayannis & Campbell, 2009), which differs from the fundamental triple-helix model of innovation by adding a fourth helix (the "media-based and culture-based public") to "university–industry–government relations" (the three helices developed by Etzkowitz & Leydesdorff (Etzkowitz & Leydesdorff, 2000), generating a national innovation system: academia/universities, industry, and state/government. Leydesdorff explained that the metaphor of a triple-helix model could be considered as a basis for making extensions to the model to more than three helices (Leydesdorff, 2012). The abovementioned quadruple helix and the later suggested quintuple helix, being ecologically sensitive (Carayannis, Barth & Campbell, 2012), could be treated as universal and, in a wide sense, be extended to an *n*-tuple-helix model (Park, 2014).

The authors discuss the impact of the open innovation concept on developing energy governance mechanism on the basis of national innovation system and various helix models. The triple-helix model of basic response mechanism, actors' capacity and practice and performance system into a multi-helix (n-tuple helix) model by combining rules-based and rights-based approaches, involvement of multi-actors and multi-sectors; the most important factor needs to be considered for the open innovation concept in developing and promoting renewables to support energy governance system for creating an ecosystem for CCD.

CONCLUSION

The results of the study depict that the capacity of the line departments (GC2) is good at federal level while it is considerable at provinces but has more or less same position at districts level. The capacity of the civil society stakeholders (GC3) is good at federal level while there is a need to do a lot at provinces and districts levels across Pakistan. There is a major missing links found regarding the capacities of the line departments on developing a consensus between the provinces over the issue of Kalabagh Dam and other water reservoirs particularly for energy as well as agricultural purposes.

Capacities of the actors under GC4 and GC5 have shown a big disconnect from mainstream governance line as the index scores correspond poor to very poor situation from federal to district context. Overall situation for the case of Balochistan is quite discouraging. There is a major disconnect found between the federal level institutions and the community based stakeholders which is a very critical and limiting factor for CCD response strategies and needs to be dealt carefully so as to actively engage all relevant stakeholders; particularly for energy efficiency and management options. The provincial governments need to strengthen this important component of local governance; particularly for the role of the private sector contribution and enhance coordination between the federal, provincial and district level institutional arrangements. Capacity mapping exercises may be done by the federal and provincial governments so as to better plan against climate response requirements for the future. This would be instrumental in enhancing the performance through better practices under GC6.

Results under GC6 depict the major issues of sustainability and regulation of rights at the level of all constituencies across Pakistan. The protection of rights of stakeholder groups in energy sector involves various types of projects and locations. It has also an interplay and cross-sectoral linkage with water and agriculture sectors *viz*-a-*viz* riparian issues at provincial and international levels. There is a need to evolve joint water-shed management prior to use for renewable energy generation by safeguarding Pakistan's rights on transboundary waters at eastern and western rivers along-with developing provincial harmony over the riparian rights. But, there is a strong disconnect found between the planning and execution at all level. There are a number of good documents exist at federal and provincial level that can support the overall climate agenda in particular and CCD in general, but their implementation has major issue. On one hand there is an issue of fiscal resources while on the other hand lack of political will and desired level of capacities act as limiting factors. There was consensus among the experts of FGDs at all level that this situation was further aggravated soon after the promulgation of the 18th amendment in the national constitution of Pakistan. This amendment has led coordination issues between the federal and provincial institutions, due to which institutional effectiveness remained poor as depicted by the governance. It is a major challenge that was also validated during all the FGDs. Strong political commitment, capacity enhancement and allocation of sufficient fiscal resources were the important issues; opined, discussed and concluded during the FGDs in the context of attaining good performance at all tiers of energy governance mechanism in Pakistan. These would be instrumental in enhancing the performance through better practices under GC6. At the moment, GC6 is fair to good for all criteria in governance index in federal context while poor in provincial and districts contexts. This major grey area under practice and performance component (GC6) particularly at provincial and districts level entails the need to develop and implement provincial actionable climate response strategies with clearly defined roles and responsibilities for energy sector in Pakistan.

Above all, the allocation of sufficient financial resources is very much needed but a missing link at the moment, particularly for the mitigation segment for which federal and provincial governments need to address this issue in their budget planning and management cycle. This would be instrumental in ensuring the sustainability of all CCD criteria with a strong adherence to the novel climate principles which were developed as part of this study, under all components of the governance system for energy sector in Pakistan.

The innovative model proved well in producing governance indices for climate compatible development in energy sector in a comprehensive way. It covered all tiers of energy governance mechanism and statistically found significant. It can be used effectively for other segments of the sectoral economy, and its extended application would certainly support the assessment and improvement of governance for a low-carbon and resilient future. Based on the analysis of case study data, it is deciphered that the overall climate response level in energy sector of Pakistan is still in readiness phase *i.e.,* within the boundaries of initial governance arrangements. Its trends are similar to the global trends for the status of climate governance in developing countries, as reflected on page 51 of the 'SDGs Report of 2020'. The overall analysis and assessment has found several challenging governance gaps that exist at federal, provincial and districts level in response strategies for climate compatible development in energy sector of Pakistan. There is a strong disconnect found between the planning and execution which has rendered major grey areas under practice and performance component at all level. The sectoral ownership remained a decades old major challenge in the governance system of Pakistan, for which capacity of the line department is an obvious and integral part of overall governance mechanism. CCD agenda for energy, water and agriculture sectors has very strong linkages due to complex interdependence among them in Pakistan. There are missing links found regarding the capacities of line departments particularly on the aspect of cascading effect of climate change on energy security *viz*-a-*viz* water availability, agriculture and marine ecosystem services. It has generated a major challenge for the sustainability of overall mechanism and regulation of rights at level of all constituencies across Pakistan, and the overall situation for the case of Balochistan is quite discouraging. There are a number of good instruments exist at federal and provincial level that can support the overall climate agenda in particular and CCD in general, but their implementation is a major challenge. A number of parallel developments and contents' overlap amongst documents also cause distortion, confusion and conflict. The success of FICCP has a very strong linkage with governance arrangements at provincial and district levels. Availability of fiscal resources is not the only issue but lack of political will and desired level of actors' capacities also act as limiting factors. This situation aggravated after promulgation of the 18th amendment in the constitution of Pakistan after which coordination issues between federal and provincial institutions rendered major challenges thus institutional effectiveness remained poor as depicted by the governance index and also validated during all FGDs.

Finally, this study rationalizes the application of multi-helix energy governance model as an open innovation concept in developing and promoting renewables to support energy governance system for creating an ecosystem for CCD.

AUTHORS' CONTRIBUTIONS

All the authors contributed substantially to the entire work reported in this paper. They read and approved the final manuscript, which was extracted from a novel and original research dissertation of the first author submitted to International Islamic University Islamabad for partial fulfillment of his PhD degree.

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CONFLICTS OF INTEREST

The authors confirm that there is no conflict of interests to declare for this publication.

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