

Towards environmental sustainability: Exploring the nexus among ISO 14001, governance indicators and green economy in Pakistan

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Abstract

The green growth paradigm has gained much attention in the last decade. Green growth not only protects the environment and human beings but also serves as a substitute for scarce natural assets. Governance institutions develop laws and policies for all industries in a country and are directly responsible for natural resource exploration and environmental protection or destruction. Pakistan is the fifth most vulnerable country to environmental hazards in the world. To address this issue, this study is the first to analyze the relations among governance indicators, ISO 14001 and green growth in Pakistan by using time-series data from 2000 to 2017. The study utilized advanced mathematical Grey Relational Analysis (GRA) models, namely, absolute grey relational grade (GRG), Deng's GRG, and Second Synthetic Degree of Grey Incidence Analysis (SSGIG) models, to capture the relations among the studied variables. The main results revealed that ISO 14001, with the highest GRA values of 0.8-0.9, proved to be effective in channeling green growth. Among all governance indicators related to green growth, the rule of law with the highest maximin criterion value of 0.644 was found to play a key role for Pakistan. The study findings provide insights into how good governance can contribute to accomplishing the objectives of environmental sustainability. They can also help legislators and organizations understand the importance of ISO 14001 certification to promote sustainable practices across sectors in Pakistan.

Keywords: Environmental Sustainability; Governance indicators, ISO 14001, Green Growth; Pakistan; Grey Relational Analysis models.

Nomenclature

Symbol	**Description**
$\boldsymbol{\delta_0}$ and $\boldsymbol{\delta_i}$	Two datasets
$\boldsymbol{\varsigma}$	the distinctive coefficient
$\boldsymbol{\mathcal{M}}$	maximum differences
$\boldsymbol{m}$	minimum differences
$\boldsymbol{\lambda_{0i}(\mathcal{L})}$	Grey incidence coefficient
$\sum \boldsymbol{w\ell}$	number of weights which should be equal to 1
$\frac{1}{n}$	depiction of equally distributed weighting criteria

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$\boldsymbol{w_k}$	weighting scheme that is unequally distributed and depicts realistic problems or challenging dilemma
$\boldsymbol{\delta_0}$, and $\boldsymbol{\delta_1}$	two different time intervals
$\boldsymbol{\xi_{01}}$	absolute degree of grey incidence
$\boldsymbol{\delta_i}$ and $\boldsymbol{\delta_j}$	data sequence of system behavior, or Zero starting points image
$\boldsymbol{C}$	a point operator starting from zero
$\boldsymbol{\delta_i C}$	zero-scale point image of δ_i. δ_i
$\boldsymbol{\delta_i^0 \, and \, \delta_j^0}$	the variables length of δ_i and δ_j
$\boldsymbol{\rho_{ij}}$	Second synthetic degree of grey relation (SSGRG)
$\boldsymbol{\Theta\eta_{ij}}$	Absolute Grey Relational Grade (Absolute GRG)
$\boldsymbol{\omega_{ij}}$	Deng's Grey Relational Grade (Deng's GRG).

1. Introduction

Environmental concerns are not confined to a specific area, region, or nation, but all fields, such as politics, economy, culture, and society and the intellectual aspects of human life, are vulnerable to environmental changes. Climate crises are witnessed in both developed and developing countries. Thus, political and social chaos and inadequate governance arising from severe inequality are some of the current challenges to overcome (Wang et al., 2018). Global attention to environmental issues is crucial, as the environment will only deteriorate over time due to the major changes in ecological and climate structures accompanying climate change. As a result of such environmental shifts, society becomes vulnerable to environmental and social hazards that produce lasting impacts on human lives (Durán-Romero et al., 2020).

The World Bank first used the word 'good governance' in 1989 (Rimmer, 1990). A variety of indicators to measure governance have since been developed, including the World Governance Indicators (WGI), which considers six aspects of a country's governance. These six governance indicators are regulatory quality, the rule of law, voice and accountability, the control of corruption, political stability and government effectiveness (Huang and Ho, 2017).

In recent years, green growth has emerged as one of the alternative paths of development that blends and incorporates environmental goals with economic and social goals. Green growth is defined as growth that preserves environmental quality and ecological status (Michael et al., 2014). Green growth is effective in utilizing environmental assets that reduce pollution and decrease environmental impact and often refers to the concept of low-carbon development or the preservation and conservation of the environment (Barbier, 2016; Ikram et al., 2021).

Environmental management systems (EMSs) help a company evaluate and track environmental issues with a systematic approach (Ashrafi, 2012). Previous studies have shown that accredited EMSs lead to superior environmental engagement, accountability and integrity (Clare et al., 2019). The ISO 14001 certification, which started in 1996 (updated in 2004 and 2015) (Omri and Hadj, 2020), has emerged as the most commonly used EMS worldwide. Huang and Ho (2017) reported that ISO 14001 accredited companies could reduce harmful emissions. In his research findings, Halis (2016) showed that the implementation of EMSs is positively associated with environmental performance.

This study links the dynamic concept of green growth with governance and ISO 14001. Bryant and Biley (1997) argued that the government structure is a source of environmental degradation in some (developed and developing) countries. Bhaskara et al., (2010) emphasized the significance of governance for environmental sustainability and the optimal utilization of sustainable resources. Salahodjaev (2015) argued that globalization, democracy and government structure are potential antecedents of environmental sustainability. Governance aspects can also pave the way for environmental protection and conservation (Bhattarai and Hammig, 2001). Governments are regarded as key players in implementing and pursuing environmental goals at the regional and international levels.

Pakistan's governance problems are extreme and troubling. The 2015 Worldwide Governance Report rated Pakistan the lowest among South Asian countries in all six governance dimensions. Pakistan reached the 21.6^{th} percentile rank in 2015, following the political transition in 2013 (WGI Report, 2015; Faisal, 2017). After a political shift in 2017, improvements were observed in the governance system, and currently, Pakistan stands at the 26.9^{th} percentile rank (WGI Report, 2018). Javaid (2010) considered corruption to be a significant cause of the poor governance in Pakistan that not only damaged the economy but also undermined the development of projects in various industries. The trend of various governance indicators in Pakistan are shown in Figure 1.

Tamazian and Bhaskara (2010) stated that governance has a significant role in protecting the environment. They further confirmed the effectiveness of good governance in maintaining resource utilization. There are few studies that consider the government to be a key player in the protection of the national or global environment (Danish et al., 2019). Moreover, previous studies have not comparatively explained how the relations between governance and green growth differ across regions of the world or addressed endogeneity issues (Kassi et al., 2020)

This study brings together two dynamic topics: governance and green development. Over the past few years, international institutions, such as (World Bank,2020; Asian Development bank, 2012; International Monetary Fund,2020), have stressed the importance of good governance.

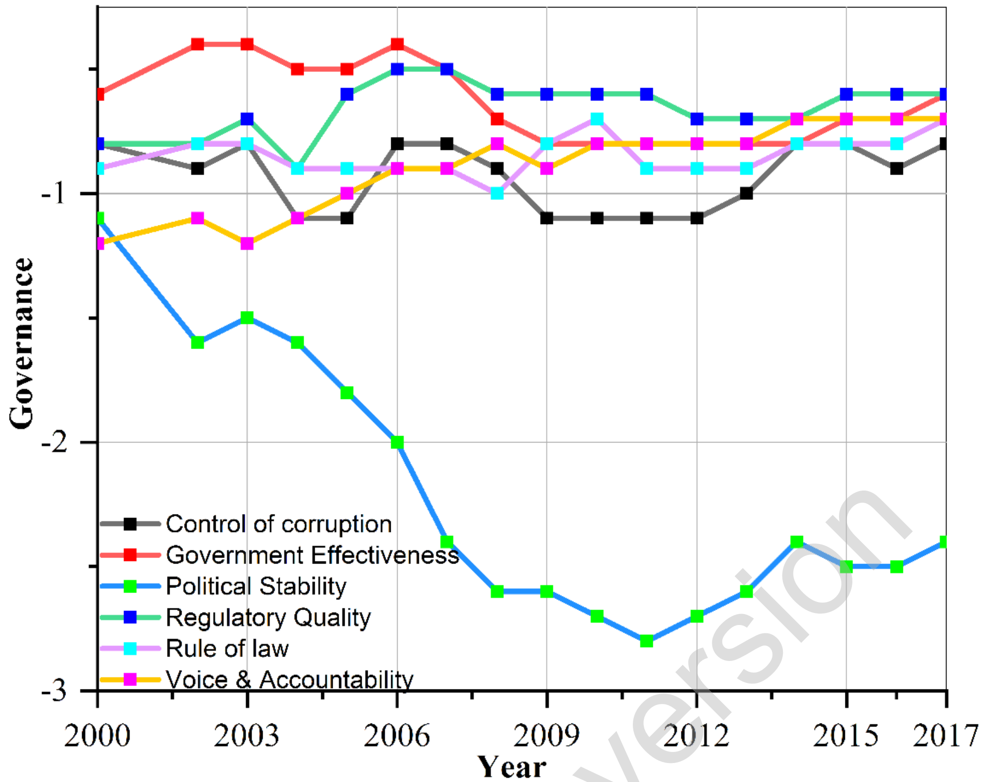

Figure 1: Governance trend in Pakistan

The analysis covers data for Pakistan spanning the period 2000 to 2017. This study brings together the three dynamic topics of governance, ISO 14001, and development in green growth, with the core objective of determining the potential impact of each governance indicator on the green growth development in Pakistan. The current literature has concentrated on carbon dioxide (CO_2) and used it as an air pollution indicator (Omri and Hadj, 2020). In addition to CO_2 emissions, we introduced PM 2.5, the fine particulates emitted from cars and power plants.

In 2012, Sustainable Development Goals (SDGs) were established to link economic, environmental and political challenges. In 2015, in the historic Paris Agreement in France, 195 states agreed to seek harmony among humans and the natural environment (United nations, 2015; Khoshnava et al., 2019). International organizations agree that “green growth” is a way to achieve sustainable development (OECD Green Growth studies, 2011; UNEP, 2011; The world bank, 2020). Green growth seeks to cope with economic challenges and aims to achieve both economic and environmental goals while protecting the interests of mankind (Kasztelan, 2017).

Pakistan is a developing country that relies heavily on natural resources to fulfil its economic and social needs, and its economic model causes extreme harm to the environment (Faisal, 2017). Although compared to developed nations, developing countries currently do not contribute much to GHG emissions, if they follow the traditional economic cycle, the long-term results on the environment will be drastic (Hynes and Wang, 2012).

Green growth incorporates economic and social factors to improve the performance of the government and organizations, but green growth can only be promoted if it is a part of national and organizational policy, and governance is a way to merge industrial, social and environmental relationships to obtain positive long-term benefits for a country (Le & Chang, 2017; Li, Xu, & Zheng, 2018). Developing countries, such as Pakistan, thus need to develop policies to support economic, social and environmental interests.

This study starts by examining the integrated effect of governance indicators and EMSs (ISO 14001) on green growth (renewable energy, CO_2 emissions, green technology, and PM 2.5 emissions). To the best of the authors' knowledge, this study is the first of its kind in the context of Pakistan. Further research contributions of this study include the development of a multidimensional environmental sustainability framework and a novel approach to the issue. Additionally, this study utilized grey relation analysis, as this technique is more suitable than other approaches to obtain persuasive findings and help prevent endogeneity problems involving the acquisition of variables. The advantage of the methodology applied in this study is its ability to provide accurate results based on limited datasets. The main advantage of GRA models is that they can manage missing information without affecting the results of the analysis. Finally, this study used the conservative (maximin) criteria method to investigate the average impact of governance indicators in Pakistan.

This article is organized in five sections. Following the introduction, we review the existing literature on governance indicators and EMSs (ISO 14001) related to green growth variables (renewable energy, CO2 emissions, green technology, and PM 2.5 emissions). The literature review is followed by a description of the research design, where the research and mathematical procedures are explained. The GRA model is developed and the results and discussion presented in section 4, and the conclusion is offered in the final section.

2. Literature review

In this section, we examine the previous empirical studies addressing the dynamics among governance, ISO 14001, and green growth.

2.1 Governance and Green growth

Governance is a government's ability to plan, develop and enforce policies for citizens and different institutions in the country (Kaufmann et al., 2010). Governance is seen as a form of the conventional setting of society and can be viewed as a governmental structure centered on the actions undertaken, partially or entirely, by federal agencies, especially at the national level (WU et al., 2020). Kaufmann et al. (1999) presented six measures of good governance, including voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, the rule of law and the control of corruption. Kaufmann et al. (1999) further stated that the impact of governance indicators on various macro phenomena varies from one country to another.

Green growth and the green economy have recently emerged as new paradigms for stimulating a growth path that integrates economic, social, and environmental interests. Many international organizations emphasize green growth as an approach to accomplish sustainable development targets (Kang, 2015). Green growth promotes growth that preserves or sustains the state of the environment and ecological balance while meeting all people's needs with the lowest possible environmental impact. Green growth entails the effective use of environmental assets and reduces the adverse environmental effects of pollution (Sellitto et al., 2020).

Environmental conditions have intensified the use of fossil-based fuels, and the resulting pollution is recognized as the primary cause of global warming and other climate issues (Yang and Lin, 2020). States must thus focus on increasing the use of alternative energy sources (renewables) to reduce the harmful effects of nonrenewable energy (Abid et al., 2020; Apergis & Garćıa, 2019; Irfan et al., 2020). The choice of energy sources plays a pivotal role in environmental protection or degradation. The available literature provides limited insight into the impact of governance on the energy-growth nexus (Kassi et al., 2020)

Pao (2014) emphasized that developing green energy offers a promising solution to environmental concerns. Marques et al. (2010) examined the drivers of renewable energy and suggested that state policies supporting conventional energy sources and CO_2 emissions limit renewable energy deployment. Poor governance hampers economic growth, and extreme social inequalities and suppression are potential obstacles to clean energy development (Saidi et al., 2018). There are few studies on governance and CO_2 emissions, and only a few have explored the role of governance in the battle against CO_2 emissions (Halkos et al. 2015). CO_2 emissions have an alarming impact on the global environment, but the solution to this issue depends directly on countries' determination to reduce CO_2 emissions (Artur & Bhaskara Rao, 2010). The consequences of CO_2 emissions from the developing world are just as significant as those from industrialized countries, but the structures in developing economies are still undeveloped, and the government lacks control over this issue (Ghani, 2012).

Developed economies have taken great strides to improve good governance, but emerging nations are still struggling with poor governance (Parker and Kirkpatrick, 2007). Samimi et al. (2012) revealed that good governance is required if an economy wishes to protect the environment by using natural assets in efficient ways. Governance indeed plays a crucial role in reducing CO_2 emissions, but the environmental impacts of governance elements differ from state to state. Halkos and Tzeremes (2013) concluded that various governance indicators impact CO_2 emissions differently. Abid (2016) investigated 25 African countries and examined the factors influencing CO_2 emissions, concluding that governance indicators contributed to minimizing CO_2 emissions.

Guo et al. (2017) and Jänicke, (2012) investigated green development, environmental protection, and green (resource-saving) technologies and suggested that green technologies are designed to meet society's demands and to effectively compete in regional markets. Adequate innovation policies in a region support the design of green growth strategies, which include the development of cleaner technologies (OECD, 2010). Green growth at the country level is driven by the implementation of green technologies (Hall et al., 2010). To facilitate green growth in a country, the government must design policies that ensure the development of low-carbon technologies (Biac OECD, 2010). Green technologies or clean technologies preserve the environment by mitigating traditional technology's harmful effects and reducing greenhouse gas (GHG) emissions (Kuan, 2010; Pakseresht et al., 2020)

The implementation of green technologies can also offer excellent opportunities to promote green growth across countries (Barbier, 2010). The industrial sector can play a crucial role in achieving green growth or a green economy in a country if this sector is transformed from conventional to green industries (Pan et al., 2019).

PM 2.5 refers to fine particles emitted from vehicle emissions and fossil-based fuel combustion emitted by manufacturers. PM 2.5 adversely affects human health and may cause serious respiratory, lung and cardiac diseases (Diao et al., 2019). Wen-li (2017) studied 167 countries from 2000 to 2013 and reported that governance has a significant positive association with PM 2.5 (air pollution) in both developed and emerging economies. He further argued that governments must consider all aspects of governance before designing a strategy or policy regarding the environment (Wu, 2017). Additionally, the findings of Thomas and Valley (2009) revealed that regulatory quality (a governance indicator) has a substantial impact on air quality and, therefore, helps reduce PM 2.5. Then, good governance can support environmental protection, combat climate change, and significantly improve overall environmental sustainability (Panayotou, 2001).

2.2 International Organization for Standardization 14001 (ISO 14001) and Green Growth

Environmental management systems (EMSs) guide organizations to cope with environmental issues and improve environmental conditions by following standard guidelines (Halis and Halis, 2016. The International Organization for Standardization (ISO) 14001 is the most widely used EMS (Huang and Ho, 2017). ISO 1400 is the most commonly adopted criterion for application to environmental regulations in accordance with globally recognized and consistent protocols (Morrow and Rondinelli, 2002). Several studies have shown that ISO 14001 certification correlates with significant environmental commitment and encourages accountability and legitimacy (Clare et al., 2019).

A considerable number of studies discuss the benefits of and barriers to ISO 14001 certification (Carrillo-Labella et al., 2020; Massoud et al., 2010; Salim et al., 2018; Wang & Zhao, 2020). To stay competitive and relevant in the dynamic global environment, ISO updated and issued the ISO 14001:2015 edition. Since September 2018, the ISO version before 2015 has not been valid, which requires organizations to transition to the updated version and comply with the ISO 14001:2015 standard to stay credible and remain EMS certified (ISO 14001:2015, 2015).

ISO 14001:2015 outlines the EMS requirements for an organization to cope with environmental challenges. ISO 14001:2015 certification applies to all types of organizations regardless of the size or the type of business, and it helps the organization fulfil environmental responsibilities (Ikram et al., 2020). ISO 14001:2015 helps a firm accomplish its environmental objectives and comply with regulations, which results in superior environmental performance (Fonseca, 2015). ISO 14001:2015 certification aligns with business strategy and increases the commitment of top management teams (Fonseca & Domingues, 2018; Ikram et al., 2020). Fonseca (2015) stated that ISO 14001:2015 offers a more flexible and transparent way to deal with environmental objectives than the 2008 version.

EMSs foster eco-innovation and green ways of carrying out and achieving organizational goals and can function as initiators for achieving sustainable development objectives (Salim et al., 2018). The results of He and Shen (2019) showed that ISO 14001 certified companies adopt modified innovative technologies over time to minimize environmental emissions, and thus, ISO 14001 certification enables green technological innovation. Radonjič and Tomic (2006) confirmed that ISO 14001 promotes technological innovation and acts as a catalyst to encourage the transition from traditional to modified technology adoption in the industrial sector. Marinova and Altham (2017) researched ISO 14001 certified and noncertified companies, suggesting that certified organizations are more likely to adopt green technologies than uncertified organizations, which rely on fewer technological advancements.

Prakash (2014) and Garrido et al., (2020) discovered that an increasing number of companies certified by ISO 14001 leads to a substantial decrease in CO_2 emissions in a country. International and national state legislators have realized the importance of EMSs for enhancing environmental quality and have thus adopted this program to facilitate the implementation of environmental legislation, which results in lower CO_2 emissions (Ulrich and Rache, 2007). The impact of ISO 14001 at the country level is prominent, so it can be used as a tool to improve the air quality and control harmful substances (such as PM 2.5) in a country (Garrido et al., 2020).

The literature shows that governance and ISO 14001 have an impact on green growth. However, there is a lack of studies that address the relation between green growth and ISO 14001 and identify the individual impact of governance indicators on green growth in the context of a developing country, particularly Pakistan. Green transformation is much needed in Pakistan. Therefore, the present study addresses this crucial issue considering the combination of these factors in the context of Pakistan for the 2000-2017 period. The research model designed for the aforementioned variables is presented in Figure 2**.**

Green growth is often constrained by the unclear definition of the responsibilities of various subjects in a country (Jänicke, 2012). Many developing countries explicitly or implicitly pursue a policy of "grow first, clean up later" (Le & Chang, 2017). Pakistan follows the same path to promote economic growth, and the country might suffer from worsening environmental and pollution conditions. Green growth incorporates economic and social factors to improve the performance of the government and organizations in a country, but green growth can only be promoted if it is part of the national and organizational policy, and governance is a way to merge industrial, social and environmental forces to obtain positive long-term benefits for the country (Li et al., 2018). ISO 14001:2015 helps a firm accomplish its environmental objectives and comply with regulations, which results in superior environmental performance (Fonseca, 2015).

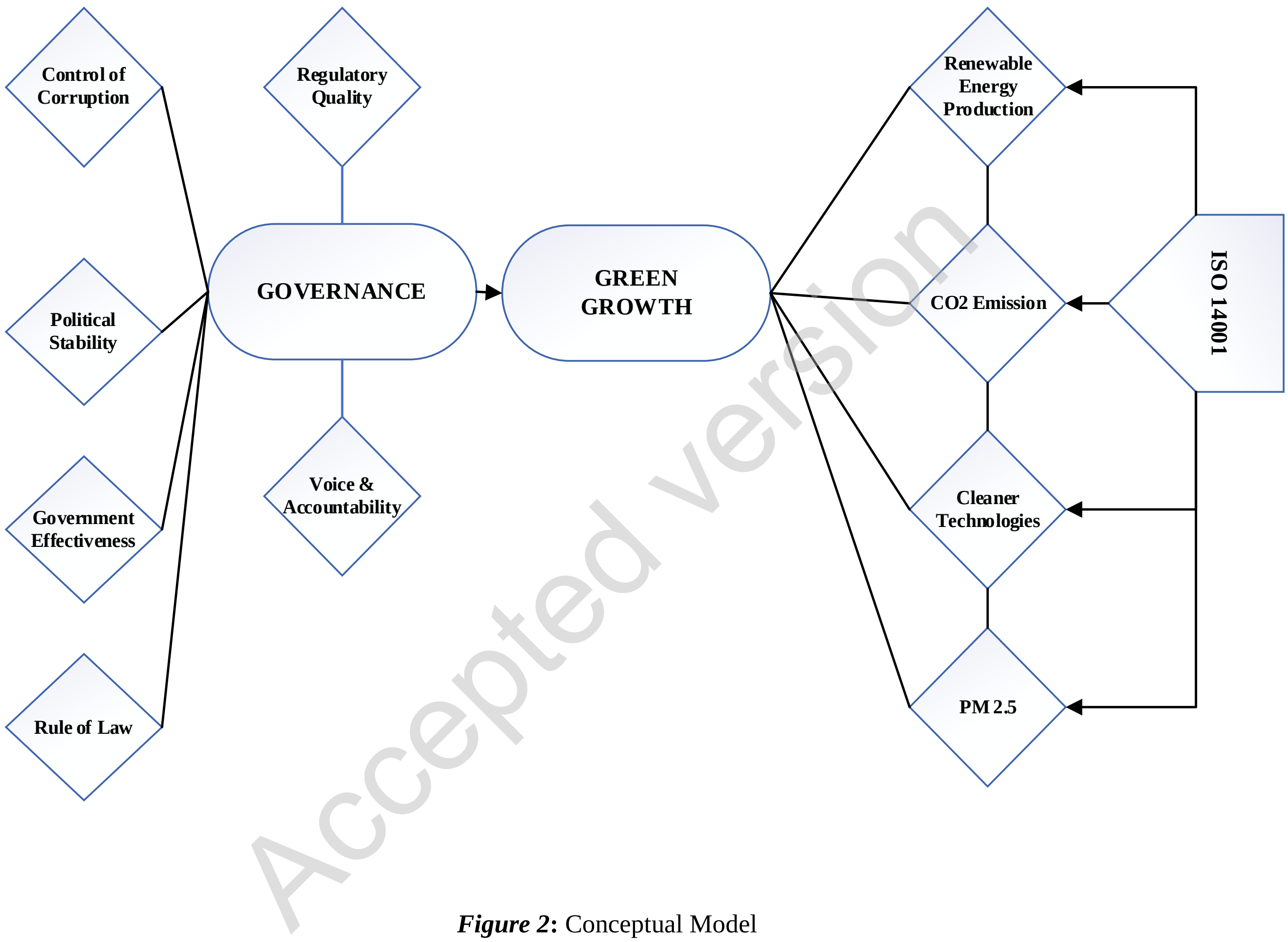

***Figure 2*:** Conceptual Model

3. Research Design and Methods

This article examines the relations among governance, ISO 14001 and green growth in Pakistan. To measure governance, the study used Kaufmann's (1999) governance indicators. A total of six governance measures were used: political stability (PS), the rule of law (RL), voice and accountability (VA), government effectiveness (GE), regulatory quality (RQ), and the control of corruption (CC). These dimensions cover all domains of governance, and the estimation values on the scale range from

2.5 to -2.5. A high score for a given governance indicator suggests that governance is strong in that particular area (Haq and Zia, 2006). ISO 14001 counts the number of certified companies in Pakistan. Green growth is measured by the renewable energy supply (% of total energy supplies), technology (% of annual development-related technology), CO_2 emissions (production-based emissions) and PM 2.5 annual exposure (micrograms per cubic meter). The data were normalized for all variables between 0 and 1 before analysis in MATLAB. The present study set the time period from 2000 to 2017. The data were collected from OECD Stats (2020), WGI (2020) and Our world in data (2018). The variables, measurement procedures and data sources are shown in Table 1.

Table 1: Variables, measurement procedures and data sources

Variables (codes)	Description of variables	Measurement	Data sources
PS	Political stability	Political stability estimates	WGI
RL	Rule of law	Rule of law estimate	WGI
V&A	Voice and accountability	Voice and accountability estimates	WGI
GE	Government effectiveness	Government effectiveness estimates	WGI
RQ	Regularity quality	Regularity quality estimates	WGI
COC	Control of corruption	Control of corruption estimates	WGI
ISO 14001	International standard organization 14001	ISO 14001 certifications	ISO
REP	Renewable energy production	Renewable energy production (TWh)	Our world in data
CO2	Carbon dioxide emissions	Production-based CO2 intensity, energy-related CO2 per capita(tons)	OECD
TECH	Green technology	Development of environment-related technologies, % all technologies	OECD
PM 2.5	Particulate Matter 2.5	Mortality from exposure to ambient PM2.5 (Per 1 000 000 inhabitants)	OECD

3.1 Grey Relational Analysis (GRA)

In this article, GRA covers four phases. First, data extracted from databanks for the period 2000 to 2017 were normalized for analysis. In the second phase, GRA models were employed to investigate the relation of governance (control of corruption, regulation quality, political stability, the rule of law and government effectiveness) and ISO 14001 with green growth (renewable energy, CO_2 emissions, green technology and PM 2.5). In the third phase, the ranking method was used based on the weights of the GRA models. According to suitable alternatives, the decision criteria were defined. Finally, in this study, a conservative model was employed to investigate which independent variable or set of variables has a strong influence on green growth in Pakistan. The GRA models operationalized in this study are presented in figure 3.

GRA models are recognized as a basis for grey incidence analysis (GIA). They are usually regarded as a primary element in systems theory (Badri et al., 2017). Deng (1982) led the foundation of the grey system theory. This approach has been broadly applied for handling vulnerability challenges in scenarios with insufficient data and uncertain data sources. One notable benefit of this technique is its potential to interpret the data appropriately in smaller samples (Ikram et al., 2020).

The GIA model describes the complexity of processes in which structural elements and operating systems have partial or incomplete physical information. GIA's fundamental concept is the use of the proximity degree of the appropriate information's spatial curve to determine whether its associations are relatively close (Ikram et al., 2020). Therefore, this model is used to evaluate the strength of the relationship among variables. A high degree of correlation or similarity signifies a strong correlation between the study factors (Rehman et al., 2020).

3.2 Deng's Grey Incident Analysis (GIA) model

Many researchers have proposed GIA models, but the model proposed by Deng (1989) is particularly notable. Deng's GIA model is a vital element in the decision-making phase of grey systems. This technique considers the pressing challenges embedded in everyday tasks, and scholars in various disciplines have used it to address problems rationally and systematically (Zuo et al., 2016).

Rehman et al. (2020) described the steps involved in the measurement of Deng's GIA for two datasets, symbolized by *a* and *b*.

- **Stage 1:** The first step in our analysis is to calculate the initial image of δ_0 and δ_i, i=1, 2, 3…, m, where:

$$\delta' i = \frac{\delta i}{\delta i(1)} = \left(\delta' i(1), \delta' i(2), \ldots, \delta' i(n)\right); i = 0,1,2, \ldots, m. \quad (1)$$

- **Stage 2:** The next step is to measure the difference in sequence δ_0' and δ_i' i=1, 2,3, …, m as:

$$\Delta i(\ell) = || \ \delta' 0(\ell) - \delta' i(\ell) \ ||, \Delta = \left(\Delta\delta(1), \Delta\delta(2), \ldots, \Delta\delta(n)\right), i = 1,2,3,4 \ldots, m. \quad (2)$$

- **Stage 3:** This step involves the calculation of the maximum and minimum values and can be seen as follows:

$$\mathcal{M} = max_i max_\ell \Delta_i(\mathcal{L}), \quad (3)$$

$$m = max_i max_\ell \Delta_i(\mathcal{L}).$$

- **Stage 4:** This step covers the estimation of the grey incidence coefficient or point relational coefficient using the following formula:

$$\lambda_{0i}(\ell) = \frac{m + \varsigma\mathcal{M}}{\Delta i(\ell) + \varsigma\mathcal{M}}; \ \varsigma\omega(0,1); \ \ell = 1,2,3,4 \ \ldots, n; \ i = 1,2,3,4 \ldots, \ m \quad (4)$$

where ς represents the distinctive coefficient. Referring to Javed & Liu, (2019), we set the value ς to be 0.5 as a distinctive coefficient.

- **Stage 5:** The final step involves the calculation of the grey relational degree (GRG) with the following formula:

$$\lambda_{0i} = \frac{1}{n}\sum_{\ell=1}^{n}\big(\lambda_{0i}(\mathcal{L})\big)\,; i = 1,2,3,4\ \ldots,\ m. \tag{5}$$

By changing the fractional form of $1/n$ with respect to weights denoted by w_t, the following is obtained:

$$\lambda 0i = \sum \mathcal{L} = 1n(\lambda 0i(\mathcal{L}) \times w\ell); i = 1,2,3,4 \ldots, m. \tag{6}$$

If the system parameters outline the specific effect, then the number of weights is equal to one, as Sarikaya & Güllü (2015) described, i.e., $\sum w\ell$=1. In the formula, $\frac{1}{n}$ is a depiction of equally distributed weighting criteria, suggesting evenly distributed weighting criteria, while w_k is a weighting scheme that is unequally distributed and depicts realistic problems or challenging dilemmas. By assigning similar weights to all the study variables, each of the single free factors can be linked to the first half of Deng's GIA model.

3.3 Grey Incident Analysis (GIA) model of Absolute degree

According to Xu and Li (2018), Deng's GIA is an efficient model for revealing the interplay between study elements while, absolute degree grey incidence analysis (ADGIA) provides a better understanding of the study variables and their relations (Zhicai and Li, 2018). Thus, by employing these models, researchers gain access to the geometric proximity between sequence curves and gain further insights into the relations between components of the sample (Liu et al. 2017). The construction of the absolute degree of grey incidence comprises three steps with two different time intervals δ_0 and δ_1.

- **Stage 1:** Following the order of interval sequence δ_0, δ_1, estimate the very base point images δ_0^0 and δ_1^0.
- **Stage 2**: Calculate $|s_0|, |s_1|$ and $|s_1 - s_0|$.

- **Stage 3**: Finally, determine the absolute degree of grey incidence (ξ_{01}) between the time interval sequence δ_0 and δ_1 using the following formula:

$$\xi_{01} = \frac{1+|s_0|+|s_1|}{1+|s_0|+|s_1|+|s_1-s_0|}. \tag{7}$$

Definition I

The Deng grey incidence analysis (DGIA) model recommends the use of Deng's grey incidence degree. The formula of the Deng degree of GIA is quantified as follows:

$$\lambda_{0i} = \sum_{\ell=1}^{n}(\lambda_{0i}(\mathcal{L}) \times w_\ell)\,;\ i = 1,2,3,4\ \ldots,\ m, \tag{8}$$

Or

$$\lambda_{0i} = \frac{1}{n}\sum_{\ell=1}^{n}\big(\lambda_{0i}(\mathcal{L})\big)\,;\ i = 1,2,3,4\ \ldots.,\ m, \tag{9}$$

where $\lambda_{0i}\,(\mathcal{L})$ represents the coefficient of grey incidence (GRA). The first element of Deng's GRA reflects the weighted version of DGIA, and the second element considers an equally weighted or nonweighted scheme.

Definition II

For the absolute degree of GRA model, also known as the ADGIA model, we utilize the absolute degree of GRA to compute the weights of COC, GE, PS, RQ, RL, V&A and ISO 14001 for Pakistan. The equation is written as:

$$\xi 01 = \frac{1+|s0|+|s1|}{1+|s0|+|s1|+|s1-s0|} \tag{10}$$

Definition III

Let the system behavioral functioning for the data sequence be represented by $\delta_i = (\delta_i(1), \delta_i(2), \ldots., \delta_i(n))$ and C represent the operation of the data sequence that meets the condition of $\delta_i(L)c = (\delta_i(L)c - \delta_i(1); L = 1,2,3,..n$. Then, C is a point of operational function, in which the value starts from 0 indicated by $\delta_i C$, which is called the zero-scale point image of δ_i. $\delta_i C$ is often written as:

$$\delta_i C = \delta_1^0 = (\delta_i^0(1), \delta_i^0(2), \ldots\ldots \delta_i^0(n)) \quad (11)$$

According to Liu et al. (2017), the variable lengths of δ_i and δ_j are considered to be the same during the one-time-interval sequences, and δ_i and δ_j are zero-starting point images, as follows:

$$\delta_i^0 = \left(\delta_i^0(1),\ \delta_i^0(2), \delta_i^0(3)\ \ldots,\ \delta_i^0(n)\right), \quad (12)$$

$$\delta_j^0 = \left(x_j^0(1),\ \delta_j^0(2), \delta_j^0(3)\ \ldots,\ \delta_j^0(n)\right). \quad (13)$$

Then,

$$|s_i| = \left[\sum_{\ell=2}^{n-1} \delta_i^0(\mathcal{L}) + \frac{1}{2}\delta_i^0(n)\right] \quad (14)$$

$$|s_j| = \left[\sum_{\ell=2}^{n-1} \delta_j^0(\mathcal{L}) + \frac{1}{2}\delta_i^0(n)\right], \quad (15)$$

$$|s_i - s_j| = \left[\sum_{\ell=2}^{n-1} (\delta_j^0(\mathcal{L}) - \delta_i^0(\mathcal{L})) + \frac{1}{2}\left(\delta_i^0(n) - \delta_j^0(n)\right)\right], |s_j| = \left[\sum_{\ell=2}^{n-1} \delta_j^0(\mathcal{L}) + \frac{1}{2}\delta_i^0(n)\right], \quad (16)$$

3.4 The Second Synthetic Degree of Grey Incidence Analysis (SSDGIA) model

Javed and Liu (2018) proposed the second synthetic degree grey incidence analysis (SSDGIA) model based on absolute GRG and Deng’s GRG. After analysis of the study variables, this GRA model illustrates the overall proximity of the underlying sequence according to Ikram et al. (2020). The SSDGIA equation formula is as follows:

$$\rho_{ij} = \Theta\eta_{ij} + (1-\Theta)\omega_{ij};\ \Theta \in [0,1], \quad (17)$$

Where:

ρ_{ij} = SS degree of grey relation (SSGRG)

η_{ij} = Absolute degree of grey relation (absolute GRG)

ω_{ij} = Deng's degree of grey incidence/grey relation (GRG)

The fundamental principle of the SSDGIA model is based on the inline proximity between two data sequence points and its integral position. The GRA model of Deng relies on the grey coefficient of relation/incidence of some points, while the absolute GRA method concentrates on the holistic perspective (Javed et al. 2019)

The SSDGIA model is based on the SDGIA model, in which the value of Θ is considered to be Θ=0.5. It is very important for decision makers to set the value of two important terms, η and ω, without favoring one decision over the other in the decision-making process. According to the decision nature and its importance, the value of Θ can be changed. If the decision makers make an optimistic decision at this point in time, the value of η is higher than the value of Θ, and vice versa.

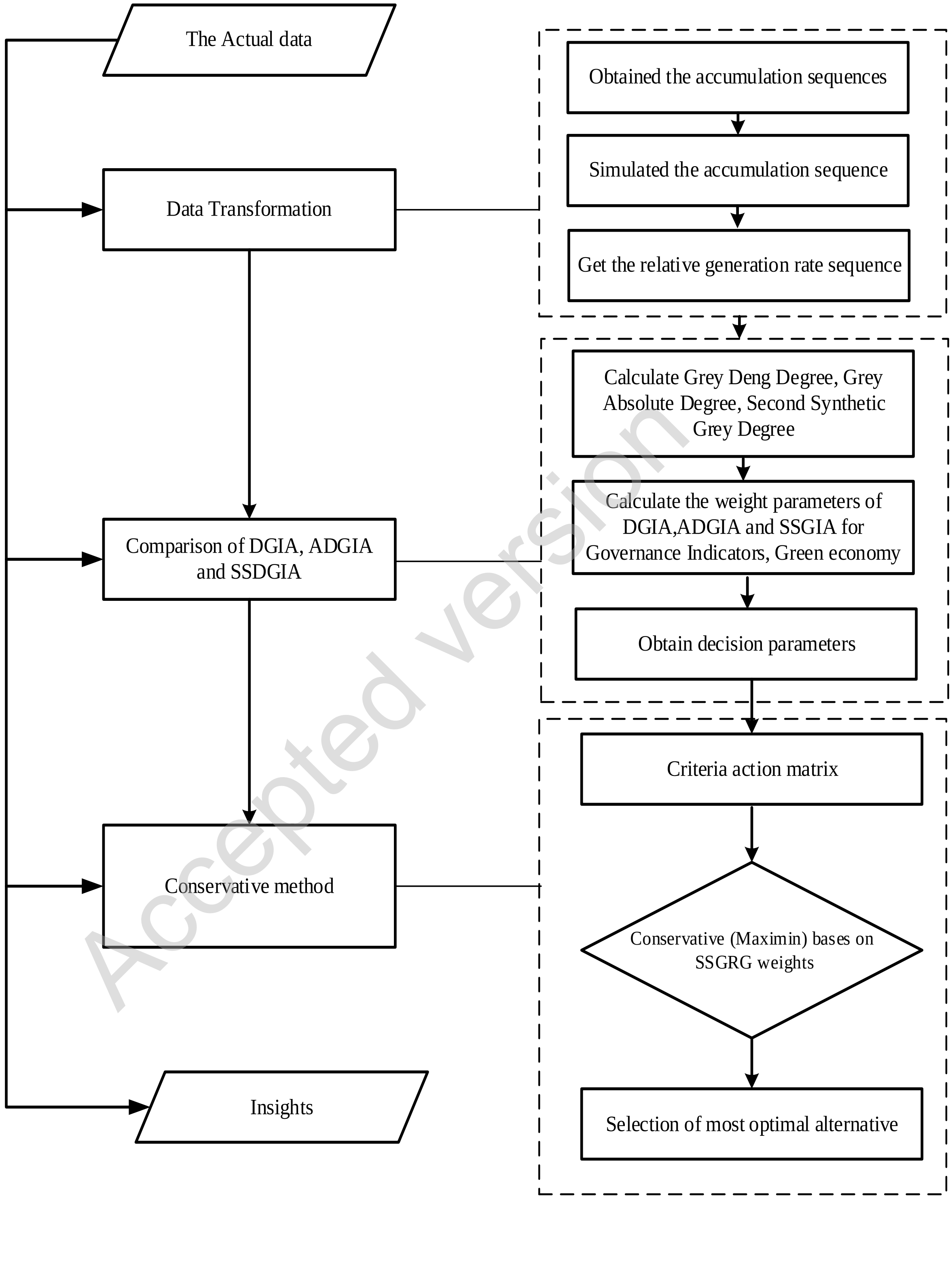

Figure 3: Grey models operationalized in this study

4. Results and discussion

GRA is an integral part of grey system approach. GRA models offer superiority over other statistical approaches in dealing with grey data (incomplete information) and producing reliable results even if the study sample is small. The accuracy of the GRA results is another benefit, and researchers from any discipline can benefit (Javed et al., 2019). The results of the grey relation models, such as Deng's GRG, absolute GRG and SSGRG, regarding governance (control of corruption, government effectiveness, political stability, regulation quality, rule of law, voice, and accountability), environmental management system (ISO 14001) and green growth (renewable energy generation, energy-related CO_2 per capita, environment-related technologies, PM 2.5) for Pakistan are shown in Tables 1 to 6. The relations among the study components can be measured using a scale between 0 and 1, where 0 refers to the weakest associations between the variables in GRG and SSGRG, and 1 denotes the strongest relations among variables. The standardized scale for Deng's GRG measures the relations between variables on a scale from 0.5 to 1.

Table 2: Grey relational assessment for renewable energy production

Indicator	Code	Absolute Grey Relational Grade	Deng Grey Relational Grade	Second Synthetic Grey Relational Grade
Government Effectiveness	GE	0.5742	0.6961	0.6352
Political Stability and Absence of Violence/Terrorism	PS	0.8958	0.7014	0.8086
Regulatory Quality	RQ	0.7846	0.7199	0.7523
Rule of Law	RL	0.6374	0.7011	0.6692
Voice and Accountability	V&A	0.8340	0.7360	0.7850
Control of Corruption	COC	0.6447	0.7064	0.6755
International Organization for Standardization 14001	ISO 14001	0.9418	0.6705	0.8061

According to absolute GRG, in the association among control of corruption, government effectiveness, political stability, regulatory quality, rule of law, voice and accountability, ISO 14001 and renewable energy production, voice and accountability shares the strongest association with REP (0.9897), followed by political stability (0.9565) and regulatory quality (0.9351). Compared to the other variables, control of corruption and the rule of law do not influence renewable energy production. The details are presented in Table 1.

Based on Deng's GRG, a separate ranking set among variables is obtained. The analysis shows that voice and accountability obtain the highest weight (0.7360), followed by regulatory quality (0.7199), then control of corruption (0.7064). Rule of law and government effectiveness share a relatively weak link with REP. Similarly, the SSGRG results reveal that political stability has the strongest effect on renewable energy production.

Our research findings are consistent with Wu's (2017) findings, which reveal that voice and accountability and political stability significantly decrease environmental pollution in both emerging and developed economies. Existing studies provide limited information on the governance-renewable energy nexus (Kassi et al., 2020). Pao et al. (2014) stressed the value of green energy as a potential key solution to environmental issues. Although Pakistan is focusing on renewable energy development, most of its future energy projects are based on fossil fuels (Abid et al., 2020). Marques et al. (2010) argued that state policies supporting conventional energy sources limit renewable energy deployment. Apergis and Garćıa (2019) suggested the use of renewable energy sources to meet the energy demand and argue that green energy and technology can significantly minimize CO_2 emissions.

Table 3: Grey relational assessment for production-based CO_2 intensity, energy-related CO_2 per capita (in tons)

Indicator	Code	Absolute Grey Relational Grade	Deng Grey Relational Grade	Second Synthetic Grey Relational Grade
Government Effectiveness	GE	0.9491	0.6121	0.7806
Political Stability and Absence of Violence/Terrorism	PS	0.8811	0.6170	0.7229
Regulatory Quality	RQ	0.9374	0.6134	0.7754
Rule of Law	RL	0.7759	0.5283	0.6521
Voice and Accountability	V&A	0.8727	0.5257	0.6992
Control of Corruption	COC	0.7835	0.5008	0.6421
International Organization for Standardization14001	ISO 14001	0.9200	0.7060	0.8630

In the analysis using a production-based CO_2 intensity-dependent variable, the GRG results show that government effectiveness with weight (0.9491) ranks first in sharing a strong association with CO_2 emissions. Moreover, regulatory quality (0.9374) occupies the second position, and ISO 14001 (0.9200) is third.

Abid (2016) confirms the importance of governance indicators in lowering CO_2 emissions. The results match those of Samimi et al. (2012) and Danish et al. (2019), which show that government effectiveness and regulation quality have a negative and significant influence on CO_2 emissions.

Deng's GRG results show that production-based CO_2 is positively influenced by ISO 14001. Moreover, ISO 14001 has already been proven to be significant in reducing CO_2 (Garrido et al., 2020). Among all governance indicators, political stability ranks second in the effect on CO_2 emissions, followed by regulatory quality, which occupies third place. However, voice and accountability and the control of corruption have little impact on production-based CO_2. According to the second synthetic GRG results in complement with Deng's GRG results, ISO 14001 has a significant influence on CO_2, and government effectiveness and regulatory quality have a substantial impact on reducing CO_2 emissions.

Then, the higher the proportion of companies with ISO 14001 certification is, the lower the CO_2 emissions will be (Garrido et al., 2020). Aseem Prakash (2014) and Azmat (2012) concluded that political stability and government effectiveness share an inverse but statistically significant relation with CO_2 emissions. Ikram et al. (2019) reported that higher CO_2 emissions in Pakistan result from less energy output from renewable sources.

Table 4: Grey relational assessment for the development of environment-related technologies (% all technologies)

Indicator	Code	Absolute Grey Relational Grade	Deng Grey Relational Grade	Second Synthetic Grey Relational Grade
Government Effectiveness	GE	0.5742	0.6961	0.6352
Political Stability and Absence of Violence/Terrorism	PS	0.8958	0.7014	0.8086
Regulatory Quality	RQ	0.7846	0.7199	0.7523
Rule of Law	RL	0.6374	0.7011	0.6692
Voice and Accountability	V&A	0.8340	0.7360	0.7850
Control of Corruption	COC	0.6447	0.7064	0.6755
International Organization for Standardization 14001	ISO 14001	0.9418	0.6705	0.8061

When we held the development of environment-related technologies as dependent variables and other variables as independent variables, the findings of absolute GRG show that ISO 14001 has a substantial influence on green technologies (the development of environment-related technologies). The value 0.9418 depicts the strength of the relationship that both variables share. Political stability and voice and accountability have the values 0.8958 and 0.8340, respectively. The remaining indicators do not present a marked influence on the dependent variable.

Several studies have shown that ISO 14001 facilitates the use of clean energy sources (Baek, 2017). Our findings are aligned with those of Radonjič and Tomnic (2006), who confirm that ISO 14001 certification drives technological development. Marinova (2017) argued that, in terms of cleaner technology, ISO 14001 certified companies are more responsive.

First, Deng's GRG results show that voice and accountability, with a value of 0.7360, has more influence in developing environment-related technologies than other governance factors, followed by regulatory quality, with a score of 0.7199. Second, in the synthetic GRG results, political stability is ranked first, and ISO 14001 is second, followed by voice and accountability and rule of law. Apergis and Garćıa (2019) stressed that organizations and industries need to use cleaner technologies, as such technologies reduce the emission of climate pollutants.

Table 5: Grey relational assessment for mortality from exposure to ambient PM 2.5 (Per 1,000,000 inhabitants)

Indicator	Code	Absolute Grey Relational Grade	Deng Grey Relational Grade	Second Synthetic Grey Relational Grade
Government Effectiveness	GE	0.9528	0.7545	0.8037
Political Stability and Absence of Violence/Terrorism	PS	0.7992	0.6912	0.6710
Regulatory Quality	RQ	0.9268	0.6445	0.7857
Rule of Law	RL	0.7828	0.5051	0.6440
Voice and Accountability	V&A	0.8637	0.4927	0.6782
Control of Corruption	COC	0.7905	0.5564	0.6734

International Organization for Standardization 14001	ISO 14001	0.8147	0.6846	0.7596

The fourth dependent variable, PM 2.5, is associated with the other variables when using absolute GRG. The results illustrate that government effectiveness (0.9528) plays a leading role in influencing PM 2.5 in Pakistan, followed by regulatory quality (0.9268) and voice and accountability (0.8637). The details are presented in Table 4. Deng's GRG indicated that government effectiveness is first, political stability is second, and ISO 14001 is third. SSGRG shows that government effectiveness is in the first position, regulatory quality in the second, and ISO 14001 in the third position regarding their influence on PM 2.5 (Air quality) in Pakistan.

These results are supported by those of Samimi and Ghaderi (2012), which prove that government effectiveness is a leading factor influencing air quality. Abid (2016) also shows that all six governance indicators play a role in reducing air pollutants. Wu (2017) and Panayotou (2001) discussed the importance of good governance and revealed that government effectiveness effectively reduces PM 2.5 levels and prevents environmental degradation.

Table 5 presents the grey relational associations of green growth variables with governance indicators and ISO 14001. The ranking approach is used in Table 5 to consider the relation of every dependent variable with the independent variables. For renewable energy, the results are similar to those of Bellakhal et al. (2019) and Horbach and Rennings (2008). In the results of Danish et al. (2019), Samimi et al. (2012), Ikram et al. (2020), and Abid (2016), ISO 14001 significantly lowers CO_2 energy-related emissions. Absolute GRG, Deng's GRG and SS GRG all support government effectiveness as a key means to improve air quality by reducing PM 2.5. Samimi and Ghaderi's (2012) findings indicate that government effectiveness significantly enhances the quality of air. The results of Wen-li (2017) and Panayotou (2001) indicate that the efficacy of governance has a significant impact on PM 2.5, thereby substantially reducing PM 2.5 pollutants. The results regarding the importance of technology in the findings of Radonjič and Tomic (2006) support our results. The results of Abid (2016) also support our conclusion that governance indicators impact air quality and environmental efficiency. The GRA evaluation-based relation of ISO 14001, governance and green growth is shown in Figure 4.

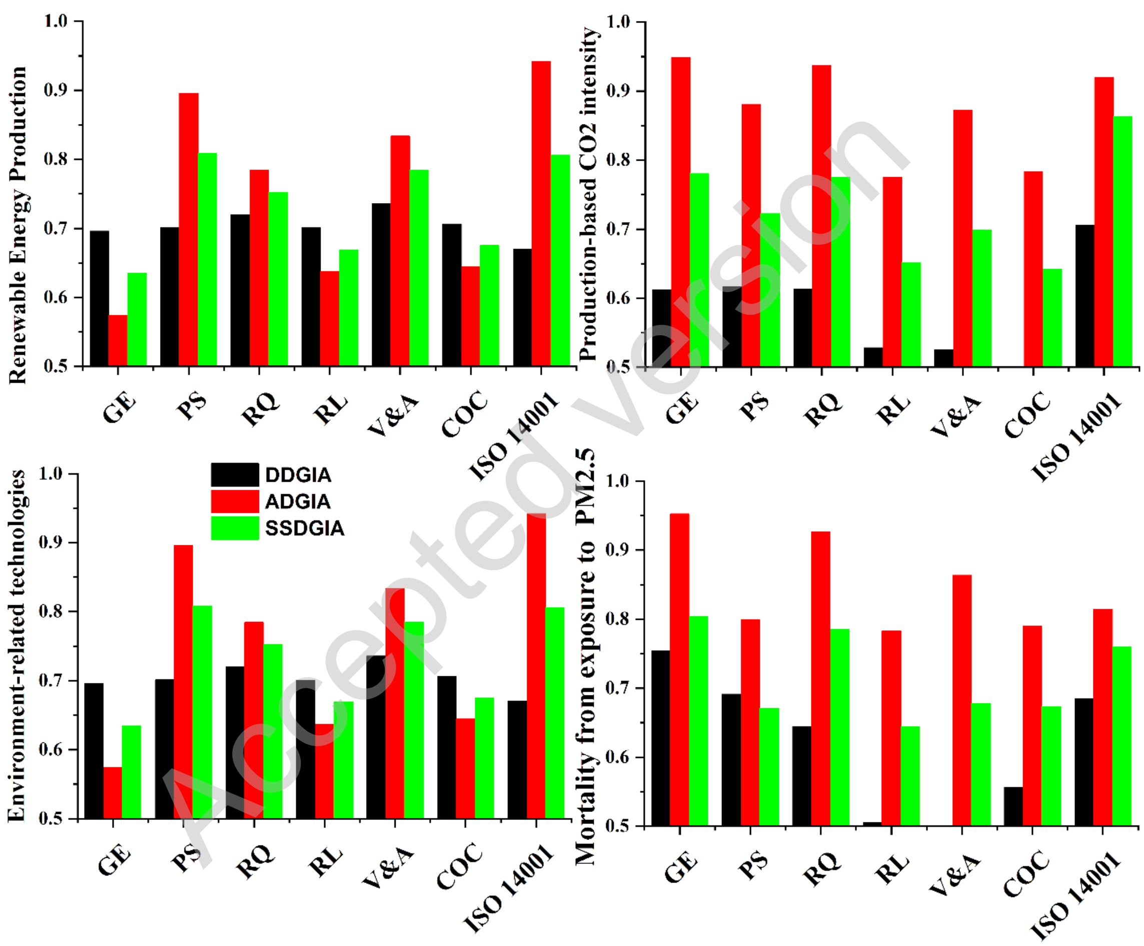

Figure 4: Grey relation analysis evaluation of ISO 14001, governance, and green growth

Table 6: Grey assessment ranking of governance, ISO 14001, and green growth variables

Variables	Grey Relational Model	Ranking

Renewable Energy Production	Absolute Grey Relational Grade	Voice and Accountability> Political Stability and Absence of Violence/Terrorism> Regulatory Quality> ISO 14001> Government Effectiveness> Control of Corruption> Rule of Law
	Deng's Grey Relational Grade	ISO 14001> Political Stability and Absence of Violence/Terrorism> Regulatory Quality> Government Effectiveness> Voice and Accountability> Control of Corruption> Rule of Law
	Second Synthetic Grey Relational Grade	Political Stability and Absence of Violence/Terrorism> Voice and Accountability> Regulatory Quality> ISO 14001> Government Effectiveness> Control of Corruption> Rule of Law
Production-based CO_2 intensity, energy-related CO_2 per capita	Absolute Grey Relational Grade	Government Effectiveness> Regulatory Quality> ISO 14001> Political Stability and Absence of Violence/Terrorism> Voice and Accountability> Control of Corruption> Rule of Law
	Deng's Grey Relational Grade	ISO 14001> Political Stability and Absence of Violence/Terrorism> Regulatory Quality> Government Effectiveness> Rule of Law> Voice and Accountability> Control of Corruption
	Second Synthetic Grey Relational Grade	ISO 14001> Government Effectiveness> Regulatory Quality> Political Stability and Absence of Violence/Terrorism> Voice and Accountability> Rule of Law> Control of Corruption
Development of environment-related technologies	Absolute Grey Relational Grade	ISO 14001> Political Stability and Absence of Violence/Terrorism> Voice and Accountability> Regulatory Quality> Control of Corruption> Rule of Law> Government Effectiveness>
	Deng's Grey Relational Grade	Voice and Accountability> Regulatory Quality> Control of Corruption> Political Stability and Absence of Violence/Terrorism> Rule of Law> Government Effectiveness > ISO 14001
	Second Synthetic Grey Relational Grade	Political Stability and Absence of Violence/Terrorism> ISO 14001> Voice and Accountability> Regulatory Quality> Control of Corruption> Rule of Law> Government Effectiveness

Mortality from exposure to ambient PM2.5	Absolute Grey Relational Grade	Government Effectiveness> Regulatory Quality> Voice and Accountability> ISO 14001> Political Stability and Absence of Violence/Terrorism> Control of Corruption> Rule of Law
	Deng's Grey Relational Grade	Government Effectiveness> Political Stability and Absence of Violence/Terrorism> ISO 14001> Regulatory Quality> Control of Corruption> Rule of Law> Voice and Accountability
	Second Synthetic Grey Relational Grade	Government Effectiveness> Regulatory Quality> ISO 14001> Voice and Accountability> Rule of Law> Control of Corruption> Political Stability and Absence of Violence/Terrorism

Next, decision analysis is used to identify the governance component that has a substantial impact on Pakistan's green growth. For this purpose, a first step is to determine the nature of the variables and alternate responses, as illustrated in Table 6.

Table 7: Description of goal and decision parameters

Goal	**Measuring Grey Relation (Association) among Control of corruption, Government effectiveness, Political Stability and Absence of Violence/Terrorism, Regulatory Quality, Rule of Law, Voice and Accountability, ISO 14001, and Green economy**
Main Criteria (Pj); P = 1, 2…., k	Control of corruption (P1) Government effectiveness (P2) Political Stability and Absence of Terrorism (P3) Regulatory Quality (P4) Rule of Law (P5) Voice and Accountability (P6) ISO 14001 (P7)
Best alternatives and actions (Si); S=1, 2,3…, m	Grey Relation was superior in Renewable Energy Production (S1) Grey Relation was superior in Production-based CO_2 intensity, energy-related CO_2 per capita (S2) Grey Relation was superior in Development of environment-related technologies (S3) Grey Relation was superior in Mortality from exposure to ambient PM 2.5 (S4)

where p = 3, n = 8, and outcome = v (S_i, D_j), with i = 1, 2, 3, and j = 1, 2, 3, 4, 5….8. Let S_1, S_2, S_3 and S_4 represent the grey relation analysis of governance indicators (control of corruption, government effectiveness, political stability, regulatory quality, voice and accountability, and rule of law) and ISO 14001 on green growth (REP, tech, CO_2 emissions and PM 2.5) in Pakistan.

Our research findings are consistent with the findings of Wu (2017) and Panayotou (2001), which revealed that governance indicators significantly decrease environmental pollution (PM 2.5). Abid (2016) confirmed the importance of governance indicators in lowering CO_2 emissions. Aseem Prakash (2014) and Azmat (2012) concluded that political stability and government effectiveness have a significant negative relation with CO_2 emissions. Our results also match those of Samimi et al. (2012) and Danish et al. (2019), which show that government effectiveness and regulation quality have a negative and significant influence on CO_2 emissions. Ikram et al. (2019) report that higher carbon dioxide emissions in Pakistan result from less energy output from renewable sources. ISO 14001 has already been proven to be significant in reducing CO_2 (Garrido et al., 2020). Then, the more widespread the certification of ISO 14001 is, the lower the CO_2 emissions will be (Garrido et al., 2020).

Our findings are aligned with those of Radonjič and Tomnic (2006), which confirm that ISO 14001 certification drives technological development. Apergis and Garćıa (2019) suggest the use of renewable energy sources to fulfil energy demand and argue that green energy and technology can significantly minimize CO_2 emissions. Marinova (2017) argued that, in terms of cleaner technology, ISO 14001 certified companies are more responsive. Apergis and Garćıa (2019) stressed that organizations and industries need to use cleaner technologies, as they reduce the emission of climate pollutants.

Table 7 illustrates the SSDGRA matrix, describing the 'second grey synthetic relationship' among decision parameters and decision criteria response. Finally, a decision-making process model is operationalized for comparative analysis of the research variables to assess the impact of governance and ISO 14001 on green growth in Pakistan.

Table 8: Second Synthetic Grey Relational Grade criteria-based matrix

Alternatives	P_1	P_2	P_3	P4	P5	P6	P7
S_1	0.6038	0.7050	0.8127	0.7640	0.5983	0.7758	0.7505
S_2	0.6421	0.7806	0.7229	0.7754	0.6521	0.6992	0.8630
S_3	0.6755	0.6352	0.8086	0.7523	0.6692	0.7850	0.8061
S_4	0.6734	0.8037	0.6710	0.7857	0.6440	0.6782	0.7596

We then used a technique that has been successfully used in several studies (Ikram et al., 2019). Since we optimize the green growth function, it is called a maximin criterion:

$$\max L_i \left\{ \min A_k \, v\left(A_p, \mathrm{C}_k\right) \right\} = \max A_p \begin{Bmatrix} 0.5983 \\ 0.6421 \\ 0.6352 \\ 0.6440 \end{Bmatrix} = 0.6440 \ \textbf{(Rule of Law)}$$

Our results reveal that the rule of law has a significant impact on Pakistan's green development (see Figure 5). Recently, the green economy has emerged as one of several paradigms that stimulate a growth path prioritizing environmental goals (Cooper et al., 2020). The institutional domain, which includes the rule of law, refers to the sovereignty of institutions supporting the economic system in Pakistan (Haq and Zia, 2006). The relation between the rule of law and good governance has not been deeply explored. However, both factors are crucial elements of a country's development. Regulations are developed to ensure the organized management of all institutions in a country, but the mere drafting of a law does not guarantee anything. Rules should be implemented and subject to evaluation on a regular basis to ensure transparency in government institutions (Zaelke and Morita, 2005). The enhancement of governance performance with the proper implementation of laws in a country along with stringent energy policies for environmental protection could increase energy efficiency (Bercu et al., 2019). The improvement in law leads to an improvement in the environment with strict policies and a reduction in CO_2 emissions and air pollutants (PM 2.5). Gani (2012) stated that governments should adopt cleaner sources of energy and more environmentally friendly technology to achieve a green growth agenda.

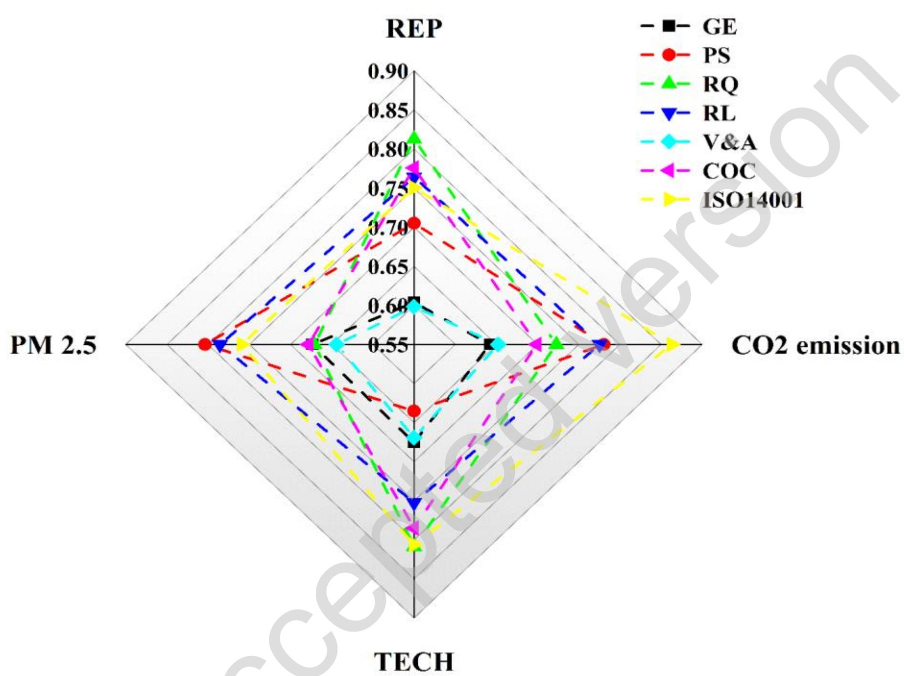

Figure 5: The Conservative (maximin) analysis

5. Conclusion

The relation between governance and green growth has not been fully explored by academia. This study incorporated a novel set of variables to check the impact of governance (in six dimensions) on green growth (REP, Tech, CO_2, PM 2.5) for Pakistan from 2000-2017. The study employed grey relational analysis (GRA), which is unique in terms of its analysis and interpretation approach and has not previously been used for this kind of study. The study employed three GRA models, Deng's GRG, absolute GRG and SS GRG, and the outcome showed that the models are well suited for this research and produce adequate findings.

Main findings reported that, according to absolute GRG, the strongest associations were between voice and accountability (0.9897), political stability (0.9565), regulatory quality (0.9351). Absolute GRG reported government effectiveness (0.9491), regulatory quality (0.9374) and ISO 14001 (0.9200) were ranked with strongest associations with CO_2 emissions. The results concerning development of environment-related technologies ranked, in absolute GRG results, ISO 14001 (0.9418), political stability (0.8958) and voice and accountability (0.8340) as strongest associations. PM 2.5 reported an association with government effectiveness (0.9528), regulatory quality (0.9528) and voice and accountability (0.8637).

We found that the green growth path in Pakistan is challenging, and the value of maximin criterion (0.6440) shows that governance dimension; rule of law is directly related to green growth in Pakistan. However, various governance indicators affect green growth differently, but the impact is not significant as rule of law. This is because of the nature of governance dimensions and the lack of integration among Pakistan's governance institutions. The performance of governance indicators, when we evaluated the green growth variables considering ISO 14001 and governance indicators. The findings suggest that increasing the number of firms with ISO 14001 certification leads to lower CO_2 emissions, more energy production from renewables, a transition from conventional to modern and cleaner technologies, and an improvement in air quality by reducing PM 2.5 particles in the air. GRA model results shows that ISO 14001 is also plays a part in green growth development, SSGRA values 0.80, 0.84, 0.86, and 0.75 suggests that ISO 14001 has a significant impact on renewable energy, CO2 emissions, green technology, and PM 2.5.

Our study has several recommendations. First, all private and public sector industries need to adopt ISO 14001 certification so they can comply with environmental laws rules and regulation to protect the environment and the society. Renewable energy deployment is another important factor which can help to improve the sustainability concerns in Pakistan. Although Pakistan has strived to improve the energy mix over the years by adding more renewables for energy production, the Pakistani governance system lacks coordination and law implementation and evaluation systems, which slows down green growth. Our study results centered on the rule of law in which Pakistan needs to carefully devise, implement, and evaluate environmental laws in coordination with governance domains to smooth the path to green growth. Pakistan needs to implement environmental laws strictly without the influence of any political shift in the country. Proper law enforcement can not only conserve the environment but can also prohibit the emissions of PM 2.5 in the air.

There are several limitations to our study. This study has academic and policy implications but lacks societal implications. It incorporated a novel yet limited set of variables, and future studies can cover environmental policies and other variables that would open a different line of inquiry. We discussed governance indicators, but there is a need to address and capture the direct influence of government actors in shaping environmental protection and green policies in Pakistan as well as in other developing countries. Future research can shed light on the adoption of green policies, law, and technology in Pakistani firms (public and private) in the presence of available resources. Future studies can focus on enterprise management and HRM policies and employees' behavior/concern towards environmental management systems and practices to promote green ways of doing things.

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