Towards a Sustainable Environment: The Nexus between ISO 14001, Renewable Energy Consumption, Access to Electricity, Agriculture and CO_2 Emissions in SAARC Countries

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Abstract

In this study, we investigate complex, country-level relationships between ISO 14001 certification, renewable energy consumption, access to electricity, agriculture, and CO_2 emissions within the South Asian Association for Regional Cooperation (SAARC) countries. These countries are important to look at they contain 20 percent of the world's population, are investing in infrastructure, and are vulnerable to the impacts of CO_2 emissions. There is a gap in the literature addressing all of these countries while using novel modeling to try and understand dynamic relationships across countries. In this study we use multiple models to examine data covering the years 2000 to 2014 starting with novel Grey Relational Analysis (GRA) models to compute the weights and ranking of countries based on CO_2 emission. Next, using a Conservative (maximin) model, we check which country has the most CO_2 emission issues among all countries based on weights obtained by Second Synthetic Grey Relational Analysis (SSGRA). Finally, a Grey preference by similarity to ideal solution (G-TOPSIS) methodology prioritizes the factors that have more intensely impact CO_2 emissions. The results reveal that among all SAARC countries, India has substantial CO_2 emission issues. We also find reductions in emissions from renewable energy consumption and the adoption of ISO 14001 certification in these countries. The outcomes of this study can assist organizations and policymakers in their decision-making and investments regarding CO_2 reduction while simultaneously improving environmental sustainability practices.

***Keyword*:** CO_2; Emission; GRA; Grey TOPSIS; ISO 14001; Renewable Energy; Sustainability

1. Introduction

Climate change is of great concern and influencing today's social and environmental business environment. The continued increase in carbon dioxide emissions (CO_2) will boost the temperature level and will result in long-term climate fluctuations. The focus on CO_2 is important due to its global warming potential and numerous problems when it comes to the health and environmental sustainability of populations. CO_2 does not influence a single nation but is troublesome for the world as a whole. Individuals cannot tackle such an issue alone. Therefore, collective efforts are needed at global and regional levels to address and to mitigate climate changes (Ben Jebli et al., 2016; Mendonça et al., 2020). Much research has been conducted on this subject worldwide. The Conference of the Parties (COP) of the United Nations Framework Convention on Climate Change was codified to reduce the level of carbon emissions below the Kyoto Protocol agreement (Apergis and Danuletiu, 2014). Likewise, reports released by the International Panel on Climate Change (IPCC) highlight and aim to resolve the problems of CO_2 emissions, but countries continue to fall short of goals and are in search of actions to diminish impacts. In 2015, the COP21 took place after failed attempts to reach goals of the Copenhagen climate change conference in 2012. The result was the Paris Agreement that has legal validity and global goals to reduce CO_2 emissions (Jeong et al., 2018). Since 2015, the United Nation has also released its 17 Sustainable Development Goals (SDGs). SDGs 7 affordable and clean energy, 8 decent work and economic growth, 9 industry innovation and infrastructure, 11 sustainable cities and communities, 12 responsible consumption and production, 13 climate action, and 17 partnerships for the goals, all help to set an agenda for sustainable development. All stakeholders, governments, civil society, the private sector, and others are expected to contribute to the realization of this new agenda. These prior research efforts, conferences, reports and goals are especially important in certain regions.

Around 60 percent of the world's population lives in the Asian region and the majority of the population meet their energy needs through the combustion of fossil fuels and other non-renewable resources that emit large amounts of CO_2 (Hanif et al., 2019a). In the past two decades, this has risen from 2,002 to 5,158 billion tons. These emissions impact human health. According to the World Health Organization, about 2.4 million people die annually in South Asia, because of air pollution. In south Asia, impacts are felt and continue to increase due to increased temperatures, unpredictable precipitation, extreme weather, and sea levels. These developments have a significant impact on the economic growth, lives and livelihoods of millions of poor people in South Asian countries. This effect is caused not only by gradual temperature and sea-level changes but more specifically by increased climate fluctuations and extremities, including more severe flooding, droughts, and hurricanes.

Sabouni et al., (2014) reported that due to rapid growth in the population and energy consumption across the world, anthropogenic and environmental problems have become the focus of social science researchers and

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environmental scientists in the 21st century. Gerlagh and van der Zwaan, (2003) explore the effect of endogenous technical changes in a macroeconomic climate model on the optimum CO_2 reduction and carbon tax rates. The findings indicate that the use of endogenous innovation requires a faster reduction in emissions to achieve the necessary limits of atmospheric carbon concentration. The production of non-fossil energy technology is the most important to focus on and has the highest potential for reducing emissions. Optimal rates of a carbon tax, and reducing the use of fossil fuels, can have lower impacts. We find parallels between this prior research and South Asian countries as they endeavor to maintain economic interests while combating climate change.

The South Asia region has expanded its global influence by increasing its financial performance supported by the South Asian Association for Regional Cooperation (SAARC). This cooperation provides a platform for South Asians to work together. It promotes the welfare of South Asians while trying to improve their quality of life, accelerate economic growth, and develop social sustainability. The World Bank reported that between 2013 and 2016 economic growth in South Asian countries increased from 6.2% to 7.5% while growth in developing countries was flat or negative. Policy makers should be particularly interested in setting a more sustainable long-term goals for this region as this growth is expected to continue while these countries invest in infrastructure, agriculture, and manufacturing. While doing this, higher temperatures are having an escalating effect on this region with greater precipitation, extreme weather conditions and rising sea levels (Hanif et al., 2019; Sahimaa et al., 2017). Most of these counties reduced their reliance on limited land-based resources and non-renewable energy resources to meet sustainability goals, with approximately 18 percent of their energy coming from renewables. On a regional level, the proportion of renewable energy consumption in West Asia amounts to approximately 6.30 percent, East Asia to 6.28 percent, South Asia to 41.44 percent, Southeast Asia to 37.73 percent, and Central Asia to 20.75 percent (International Energy Agency, 2016). Land and agriculture provide the principle basis for human livelihood including the supply of food, freshwater, and ecosystem services. With humans directly impacting more than 70 percent of global land surfaces, land and agriculture play an important role in climate systems and the IPCC wants policy makers to take this into account when making country level policy decisions (IPCC, 2019).

The SAARC countries (Afghanistan, Bangladesh, Bhutan, India, the Maldives, Nepal, Pakistan, and Sri Lanka) have adopted several strategies involving sustainable development and since 1987, they have reaffirmed the need for a stronger regional partnership to protect, maintain and deal with fragile environments in the region, including the need to deal with climate and environmental disaster problems. We selected SAARC countries for this study

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because more than 20 percent of the world's population live in these countries putting the lives of 1.7 billion people at risk due to the effects of CO_2 emissions. Fossil fuels, nevertheless, are constantly increasing in demand and have made a significant contribution to economic performance (International Energy Agency, 2016). When non-renewable sources continued to increase, CO_2 increased by 6.26 billion metric tons between 1974 and 2014 in Asian countries.

The application and relevance of ISO 14001 for environment management, which is very important in both developing and developed countries as demonstrated by Ikram et al. (2019). The requirements of these systems tend to be directed both by policymakers and organizations and they recognize systems as an essential element of cooperation between regulators, standards and institutions. Despite extensive work on EMS (Melnyk et al., 2003; Darnall et al., 2008), the design of ISO 14001 environment management systems still needs in-depth research on internal dynamics (Balzarova and Castka, 2008). EMS deployment does not ensure environmental management efficiency (Rondinelli and Vastag, 2000; Melnyk et al., 2003; Campos, 2012). It is also important to constantly monitor the important integrated elements of the system and these elements are usually unique to every type of industry. Some studies Poksinska et al., (2003), Balzarova and Castka, (2008) suggest that environmental performance indicators are not directly related to EMS maintenance. Enterprises that do not use a variety of metrics for EMS performance cannot control their environmental systems and be unable to relate them to external systems (Henri and Journeault, 2008; Nawrocka and Parker, 2009). Therefore, the environmental outputs of management systems can be continually assessed in order to ensure that sustainability is integrated within enterprises, regions, and both developed and developing countries.

Given its importance, there is a wide range of research and analysis methods employed to investigate the relationship between renewable energy, agriculture, ISO 14001 and CO_2 emission (Garrido et al., 2019; Hashmi and Alam, 2019; Saidi and Mbarek, 2017; Waxin et al., 2019). All of these studies include a limited set of countries for their analysis and none quantitatively considered the role of including all SAARC countries in their analysis. These studies have provided foundational insights into the literature. Yet, we can uncover a more dynamic understanding of the relationships by considering all the SAARC countries simultaneously. Therefore, in this study, we are trying to fill this gap in the literature by investigating the nexus between ISO 14001, Renewable Energy, Access to Electricity, agriculture and CO_2 emission by adopting novel Grey Relation Analysis and Grey TOPSIS techniques as these methods are more suitable as compared to other approaches for compelling results and help avoid endogeneity issues involved with acquiring CO_2 emission factors. What makes the applied methodology in this study appropriate is that

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the grey relational analysis models (GRA) and Grey TOPSIS have significant advantages over other models and prior studies due to their ability to provide super accuracy on small sets of data and when using data with incomplete information. We would further add that it is critical to examine these contemporary relationships because more than 20 percent of the world's population lived in SAARC nations. The lives of 1.7 billion humans are at risk due to CO_2 effects.

This study had five main objectives: (I) to determine how renewable energy consumption affects the CO_2 emission in SAARC region, (II) to what extent access to electricity does change CO_2 emission (III) to characterize the degree of impression of agriculture production on CO_2 emission (IV) How registration of ISO 14001 certification help to develop environmental sustainability through reduction of CO_2 emission and finally, (V) which factor can contribute more in reduction of CO_2 emissions for SAARC countries. The expected new insights gained from this study and our methods include; an analysis of relationships between renewable energy, access to electricity, agriculture, ISO 14001 certification and CO_2 emissions across all SAARC countries, testing to see if ISO 14001 certifications help decrease CO_2 emissions, assessing the relative effects of renewable energy systems across countries, and the application of new modeling techniques to develop more accurate results.

The structure of this paper has five main sections. After the introduction, we review the existing literature related to access to electricity, ISO 14001, agriculture, renewable energy consumption, and carbon emissions. Next, we detail the research framework and methods of analysis. The empirical results and discussion are then covered before going into the conclusions.

2 Literature Review

Human beings face challenges in the form of climate change. Collective attempts to tackle and mitigate climate change can be complex and interrelated. The countries of the South Asian Association of Regional Coordination (SAARC) in the area of South Asia are working on this and taking a series of measures to ensure security, sustainability and a balance of ecological change. One important measure of global warming potential is CO_2.

By using the environmental Kuznets curve from 1980 to 2009, Al Mamun et al. (2014) calculated the effects of CO_2 and per capita GDP. The findings showed that GDP per capita is positive and significantly associated with carbon dioxide emissions. To analyze the relationship between economic growth, CO_2 and energy use during 1971 and 2007 in six association of southeast Asian nations (ASEAN) countries, Cowan et al., (2014) presented a 3 variable VAR method panel. The findings showed that the relationship between selected variables is unidirectional. Results revealed

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that there was a unidirectional relation between selected variables. Moreover, Shahbaz et al., (2016) investigated the effect of energy intensity on CO_2 emission by using the Environmental Kuznets Curve (EKC) in 9 African countries. The finding showed the positive relationship in Africa. Saidi and Hammami (2015) emphasized Italy's GDP and power consumption ratio from 1970 to 2009 and the result was a short-term unidirectional energy-to-GDP relationship and a long-term bi-directional association. The unidirectional link between renewable energy outputs and CO_2 emittance for Italy persists, as identified by Bento and (Cerdeira Bento and Moutinho, 2016).

Kais and Mounir (2017) have further explored similar relationships in Japan, Canada, Spain, France, Switzerland, Netherlands, the United Kingdom, Sweden and the USA connection between nuclear energy, environmental degradation, GDP and renewable energy for the period from 1990 to 2013. The results showed a relationship between CO_2 and GDP, yet they did not find a relation between renewable energy and environmental degradation. The correlation between economic growth, renewable energy use and CO_2 for Algeria has been explored by Bélaïd and Youssef (2017). Further, the relationship between Tunisia's renewable energy use and CO_2 was found to be negative by Ben Jebli and Ben Youssef (2017).

Bayrakci and Koçar (2012) and Waheed et al. (2018) also assessed the relationship between renewable energy, agriculture and CO_2 using Granger causality and vector error correction models. Their findings indicated that agriculture has a bi-directional relationship with carbon emissions. Similarly, Bhattacharya et al. (2017) applied the general approach of moments & OLS methods and reached the conclusion that in 85 industrialized & evolutionary countries, renewable energy consumption had a negative impact on CO_2 emissions. The effect of CO_2 emissions, energy consumption, and economic growth in Pakistan has been measured in the years 1975 to 2011 by Khan (2019). Al-Mulali et al., (2016) calculated the effect of renewable energy consumption on pollution by using environmental Kuznets curve. The findings indicated that renewable energy consumption has less influential effect on pollution in the Middle East and North Africa and Sub-Saharan Africa.

Akhmat et al., (2014) investigated causal relationships in the countries of South Asia, namely Sri Lanka, Bangladesh, Bhutan, India, the Maldives, Pakistan, Nepal, and Afghanistan between the years 1975-2010 and the cause of nuclear use, commercial energy consumption (i.e. electricity usage, oil consumption, gas consumption, and the coal usage). The findings show that the use of nuclear energy in Bangladesh, Bhutan, Maldives, Nepal and Srilanka is causing economic growth, while the industrial use of electricity is causing economic growth in India, Nepal, Maldives and Bhutan, and the use of nuclear power is causing economic growth in Pakistan and Bangladesh. The relationship between energy use and growth in China during the period 1971–2011 is explored in Balsalobre-Lorente et al. (2018). The results have shown a positive impact on the economic growth of energy use, financial development, international trade, importations, exports, and capital. The causality analysis of Granger shows a unidirectional causal link between energy consumption and economic growth. Granger is responsible for financial growth and energy use. The causalities between the use of energy and international trade are bidirectional. The input relationship between foreign and financial growth exists. There is also bidirectional causality between the demand for capital and resources, between financial and economic development, between foreign trade and economic growth. The discussion above suggests that environmental pollutants have an important relationship with energy consumption. In the following section, we establish statistical energy-atmosphere relationships in selected SAARC countries.

The wide geographical context of ISO 14001 has encouraged a broad, yet unambiguous, academic debate about its effectiveness. Most research studies (Ann et al., 2006; Melnyk et al., 2003; Potoski and Prakash, 2005; Pun and Hui, 2001; Gasbarro et al., 2013), have shown positive effects from the regulations, while the results of certification ISO 14001 boost environmental efficiency, while some studies question these benefits (Welch et al., 2003; King et al., 2005; Barla, 2007; Christmann and Taylor, 2006). Boiral and Henri (2012) emphasize in their review article that the majority of the empirical studies analyzed show positive relationships between environmental management activities (e.g. ISO 14001) and company environmental performances. The research reflects the positive results of ISO 14001 implementation and environmental efficiency (Garrido et al., 2020) . One example is the report by Melnyk et al., (2003b), where a survey of 1510 manufacturing companies in the USA reveals significant improvements related to waste indicators. Another research by King et al., (2005) on US plants shows that the performance enhancement of ISO14001 could be accomplished. This study includes a list of 7899 factories and data from the Toxic Release Inventory (TRI). Anton et al. (2004) implemented a similar approach to the kind of data used in assessing environmental efficiency, which found the implementation of a more robust EMS had a substantial impact on reducing the severity of toxic releases and stressed that the value of those measures appears to be important for companies whose environmental performance is initially low. In a research in the environmental sciences, Nishitani et al. (2012), using a data panel of 500 Japanese manufacturing companies and emissions and data from the Japan Pollution Release and Transfer Register (PRTR) from 2002 to 2008, found out that approximately 60% of companies have adopted ISO14001 for more than 4 years. In these situations, their statistical model indicates that industries that adopt an EMS are more likely than those who do not adopt, to reduce their pollution emissions.

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In the SAARC countries, CO_2 emissions are a growing issue. Several studies have been conducted in order to study the ties between the use of renewable energy and CO_2 in SAARC countries, but no effort has been made to take all SAARC countries into consideration and the results have been mixed. We believe this indicates the previous studies have been incomplete in not including other SAAC countries such as Maldives, Afghanistan, and Bhutan. In this study, we have employed mathematically model namely GRA model to compute the weights and further GTOPSIS was used to prioritize the intensify factors that can overcome the CO2 emission. This study also bridges the gap in the literature by exploring the association between the use of renewable energy, access to electricity, ISO 14001 certification, agriculture as well as carbon dioxide emissions for all SAARC countries.

3. Methods

3.1 Data

The purpose of this study is to investigate the useful connections between renewable energy consumption, access to electricity, agriculture, EMS, and carbon emission. To start, SAARC countries were selected included Bangladesh, India, Nepal, Pakistan, Afghanistan, Bhutan, Maldives, and Sri-Lanka. The data used in this study adopted from World Development Indicators (WDI) and the International Organization for Standardization (ISO 2018) from 2000 to 2014. The detailed description of variables is presented in Table 1. The advanced mathematical technique namely GRA and TOPSIS are used to enable analysis; Grey software v8.0 developed by Nanjing University of Aeronautics and Astronautics (NUAA) was used to gauge the effect of renewable energy consumption, access to electricity, agriculture, EMS on CO_2 emission. A conservative (maximin) model was used for decision making under uncertainty. Further, G-TOPSIS was employed to prioritize the factors with increased effects on CO_2 emissions and solved with the help of MATLAB and MS excel. The study framework can be seen in Figure 1.

Table 1: The description of Variables and data source

Variables	Description of variables	Unit of measurement	Data source
CO_2	Carbon emission	per capita in metric	WDI
RE	Renewable energy consumption	% of total energy consumption	WDI
EMS	Environmental Management System	ISO 14001 certifications	ISO
AC	Access to electricity	% of population	WDI
AG	Agriculture value added	% of GDP	WDI

Source: Self elaboration.

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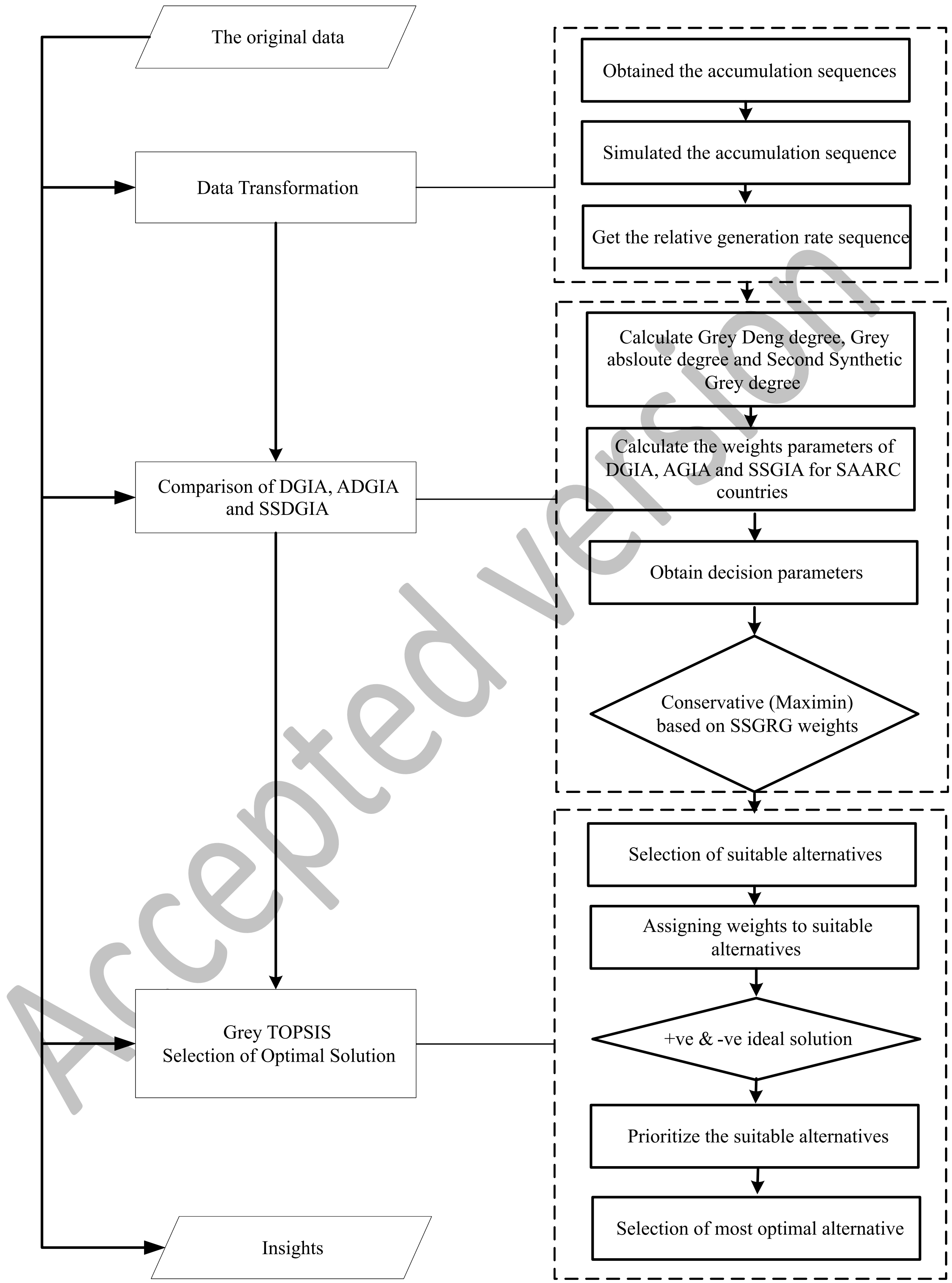

Figure 1. Framework operationalized in this study

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3.2 Grey Relational Analysis (GRA) models

GRA models are also known as Grey Incidence Analysis (GIA) models (Javed et al., 2019), and generally regarded as a preliminary part of the new theory of grey systems (Badri Ahmadi et al., 2017). The theory of the grey system is based on the work performed in 1982 by a Chinese scientist, Professor Julong Deng, which was used at that time in various areas of learning for handling vulnerability issues for poor information and largely obscure processes. An important advantage of utilizing this approach is its applicability even for small data samples (Ajdadi et al., 2017). In 1985, Deng presented GRA's model with the concept of the grey relational grade (GRG). As reported by Wang and Ye (2017), it is observed that the accuracy level of grey incidence model is higher over statistical models of system analysis. The benefit of of the grey incidence model is to ensure accuracy in assessment and solve the unknown problems in any process that lack's physical details and ambiguous mechanical functions and working design (Javed and Liu, 2018a). The basic principle behind GRA models is to utilize the degree of proximity for a geometric curve in an open data structure to assess in order to check the associations (Liu et al., 2017, p.68). There are three types of proximities in GRA models If Deng's GRA model relates partial closeness/proximity, then absolute GRA relates integral closeness/proximity between two data sequences, whereas, the second synthetic GRA aims to reveal a more comprehensive closeness /inclusive proximity (Javed et al., 2019).

Deng's degree of GRA Model: Several GRA models have been proposed by various researchers, but Deng's proposed model (1985) tends to be more influential and effective and plays a key role in grey system theory (Bayramoglu and Hamzacebi, 2016). Taking the original concept of this model into consideration, the Deng's degree of GRA model has been used in several real-life problems in various fields, either related to theoretical or empirical questions (Zuo et al., 2016). According to Ikram et al. (2019) below are the two sets of data shown by X0 and X1 for the estimation of Deng's gray incidence:

The first step involved the computation of the initial image of X_0 and X_i, i=1, 2, …, m, where:

$$X'i = Xi / xi(1) = (x'i(1), x'i(2), \ldots, x'i(n)); i = 0,1,2,3\ldots,m. \tag{1}$$

The second step calculates the difference of sequence X'_0 and X'_i i=1, 2,3, …, m, as:

$$\Delta i(l) = |\, x'0(l) - x'i(l) \,|, \Delta = (\Delta i(1), \Delta i(2), \ldots, \Delta i(n)), i = 1,2,3,\ldots,m. \tag{2}$$

The third step includes the difference of maximum and minimum written as:

$$M = \max_i \max_l \Delta_i(L),\ m = \min_i \min_l \Delta_i(L). \tag{3}$$

Further, the 4th step calculates the grey incidence coefficients (sometimes termed as Grey/Point relation coefficients) by using the following formulae:

$$\gamma_{0i}(l) = \frac{m + \xi M}{\Delta i(l) + \xi M}; \xi \in (0,1); l = 1,2,\ldots,n; i = 1,2,\ldots,m, \tag{4}$$

The distinctive coefficient is represented by ξ and value assumed to be ξ=0.5.

The last, and fifth step is estimated the grey Incident degree also called grey incidence Deng's degree follow as:

$$\gamma_{0i} = \frac{1}{n}\sum_{l=1}^{n}\left(\gamma_{0i}(L)\right); i = 1,2,\ldots,m. \tag{5}$$

If we change this fractional form of 1/n with weights wk, then, it can be written as:

$$\gamma 0i = \sum L = 1n(\gamma 0i(L) \times wl); i = 1,2,3\ldots,m. \tag{6}$$

If the impact for each factor is not the same on the system, then the sum of weights will be equivalent to one i.e. $\sum wl = 1$. This description is available in (Sarıkaya and Güllü, 2015). This means $\frac{1}{n}$ implies that the weighting parameters are equally distributed, while w_k is an unequally distributed weighting scheme that is common in real-life challenges (Javed and Liu, 2018b). The first half of Deng's relational model can be linked effectively as each free factor is equally weighted in the top three CO_2 emitting sectors.

Absolute degree of GRA model: Xu and Li (2018) demonstrates that when the Deng GRA provides insight into the impact of the GRA components (represented through the Grey Dataset sequence), the ADGRA, also known as the absolute GRA model, offers insight into the relations between these factors (Zhicai and Li, 2018). Deng degree and absolute degree of GRA models are intended to reach the primary goal by analyzing the geometrical vicinity of the succession curves through their specific manner and attained a considerable worth in the research.

The following are the steps to determine the absolute Grey Relation in two equal time intervals evenly between X0 and X1:

In the first step, X_0^0 and $X_1^0$are the zero starting point which is calculated on the basis of the interval sequence in X0 and X1.

The second step involves the computation of $|s_0|, |s_1|$ & $|s_1 - s_0|$.

Lastly, the absolute degree of grey incidence (ε01) is estimated through the time interval sequence i.e. X0 and X1. For that, the following formula is:

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

Further details on the GRA models i.e. Deng's incidence, the absolute relational model and their characteristics, (Liu et al., 2017, Chapter 5) is recommended.

Definitions

Definition I: Degree of GRA model

Deng's GRA model proposed the Deng degree of grey incidence or GRG which is also known as Deng's grey relation analysis (DGRA) model. It is presented as:

$$\gamma_{0i} = \sum_{l=1}^{n}\left(\gamma_{0i}\left(L\right)\times w_l\right); i = 1,2,3,\ldots,m, \tag{8}$$

Or

$$\gamma_{0i} = \frac{1}{n}\sum_{l=1}^{n}\left(\gamma_{0i}\left(L\right)\right); i = 1,2,3,\ldots,m, \tag{9}$$

Where γ0i (L) denotes the grey relational coefficient also known as coefficient of grey incidence. The first equation of the DGRA model denotes the weighted form of GRA and the second is a non-weighting (or equal weight) scheme.

Definition II Absolute Degree Grey Relational Analysis (ADGRA)

The Absolute GRA model introduced the concept of the absolute degree of grey relation that is also known as the ADGRA model. It is as follows:

$$\varepsilon_{01} = (1+|s_0|+|s_1|)/\,(1+|s_0|+|s_1|+|s_0-s_1|) \tag{10}$$

Definition III: zero-starting point image

Let the system behavior data sequence represent as $X_i = (x_i(1), x_i(2), \ldots, x_i(n))$ and C indicate the satisfying sequence operator, and $X_i(L)c = (x_i(L)c - x_i(1); L = 1,2,3,..n$ then C is point operator starting from zero and XiC is known as Xi's zero-scale point image. XiC is often written as $X_iC = X_1^0 = (x_i^0(1), x_i^0(2), \ldots x_i^0(n))$.

Definition IV: |s0|, |s1| and |s1−s0|

We assume that Huang et al., (2019), Dong et al.,(2017) X_i and X_j are the same in length as one time-interval sequence variables and Xi and Xj are the following zero-starting point images:

$$X_i^0 = \left(x_i^0(1), x_i^0(2), x_i^0(3)\ldots, x_i^0(n)\right),$$

$$X_j^0 = \left(x_j^0(1), x_j^0(2), x_j^0(3)\ldots, x_j^0(n)\right). \tag{11}$$

Then

$$|s_i| = \left|\sum_{l=2}^{n-1} x_i^0(L) + \frac{1}{2} x_i^0(n)\right|$$

and

$$|s_j| = \left|\sum_{l=2}^{n-1} x_j^0(L) + \frac{1}{2} x_j^0(n)\right| \tag{12}$$

The absolute difference between $s_i - s_j$ is calculated as:

$$|s_i - s_j| = \left|\sum_{l=2}^{n-1} \left(x_i^0(L) - x_j^0(L)\right) + \frac{1}{2}\left(x_i^0(n) - x_j^0(n)\right)\right| \tag{13}$$

Definition V: Second Synthetic Degree of Grey Relation Analysis (SSDGRA) model

The Second Synthetic GRA model or the SSDGRA model proposed by (Javed and Liu, 2018b) is given as:

$$\rho_{ij} = \theta\varepsilon_{ij} + (1-\theta)\gamma_{ij};\ \theta \in [0,1], \tag{14}$$

Where ρij is a Second synthetic degree of grey incidence/grey relation (SSGRG), γij is denoted as Deng's degree of grey incidence (GRG) and εij denotes the absolute degree of grey relation (absolute GRG). The Grey incidence model of Deng relies on the coefficient of grey relation/incidence at certain points. The absolute relational model relies on an integrated (comparatively broader) perspective (Liu et al., 2016, p. 69). The SSDGRA determines the overall relationship between two sequence levels and an integral role. The first synthetic grey model methodology (SDGRA) was introduced in conjunction with absolute and relative grey incidence Liu et al. (2016).

The SSDGRA model was developed based on the SDGRA model's working standard. It recommends considering θ=0.5 when making decisions when achieving a thorough positioning that equally combines the advantages of the two terms, i.e. γ and ε, without preferring one over the other and, if appropriate, θ could be changed. If someone wants to endorse γ, then the θ calculation might get decreased at that point, but if you want ε then the total value can also be increased at that point (Javed and Liu, 2018b).

3.3 Grey System Theory

The concept of Grey system theory was first time introduced by Deng in 1982. Grey system works with partial and incomplete data and has been adopted globally to solve complex and uncertain problems. The technique of Grey system has been used in many fields such as medical sciences, social science, natural sciences, industrial engineering etc. The main advantage of Grey models is that they can provide accurate results on small sets of data which provides superiority over other methods. The degree of data transparency is an important feature of Grey system (Liu and Forrest, 2010). Grey system data exist between white and black system data on partial and incomplete data; if the system has full and known data it's called white data. If a system has unknown data it is said to be black data (Feng et al., 2019). We employed the Grey TOPSIS method based on weights obtained by GRA models to investigate which factors, i.e., Access to electricity, Consumption of renewable energy, Agriculture and ISO 14001 certification will have a larger effect on CO_2 emission in SAARC countries.

3.4 Grey Numbers

A Grey number is an interval between a known and unknown range of partial and incomplete values which is represented by symbol$\otimes$. There are several types of grey numbers in grey system; however, this study utilizes several types of grey numbers. The description of these grey number as follows (Sifeng Liu, Yingjie Yang, 2016):

Type (1): If $\otimes$ D is a grey number consisting of only a lower bound is said to be grey number with lower bound. We can only calculate the lower bound of this grey number and is represented by$\otimes D = [\underline{D}, \infty)$.

Type (2): If $\otimes$ D is a grey number consisting of only a lower bound is said to be grey number with lower bound. We can only calculate the lower bound of this grey number and is represented by$\otimes D = (\infty, \overline{D}]$.

Type (3): If $\otimes D$ is a grey number consisting of only a lower bound is said to be grey number with lower bound. We can only calculate the lower bound of this grey number and is represented by$\otimes D = [\underline{D}, \overline{D}]$.

If $\otimes D = [\underline{D}, \overline{D}]$ and $\otimes E = [\underline{E}, \overline{E}]$ are two grey numbers, then arithmetic operations (Zare et al., 2018), can be written on them as Eqs. (15) to (18):

$$\otimes D + \otimes E = [\underline{D} + \underline{E}, \overline{D} + \overline{E}] \quad (15)$$

$$\otimes D - \otimes E = \otimes D + (-\otimes E) = [\underline{D} - \overline{E}, \overline{D} - \underline{E}] \quad (16)$$

$$\otimes D \times \otimes E = [Min\{\underline{D}\,\underline{E}, \overline{D}\,\overline{E}, \overline{D}\,\underline{E}, \underline{D}\overline{E}\}, Max\{\underline{D}\,\underline{E}, \overline{D}\,\overline{E}, \overline{D}\,\underline{E}, \underline{D}\overline{E}\}] \quad (17)$$

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$$\frac{\otimes D}{\otimes E} = \otimes D \times \otimes E^{-1}$$
$$= \left[Min \left\{ \frac{\underline{D}}{\underline{E}}, \frac{\underline{D}}{\overline{E}}, \frac{\overline{D}}{\underline{E}}, \frac{\overline{D}}{\overline{E}} \right\}, Max \left\{ \frac{\underline{D}}{\underline{E}}, \frac{\underline{D}}{\overline{E}}, \frac{\overline{D}}{\underline{E}}, \frac{\overline{D}}{\overline{E}} \right\} \right] \tag{18}$$

The length of the grey number $\otimes D = [\underline{D}, \overline{D}]$ is represented by Eq. (19):

$$Z(\otimes D) = \overline{D} - \underline{D} \tag{19}$$

If $\otimes D = [\underline{D}, \overline{D}]$ and $\otimes E = [\underline{E}, \overline{E}]$, represent two grey numbers, we can obtain the degree of greyness between these two numbers by using Eq. (20) (Bakar et al., 2019). This study checks the overall impact of main factors effecting the CO2 emission by using the Grey linguistic variables based on grey numbers which is presented in Table 2.

$$P\{\otimes \boldsymbol{D} \leq \otimes E\} = \frac{Max\{0, Z^* - Max(0, \overline{D} - \underline{E})\}}{Z^*} \qquad \text{Where } Z^* = Z(\otimes D) + Z(\otimes E) \tag{20}$$

Table 2: Linguistic variable based on grey numbers

High Ineffective	Ineffective	Moderate	Effective	High Effective
H I	I E	M	E	H E
[0.0,0.2]	[0.2,0.4]	[0.4,0.6]	[0.6,0.8]	[0.8,1.0]

3.5 Grey TOPSIS Method

The concept of TOPSIS was introduced by Huang and Yun in 1981, in which n alternatives are ranked by the m criteria. The benefit of TOPSIS method provides the positive and negative ideal solutions of problem. The positive ideal solution depicts the increase in profit and reductions in cost standards. Further, the selection of optimal alternatives is based on the least distance from the positive ideal solution and maximum distance from the negative solution. Considering, the benefit of Grey system to help ensure accuracy in assessment for uncertain system data. We define the steps of grey TOPSIS method as fellow below (Ikram et al., 2020).

Level 1: First, we calculate the weights of each criterion based on expert opinion by using grey linguistic variables as presented in Table 4. If the number of decision makers is e, the criterion g weight of alternatives is computed using Eq. (21).

$$\otimes w_g = \frac{1}{e}\left[\otimes w_g^1 + \otimes w_g^2 + \cdots + \otimes w_g^e\right] \tag{21}$$

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Level 2: The Grey linguistic variables should be used to check the status of each research alternative in each of the criteria. If the number of decision makers is e, the value of alternative h in the criterion g is calculated by Eq. (22).

$$\otimes G_{hg} = \frac{1}{e}\left[\otimes G_{hg}^{1} + \otimes G_{hg}^{2} + \cdots + \otimes G_{hg}^{e}\right] \tag{22}$$

Level 3: Propose the grey decision matrix as written in Eq. (23).

$$E = \begin{bmatrix} \otimes G_{11} & \otimes G_{12} & \dots & \otimes G_{1n} \\ \otimes G_{21} & \otimes G_{22} & \dots & \otimes G_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \otimes G_{m1} & \otimes G_{m2} & \dots & \otimes G_{mn} \end{bmatrix} \tag{23}$$

In Eq. (24), $\otimes G_{hg}$ shows the importance of the alternative h in the criterion g.

Level 4: Normalize the grey decision matrix is represented in (12)

$$E^{*} = \begin{bmatrix} \otimes G_{11}{}^{*} & \otimes G_{12}{}^{*} & \dots & \otimes G_{1n}{}^{*} \\ \otimes G_{21}{}^{*} & \otimes G_{22}{}^{*} & \dots & \otimes G_{2n}{}^{*} \\ \vdots & \vdots & \vdots & \vdots \\ \otimes G_{m1}{}^{*} & \otimes G_{m2}{}^{*} & \dots & \otimes G_{mn}{}^{*} \end{bmatrix} \tag{24}$$

If the criteria is of benefit attribute, Eq. (25) is used for normalization.

$$G^{*}{}_{hg} = \left[\frac{\underline{G}_{hg}}{G_{g}^{max}}, \frac{\overline{G}_{hg}}{G_{g}^{max}}\right] \ Where\ G_{g}^{max} = max_{1\leq g\leq m}\{\overline{G}_{hg}\} \tag{25}$$

If the criterion is of cost attribute, Eq. (26) is used for normalization.

$$G^{*}{}_{hg} = \left[\frac{G_{g}^{min}}{\overline{G}_{hg}}, \frac{G_{g}^{min}}{\underline{G}_{hg}}\right] \ Where\ G_{g}^{min} = min_{1\leq g\leq m}\{\underline{G}_{hg}\} \tag{26}$$

Grey matrix values will be in the range [0,1] after the normalization process.

Level 5: A weighted normalized grey decision grey decision matrix is formulated at this stage and expressed in Eq. (27).

$$X = \begin{bmatrix} \otimes X_{11} & \otimes X_{12} & \dots & \otimes X_{1n} \\ \otimes X_{21} & \otimes X_{22} & \dots & \otimes X_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \otimes X_{m1} & \otimes X_{m2} & \dots & \otimes X_{mn} \end{bmatrix} Where\ \otimes X_{hg} = \otimes G_{hg}^{*} \times \otimes w_{g} \tag{27}$$

Level 6: The value of positive and negative ideal solutions can be computed by Eqs. (28) and (29).

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$$S^{max} = \{[max_{1\leq g\leq m}\,\underline{X}_{\,h1}, max_{1\leq g\leq m}\,\overline{X}_{\,h1}], [max_{1\leq g\leq m}\,\underline{X}_{\,h2}, max_{1\leq g\leq m}\,\overline{X}_{\,h2}], \dots, [max_{1\leq g\leq m}\,\underline{X}_{\,hn}, max_{1\leq g\leq m}\,\overline{X}_{\,hn}]\} \quad (28)$$

$$S^{min} = \{[min_{1\leq g\leq m}\,X_{\,h1}, min_{1\leq g\leq m}\,\overline{X}_{\,h1}], [min_{1\leq g\leq m}\,X_{\,h2}, min_{1\leq g\leq m}\,\overline{X}_{\,h2}], \dots, [min_{1\leq g\leq m}\,\underline{X}_{\,hn}, min_{1\leq g\leq m}\,\overline{X}_{\,hn}]\} \quad (29)$$

Level 7: The calculation of degree of greyness between the ideal solution and alternatives is presented in Eq. (30) (Zare et al., 2018).

$$A\{S_h \leq S^{max}\} = \frac{1}{n}\sum_{g=1}^{n} A\{\otimes X_{hg} \leq \otimes G_g^{max}\} \quad (30)$$

Level 8: An ascending order was set for alternatives; and considers a high priority with lowest degree of greyness based on the values obtained in step 7.

4 Results and Discussion

The results of the grey relation models such as Deng GRG, Absolute GRG and SSGRG between access to electricity, renewable energy consumption, agriculture, ISO 14001 certification and carbon emissions of SAARC countries (Pakistan, Nepal, Maldives, Sri Lanka, India, Bhutan, Bangladesh, and Afghanistan) are shown in Tables 1 to 3. The measurement scale of relationships between access to electricity, renewable energy and population, and carbon emissions is 0 to 1. The weakest relationship in Absolute GRG and SSGRG denoted by 0, whereas, strongest associations among variables is represented by 1. For Deng RGR the standardized scale is 0.5 to 1. Absolute GRG and second synthetic are between 0 to 1.

According to Absolute GRG, the association between access to electricity and CO_2 emission, a strong relationship is observed in Sri Lanka by obtaining the weight (0.98519) is presented in Table 3. Moreover, Bangladesh has the second height weight (0.98494). Whereas, Afghanistan and India observed the least influencing countries where a weak association of access to electricity and CO_2 emission was measured based on Absolute RGR. Similarly, a different sequence of ranking is obtained among SAARC countries based on Deng GRG. According to Deng GRG, Bhutan obtained the highest weight (0.68721) followed by Afghanistan and Pakistan by obtaining weight (0.61329) and (0.60369), respectively. Bangladesh and India show the weak effect of access to electricity on CO_2 emission. Similarly, SSGRG reveals the strong effect of access to electricity on CO_2 emission observed in Pakistan and Bhutan by obtaining the weights (0.81625) and (0.81241), respectively as presented in Figure 2.

Table 3: Grey Relational assessment for access to electricity and CO_2 emission in SAARC countries

Country	Absolute GRG	Deng GRG	SSGRG

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Pakistan	0.9657	0.66681	0.81625
Nepal	0.98334	0.62806	0.80570
Maldives	0.94231	0.63004	0.78618
Sri Lanka	0.98519	0.63269	0.80894
India	0.91219	0.60369	0.75794
Bhutan	0.93761	0.68721	0.81241
Bangladesh	0.98494	0.61329	0.79911
Afghanistan	0.92682	0.68513	0.80597

This positive high value results suggests that SAARC countries produced electricity with fossil fuels, gases and other non-renewable sources without considering its harmful impact on the atmosphere (Mohsin et al., 2019)

In Table 4, the estimation results show that renewable energy consumption is strongly associated with CO_2 emissions as measured by Absolute GRG supporting relationships in prior studies by Jebli and Youssef (2017), along with Bayrakci and Kocar (2012), and Al-Mulali et al., (2016). It indicates that CO_2 emissions are higher in Pakistan due to less use of renewable sources for energy production. Therefore, Pakistan is listed top seventh vulnerable country to climate change (M. Ikram et al., 2019b). While in the model of Deng GRG, a strong association of renewable energy consumption and CO_2 emission observed in Sri Lanka by obtaining the weight (0.57016) followed by Nepal, Bhutan, and Pakistan (0.67289), (0.65013) and (0.64279) weights respectively. According to the SSGRG, Sri Lanka obtained the heights weight (0.84208) and ranked 1st among the SAARC countries. Whereas, Afghanistan comes in 8th with a weight of (0.45583), showing the weakest relationship of renewable energy consumption and CO_2 emission.

Table 4: Grey Relational assessment for Renewable energy consumption and CO_2 emission in SAARC countries

Country	Absolute GRG	Deng GRG	SSGRG
Pakistan	0.93741	0.64279	0.79010
Nepal	0.77102	0.67289	0.72195
Maldives	0.73801	0.57911	0.65856
Sri Lanka	0.92042	0.76374	0.84208
India	0.72090	0.57016	0.64553
Bhutan	0.75525	0.65013	0.70269
Bangladesh	0.70721	0.56832	0.63776
Afghanistan	0.31708	0.59458	0.45583

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Our results endorsed the study of SUn et al.., (2019), that also showed the positive effect of renewable energy consumption with CO_2. This result raises the importance of renewable energy as an alternative source and suggests that reduction of CO_2 emission is possible through its extra use.

A review of the association of agriculture and CO_2 emission using the estimation of grey relational models can be found in Table 5. The results support prior findings confirming the relationship and importance of agriculture and other variables in this study in work by Waheed et al., (2018) and Bayrakci and Kocar (2012). According to Absolute GRG weight calculation, Pakistan obtained the highest weight (0.98591) and ranked 1st among all SAARC countries based on the association of agriculture and CO_2 emission. Moreover, Afghanistan and Bhutan considered the least influential countries regarding the effect of agriculture on CO_2 emissions with weights of (0.64850) and (0.61770), respectively. Similarly, Nepal appeared the most influential country among SAARC countries based on Deng GRG and SSGRG within the category by obtaining the weights (0.82811) and (0.79119), respectively.

Table 5: Grey Relational assessment for agriculture and CO_2 emission in SAARC countries

Country	Absolute GRG	Deng GRG	SSGRG
Pakistan	0.98591	0.58736	0.78663
Nepal	0.75427	0.82811	0.79119
Maldives	0.93661	0.59664	0.76663
Sri Lanka	0.78023	0.68293	0.73158
India	0.79978	0.57168	0.68573
Bhutan	0.61770	0.60751	0.61260
Bangladesh	0.74762	0.56912	0.65837
Afghanistan	0.64850	0.60648	0.62749

We have investigated how the adoption of ISO 14001 certification help to overcome CO_2 emission. Interestingly, and according to Absolute, Deng and SSGRG, a strong association was observed in Afghanistan by obtaining the highest weight (0.92326), (0.87271) and (0.89799), followed by Bhutan and Nepal by receiving weights (0.88916) and (0.85633) respectively. Whereas Pakistan considered the least influential country to control the CO_2 emission through the adoption of ISO 14001 certification by obtaining the weights (0.70125) and (062465) is presented in Table 6. Moreover, Sri Lanka and Maldives sustain their position by obtaining the weights (0.63731) and (0.68286) respectively. This analysis strengthen the arguments of ISO 14001 and environmental efficiency (Girrido et al., 2020) and Waheed et al., (2018), which explained that CO2 emission in agriculture is mainly caused by nitrous oxide and

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methane which are produced by livestock residuals and soil management. In addition, non-renewable energy like diesel fuel was used in agricultural sector for the purpose of irrigation which cause CO_2 emission. Farmers also utilizes different chemical pesticides and fertilizers with high amount of nitrogen to protect and raise the level of their yields which also surge the CO_2.

Table 6: Grey Relational assessment for ISO 14001 and CO_2 emission in SAARC countries

Country	Absolute GRG	Deng GRG	SSGRG
Pakistan	0.70125	0.54805	0.62465
Nepal	0.85633	0.58684	0.72159
Maldives	0.76229	0.60342	0.68286
Sri Lanka	0.70635	0.56827	0.63731
India	0.81638	0.58966	0.70302
Bhutan	0.88916	0.54210	0.71563
Bangladesh	0.79492	0.63063	0.71278
Afghanistan	0.92326	0.87271	0.89799

In Table 7, the Grey Relation association between accesses to electricity, consumption of renewable energy, population add value to % of GDP, ISO 14001 certification and CO_2 within SAARC countries is represented. The results support prior arguments for improved environmental performance by Boiral and Henri (2012). To make it simpler, the ranking position for each grey model has been used in every country with respect of the corresponding variable CO_2 emission has been displayed. In the case of access to electricity, India has the same position due to weak association between electricity consumption and CO_2 emission. According to renewable energy consumption and CO_2, India also maintained its position based on Absolute GRG and SSGRG. Whereas, Nepal obtained the highest weight regarding the association of agriculture and CO_2 emission and is in the 1st row based on Deng GRG and SSGRG. When looking at ISO 14001 adoption and CO_2 emission, Afghanistan showed the same ranking position based on Absolute GRG, Deng GRG and SSGRG.

Table 7: Grey Assessment Ranking of SAARC countries

Variables	Grey Relational Model	Ranking
Access to electricity	Second Synthetic GRG	Pakistan> Bhutan> Sri Lanka> Afghanistan> Nepal> Bangladesh> Maldives> India

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Renewable energy consumption	Second Synthetic GRG	Sri Lanka> Pakistan> Nepal> Bhutan> Maldives> India> Bangladesh> Afghanistan
Agriculture value added	Second Synthetic GRG	Nepal> Pakistan> Maldives> Sri Lanka> India> Bangladesh> Afghanistan> Bhutan
EMS (ISO 14001)	Second Synthetic GRG	Afghanistan> Nepal> Bhutan> Bangladesh> India> Maldives> Sri Lanka> Pakistan

This decision analysis helps to quantify the difference of CO2 emission between all SAARC countries. For this objective, a first step is necessary to assess the states of nature and alternative actions as characterized in table 8.

Table 8: Decision Parameters description

Goal	**Measuring Grey Relation (Association) between Access to electricity, Renewable Energy consumption, Agriculture value added, ISO 14001 and CO2 emission within SAARC Countries**
State of Nature/Criteria (Dj); N = 1, 2,…,k	Pakistan (D_1) Nepal (D_2) Maldives (D_3) Sri Lanka (D_4) India (D_5) Bhutan (D_6) Bangladesh (D_7) Afghanistan (D_8)
Alternative Actions (Si); p=1, 2,…,m	Grey Relation was superior between Access to electricity and CO_2 emission (S1) Grey Relation was superior between Renewable consumption and CO_2 emission (S2) Grey Relation was superior between Agriculture value-added and CO_2 emission (S3) Grey Relation was superior between ISO 14001 and CO_2 emission (S4)

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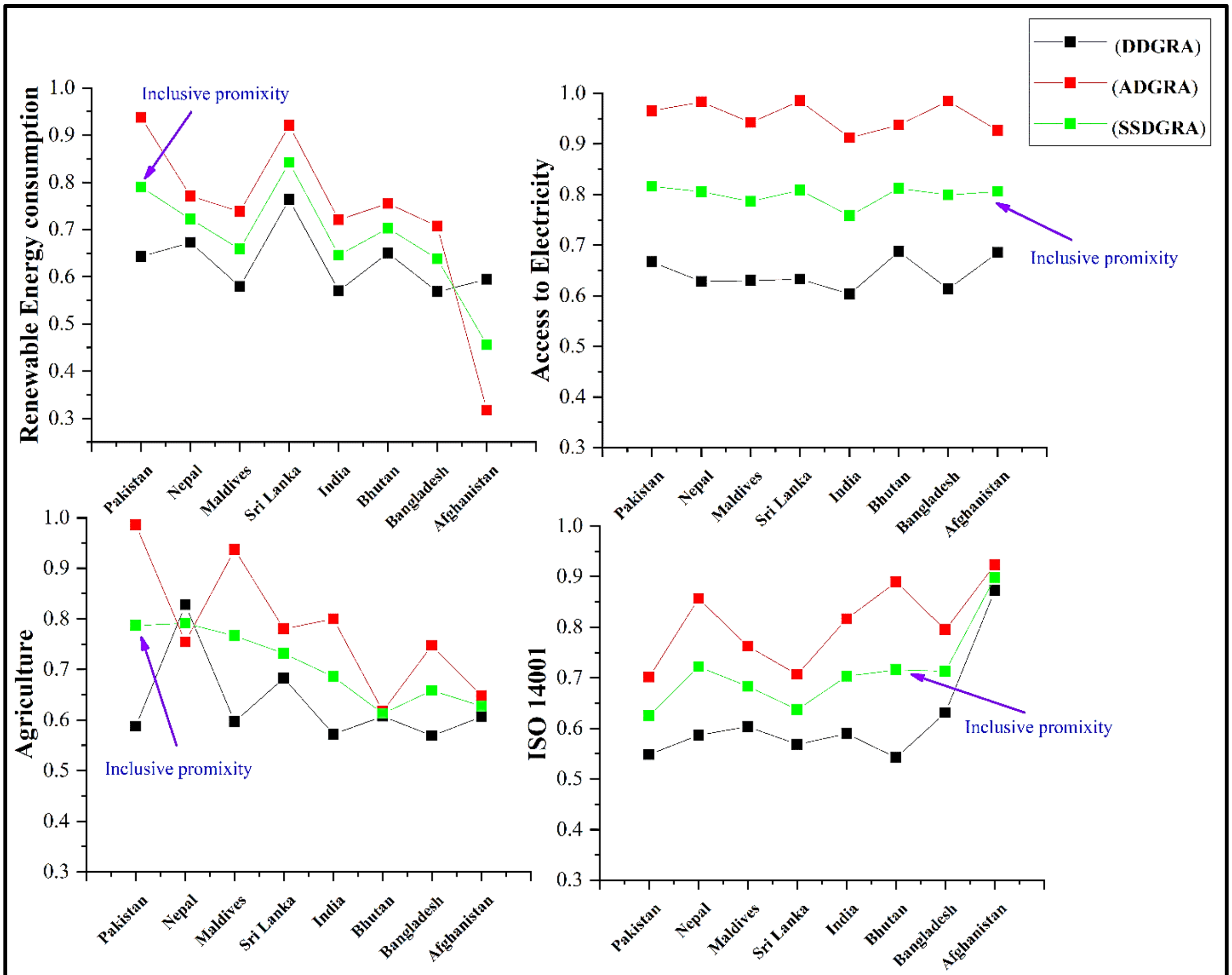

Figure 2: The comparative assessment of RE, ISO14001, AE and AG on CO_2 emission based on GRA

Where, p = 3, n = 8, and outcome = v (S_i, D_j) whereas i = 1, 2, 3 and j = 1, 2, 3, 4, 5….8. Let S_1, S_2, S_3 and S_4 represents the superiority grey relation analysis of access to electricity, renewable energy consumption and agriculture value added and ISO 14001 (EMS) on CO_2emission in SAARC countries. Table 9 shows the Second Synthetic (SSDGRA) Degree of Grey Relation-based Matrix, reporting the "second synthetic grey relations" between the decision criteria and decision actions. Finally, we operationalized a decision-making model to see the comparative analysis countries to measure the effect of access to electricity, renewable energy consumption and agriculture on CO_2 emission among SAARC.

Table 9: Criteria Action Matrix

Second Synthetic GRG	**D_1**	**D_2**	**D_3**	**D4**	**D5**	**D6**	**D7**	**D8**

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S_1	0.81625	0.80570	0.78618	0.80894	0.75794	0.81241	0.79911	0.80597
S_2	0.79010	0.72195	0.65856	0.84208	0.64553	0.70269	0.63776	0.45583
S_3	0.78663	0.79119	0.76663	0.73158	0.68573	0.61260	0.65837	0.62749
S_4	0.62465	0.72159	0.68286	0.63731	0.70302	0.71563	0.71278	0.89799

4.1 The Conservative (maximin) model Analysis

We next used, the following methodology which have been successfully utilized in many studies (M. Ikram et al., 2019a; Javed and Liu, 2018b) . As we maximize the function for CO_2 emission, so it is a maximin criterion:

$$\max S_i \left\{ \min S_k \ v\left(S_p, \mathrm{D}_k\right) \right\} = \max S_p \begin{Bmatrix} 0.75794 \\ 0.45583 \\ 0.61260 \\ 0.62465 \end{Bmatrix} = 0.75794.$$

Our findings demonstrate that India has substantial CO_2 emission issues among all SAARC countries. India is the world's third largest emitter of GHG emissions with rapid increases in energy use fueled largely by coal. Oil, gas and coal making up the bulk of energy consumption by source, yet India's coal consumption has more than tripled since 2000 (Timperly, 2019). The outcomes of the decision-making approach show that India has the biggest opportunity to develop new policy and take corrective measures to control CO_2 emissions. Our results can help enable decision makers in industry and new policy at the country level that promotes the use of renewable energy, and divestment in coal-based energy systems. There is a legitimate need to enhance environmental management systems to improve environmental sustainability. We know from prior studies (Melnyk et al., 2003; Ann et al., 2006; Potoski and Prakash, 2005; Gasbarro et al., 2013) that there are positive effects from EMS regulations that support the opportunity for policy makers to also support reduced environmental impacts. Now the question is which variable contributes to increased environmental pollution. For this additional insight, we have used the Grey TOPSIS method.

4.2 Grey TOPSIS Result

We employed grey relational models to calculate the weights of access to electricity, consumption of renewable energy agriculture (added value to GDP) and ISO 14001 certification affecting the CO_2 emission of SAARC countries. We used the Conservative (maximin) model to investigate which country is contributing more to CO_2 emission. India has emitted more CO_2 emissions among all SAARC countries. In doing this, an important question arises as to which variable contributes more to CO_2 emissions and increased environmental pollution.

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In this section, we have applied Grey TOPSIS to rank the intensity of four main independent variables access to electricity (AC), Renewable Energy Consumption (RE), Agriculture (AG), ISO 14001 certification (EMS) on carbon emission (CO_2). We have calculated weights of each of the variables by applying Absolute GRG, Deng GRG and SSGRG. The analysis by the Grey Relational has established a grey evaluation matrix into a grey number using linguistic variables. Access to electricity and agriculture have considered as a cost criterion, whereas consumption of renewable energy is a benefit criteria.

Table 11 present the grey positive and negative ideal solution. The possible degree of greyness between access to AC, RE, AG and CO_2 emission was calculated and ranked in Table 10.

Table 10: Positive and Negative ideal solution

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8
S^{max}	[0.30,0.65]	[0.36,0.70]	[0.40,0.75]	[0.42,0.80]	[0.19,0.45]	[0.42,0.75]	[0.50,0.85]	[0.69,1.00]
S^{min}	[0.19,0.35]	[0.31 0.56]	[0.34,0.60]	[0.30,0.51]	[0.13,0.34]	[0.34,0.63]	[0.35,0.65]	[0.29,0.57]

Table 11: Final ranking of variables based on Grey TOPSIS

Codes	**Variables**	**possibility degree of greyness**	**Ranking**
AC	Access to Electricity	0.685	4rd
RE	Renewable Energy Consumption	0.566	1st
AG	Agriculture value added (GDP)	0.610	3nd
EMS	ISO 14001 Certification	0.590	2nd

$$AC(S_1 \leq S^{max}) = 0.685 \tag{31}$$

$$RE(S_2 \leq S^{max}) = 0.566 \tag{32}$$

$$AG(S_3 \leq S^{max}) = 0.610 \tag{33}$$

$$EMS(S_4 \leq S^{max}) = 0.590 \tag{34}$$

Based on the values obtained by the possibility degree of greyness ranking of the alternatives is presented in Eq. (35)

$$\text{RE} > EMS > AG > \text{AC} \tag{35}$$

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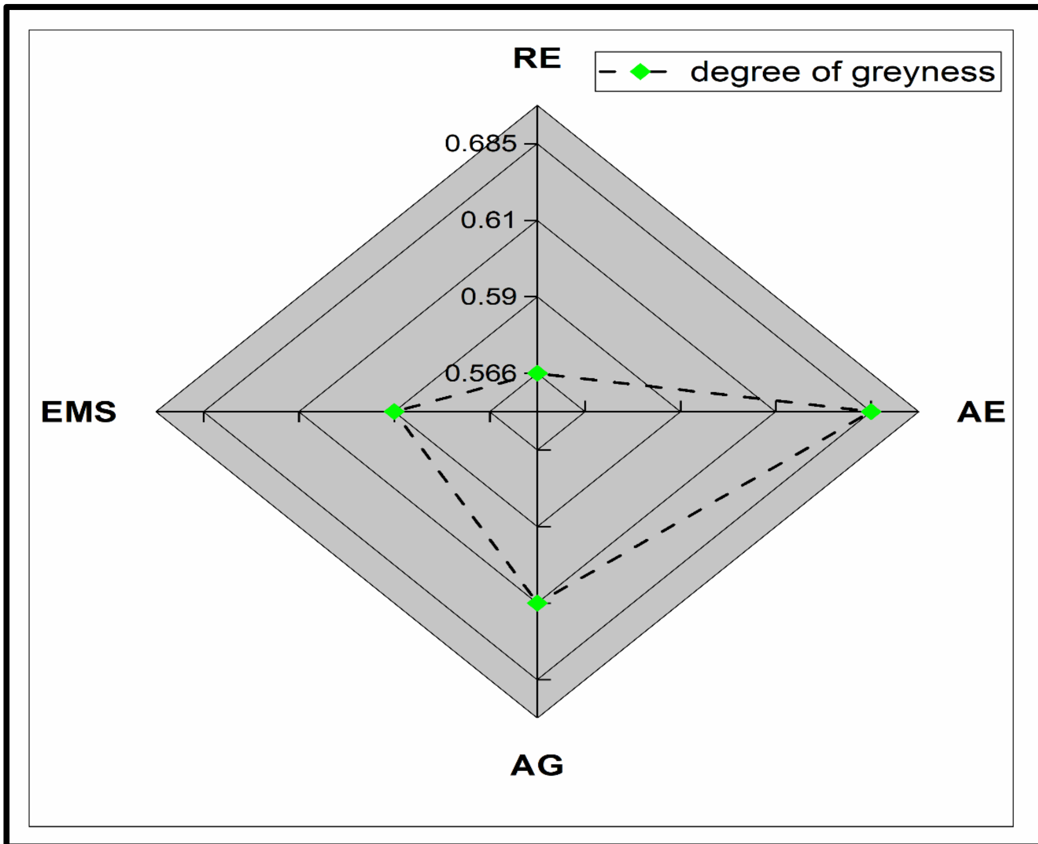

Figure 3: Degree of greyness of RE, AC, AG and EMS of Grey TOPSIS

Based on the methods used in this study, Grey group TOPSIS results are presented in Table 14. The results reveal that adoption of renewable energy consumption contributes more to reduced CO_2 emissions followed by ISO 14001 certification adoption by obtaining the weight (0.566) and (0.590) in SAARC countries can be seen in Figure 3. The agriculture value added to GDP and access to electricity obtained weight (0.610) and (0.685), which implies that these two factors consider comparatively increasing more CO_2 emissions in SAARC countries. Using Grey group TOPSIS increases the accuracy of the decision making in uncertainty conditions. Thus, the approach used in this study can help decision-makers, enterprises, governments and policymakers in the reduction of CO_2 emission.

Researchers, scientists and policy makers need to work together to use science to identify policy opportunities and to help provide solutions to help reduce emissions. The outcomes of research found in this study and other studies can provide information to improve societal outcomes by enabling further research and guiding policy and decision makers in ways that are transformative. The collaboration between researchers, policy makers, and business enterprises can support and achieve ambitious goals for sustainable development bringing together national governments, the international community, civil society, the private sector and other actors. Global goals can only be

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met if we work together. Country level investments are needed to ensure innovative technological development, trade, access to markets, and action as we strengthen the science, technology and innovation capacity of SAARC countries.

5 Conclusions

The aim of this study is to fill in the gap in the literature by analyzing the relationship between renewable energy consumption, access to electricity, agriculture, ISO 14001 certification and, CO_2 emission in SAARC countries from 2004-2014. Contributions to this field of research includes addressing endogeneity issues in acquiring the CO_2 emission factors, we utilized a novel mathematical model, grey relational models and Grey TOPSIS to both analyze and compare the average impact of CO_2 emission in SAARC countries. Our results demonstrate that by consumption of renewable energy and the adoption of ISO 14001 fundamentally decrease CO_2 emission and there are a number of other benefits to investing in and developing environmental sustainability for this region of the world and beyond.

Our results help to demonstrate that the mitigation of CO_2 can be achieved in the energy mix by enhancing renewable energy. To this end, access to electricity has a positive relationship with CO_2 in the second synthetic grey Relational Analysis model among SAARC countries. Interestingly, agriculture has weak impact on CO_2 emission in the GRA model. In Grey TOPSIS analysis, renewable energy consumption ranked as a top contributor in the reduction of CO_2 emissions. On the basis of these results, this study finds that ISO 14001 certification and renewable energy consumption are key areas of focus for the reduction of CO_2. All the results of the analysis were well concentrated, and we were able to provide insight for all of the defined goals of the study.

Further contributions of this study include finding a rise in the consumption of renewable sources in the energy mix, adoption of ISO 14001 certification and low carbon emission steps will help achieve sustainable development in the SAARC region. Governments of these countries should provide incentives for ISO 14001 certification training and should start awareness programs to help enable enterprises, supply chains, infrastructural systems, and value chains more sustainable to parallel efforts to reduce impacts on the environment that can also help achieve global sustainable development goals (SDGs).   Our findings have direct implications for policy and decision makers regarding SDGs; 7 affordable and clean energy, 8 decent work and economic growth, 9 industry innovation and infrastructure, 11 sustainable cities and communities, 12 responsible consumption and production, 13 climate action, and 17 partnerships for the implementation and success of the SDGs. All stakeholders, governments, civil society, the private sector, and others are expected to contribute to the realization of this new agenda.

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Investments in sustainable development will help address climate change by reducing GHG emissions and building climate resilience. The transition from fossil fuels to renewable energy is essential in order to promote an eco-friendly economy and these resources could be used to meet the Kyoto Protocol targets and goals from the United Nations. To this end, India has pledged to reduce emissions intensity of its economy by 35 percent by 2030 and plans for 40 percent of installed electricity capacity to be renewable or nuclear by this same year (Timperley, 2019). Climate change is already impacting public health, food and water security, migration, infrastructure, peace and security. Agriculture production should increase to a maximum level with modern technologies and low negative impacts on the environment. If left unchecked, climate change and CO_2 emissions will roll back the development gains we have made over the last few decades and will make further gains impossible.

Finally, the governments of the SAARC countries should mutually coordinate, support and focus on policies that can boost renewable energy productions while adopting environmental management systems, and regulate emissions at the regional level. Together, this combination of activities will enable decision-makers, enterprises, economies and value chains to understand that emissions such as CO2 are important to measure, manage and reduce when fighting climate change and simultaneously achieving global goals for sustainability.

Conflict of Interest: The authors declare that they have no conflict of interest.

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