Sectoral based CO_2 emissions of Pakistan: A novel Grey Relation Analysis (GRA) Approach

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Abstract

Global warming regarded as the major global issue over the past few decades, whereas carbon dioxide (CO_2) emissions have been cited as one of the main causes of this problem. Therefore, this study aims to investigate the effect of energy consumption, economic development, and population growth on high CO_2 emitting sectors of Pakistan such as transportation, industrial, and household. The data used in this study from 2000 to 2018. We employed novel Grey Relational Analysis (GRA) models to assess the connection between Gross Domestic Product (GDP) per capita, population, energy consumption, and CO_2 emission. Further, the Hurwicz method was used to analyze which factor contributing more to CO_2 emission. Result reveals that CO_2 emission, Gross Domestic Product per capita, population and energy consumption showed a strong association among all sectors. Whereas population contributes more to intensifying CO_2 emissions in the transportation sector of Pakistan. This study provides useful insights for policymakers to take preventive and corrective measures to overcome CO_2 emissions as well as sustainable development.

Keywords: CO_2 emissions; energy consumption; transportation; household; grey relational model; Pakistan

Highlights

- This study focuses on transportation, industrial and household sectors of Pakistan.
- We explore multidimensional relationship of energy, economic development, population growth and CO_2 emissions.
- Population contributes more to intensifying CO_2 emissions in the transportation sector of Pakistan.
- Useful Insights benefit for decision makers and policy makers take corrective measures in CO_2 emission reductions.

1. Introduction

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Environmental pollution, caused by the concentration of CO_2 emissions, has become the most important concern in the current debate on sustainable development and environmental protection. Most scientists have identified CO_2 is a major cause of global warming through greenhouse effects (Mallick & Tandi 2015). According to the Intergovernmental Panel on Climate Change (IPCC) report of 2019, human interference accounts for 80% of global CO_2 emissions, such as fuel combustion through vehicle travel, construction. Whereas, manufacturing processes have also been identified as a significant source of CO_2, and corrective actions are required when making country-level policy decisions (IPCC 2019)

CO_2 emissions influenced by many factors, including fossil-fuel energy consumption, industrial activity rates, and the population (Heede 2014). Energy has become a key factor in the world economy, both in terms of consumption and production. Whereas, the extensive use of energy has resulted in CO_2 emissions globally (Azomahou 2005).

In the past decade, researchers, industry experts, and various government agencies around the world have paid more attention to reporting on CO_2 emissions and defining methods to mitigate climate change, leading to significant increases over related research publications. Additionally, Lu et al. (2016), studied the construction industry's CO2 emissions and provided insight into various industry’s CO_2 emissions. As shown by Hammond and Norman (2012), the study of past trends in CO_2 has become a useful strategy for understanding current emissions and thus predicting future emissions. Additionally, the world economy is developing at a normal pace of 3.4 % every year, and the population will expand in 2040 from the present 7.4 billion to 9 billion approximately (World Energy Outlook, 2017). As reported by the International Energy Agency (IEA) 2016, the growth rate in large cities will elevate from 22 (the present megacities number) to 100 quadrillions British thermal units (Btu) till 2050 (U.S. Energy Information Administration, 2016).

While the transportation industry contributes 23 % to the world's whole CO_2 emission, whereas the consumption level is about 25% of the world's energy (Mohsin et al. 2019a). However, it is expected that energy consumption of the transportation sector is going to elevate in 2040 reaching the level of 155 quadrillions Btu (Sarkodie & Owusu 2016).

However, in developing nations, the transportation industry energy consumption is consistently expanding, and this increment is expected up to 30% because of improved living standards (Liu & Xu 2016). In addition to this, atmospheric pollution issues, for example, CO_2, Nitrogen Dioxide (NO_2), Sulphur dioxide (SO_2), and micro particles hazardously affecting wellbeing as a result of the transportation industry. In any case, CO_2 performs a noteworthy job in damaging the air quality and causes serious health issues. Therefore, all these elements also make climatic changes quite fragile and lead towards the deteriorating of the environment (Ratti and Vespignani, 2016).

Pakistan is regarded as prone to ecological fluctuations and inclined towards environmental deterioration because of CO_2 emission from the major sectors like transportation, industries, and household. Since the most recent decade, the antagonistic effects of environmental variation are noticeable because the expansion of atmosphere catastrophes, for example, earthquakes, and floods, etc. in the locale. Nonetheless, the immensity to which the of 2010 flood-affected Pakistan was unusual and it turned out to be evident that the environmental variation incidents can happen on a massive level (Tariq et al. 2017).

Pakistan incorporates the transition to economic activities, and therefore, the region is the focal point of the spectacular pattern of the world, for example, environmental change, misusing the resources, energy crisis, and water security issues. The transportation part emission demolishing the economic and social advantages in Pakistan. Financial development, combined with the most noteworthy pace of population storm in the entire globe, applies intense pressure on environment and energy demand (Flachsland & Creutzig 2011).

A few investigations were conducted to survey the anthropogenic emission and finished up fast economic growth, improving living standards increasing in CO_2 emissions. Because of this increasing rate in traffic, the massive CO_2 emission caused by extraordinary changes in the atmosphere and local climate produces photochemical pollution, smog, and fog (Mohsin et al. 2019b). Further, Cherp et al. (2018) carried out an investigation and identified atmospheric pollution majorly affects general wellbeing, radioactive forces and climate model. Therefore, air pollution attributes are required to demonstrate their sources, characteristics, and chemical compositions (Löffler et al. 2010). The target of this investigation is to build up a system to break down the integrated effect of energy consumption, pollution growth, and Gross Domestic Product (GDP) per capita on CO_2 emissions Further, it explores the inter-temporal relationship them (Shahbaz & Hussain 2019).

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 Analysis (GRA) models and Conservative (Maximin) criteria method to both analyze and compare the average impact of CO_2 emission in Pakistan.This study is providing the expected new insights gained from our methods include; an analysis of relationships between energy consumption, economic development, and population growth on high CO2 emitting sectors of Pakistan such as transportation, industrial, and household. Further this study is testing to see which factor contributing more to CO_2 emission, and the application of new modeling techniques to develop more accurate results. Additionally, we see the GRA results as a foundation for understanding important for decision-makers and researchers as we uncover new insights as to meaningful factors. Since the transport, industrial and household sectors in Pakistan is to be maximized CO_2 emission to enhance and validate the consistency of results.

The structure of the paper is organized as follows: Section 2 presents literature review sector-wise. Section 3 represent data grey relation models. Section 4 presents numerical results and discussions. Finally, section 5 concludes the major findings and suggest policy implications.

2. Literature Review

There is extensive literature that establishes a causal relationship with mixed findings between energy consumption and economic activity. Several studies have found that the causality runs from the consumption of energy to the growth of economies which means that the conservation of energy can be detrimental to economic growth (Khan et al., 2019; Gökmenoğlu and Taspinar, 2016; Zeb et al., 2014). About 19% of growth rate was reported in Pakistan's transportation sector from the year 1990 to 2015 which is regarded to be a tremendous pace, and inefficient transportation could be improved (Ahmad & Puppim 2016). A complete list of registered engine vehicles in Pakistan were17,715,428 according to the estimated figure in 2015 (Aadil et al. 2018). At the same time, Pakistan Railway diminished its delivery shipment whereas this method of transport was noteworthy and it was at its crest during the 1950s, which was in charge of 73% of the cargo traffic and it was declined later and reported less than 5% in 2015. Moreover, about 90% of the travelers are dependent on the transport sector and at present, nearly 95% of inland shipments are handled (Qamar & Saeed 2016).

The transportation industry added more than 10 percent to the GDP at the national level and about 25-26 percent to federally public schemes. Moreover, the number of vehicles out together is significantly higher as it was before i.e. 2 million in the 1990s and reached nearly 17 million in the year 2015, with a substantial growth rate, while more than 80 percent is comprised of cars and motorbikes. In addition, 2-stroke motors contributed about 5.6 million out of entire vehicles while trucks and diesel transports were over 4 million till 2015. These kinds of vehicles in transportation are a drastic way of expanding CO_2 emission and polluting the environment (Holmberg and Erdemir, 2017; Shahbaz et al., 2017).

The transportation area expends 35% of energy consumption in Pakistan. However, it produces about 29% of all CO_2 emissions. Energy consumption from the transportation sector is anticipated to reach a level of 52 percent by the year 2040 (U.S. Energy Information Administration | International Energy Outlook 2016). These days the energy consumption is a hot issue (Ouyang & Lin 2015). Ramanathan, (2006) used Data Envelopment Analysis (DEA) from 1980 to 2001 to analyze the relationship between CO_2 emissions, GDP per capita, consumption of energy and population growth simultaneously. Ramanathan observed the high economic growth rate globally in 1980's due to lower CO2 emission at a given level of energy. Moreover, the efficiency index has fallen over the next eight years, varied with a declining trend in the next 7 years and then started to grow from the year 1996 to 2001. Kim (2017), has decomposed and evaluated the specific feature of energy consumption affecting the industrial sector using Logarithmic Mean Divisia Index (LMDI) techniques significantly over the past 20 years from 1991 to 2011. In addition to the additive LMDI methods, he also used multiplication methods to determine what variable influences energy consumption.

Pakistan's energy consumption is fundamentally dependent on imported oil for energy production. The consumption of oil in Pakistan was 216.69K barrels in 1990-91 whereas this figure nearly multiplied until the year 2017 to 588.62K barrels (Sindhu et al. 2018). Conversely, oil generation was left only 62 barrels in 2017, against the 440 barrels of utilization. Such environmental issues which are triggered by the human interface using the natural resources, for example, trade liberalization, growing population , urbanization and industrialization all can increment pollution and environmental degradation.

With the purpose of minimizing the expanding level of CO_2 emission and climate variations, the Conference of Parties (COP) and the United Nations Framework Convention for Climate Change (UNFCCC) in 2015, consented to diminish the worldwide temperature to 2 degree centigrade which will be above pre-industrial levels by the end of 2020 (Inglesi-Lotz and Dogan, 2018; Dogan and Seker, 2016). Subsequently, climate fluctuations and environmental sustainability has become a hot topic at a national level and also, around the globe to plan renewable energy production (Solaymani et al., 2015; Steffen et al., 2018). An economy may go on a sustainable economic track if consumption of energy includes an optimal mixture of nonrenewable and renewable energy (Khan and Ghouri, 2011; Zeb et al., 2014) with the goal that the policy and decision-makers must know the respective contribution of energy resources sources on economic development and CO_2 emission (Shahbaz et al., 2016).

Similarly, Bhattacharya et al. (2017) investigated the 85 industrial countries by using OLS method and observed the negative effect of renewable energy consumption on CO_2 emissions. Wang et al. (2018) used GRA models to select 11 influencing factors which cause CO_2 emissions and serious threat to the environment. Further, Ikram et al. (2020), investigated the relationship of renewable energy consumption, agriculture, ISO 14001 and CO_2 by applying novel GRA models in SAARC countries. Economic development and industrialization are constantly resulting in an increase in energy consumption (Shanthi 2018). The demand for electricity consumption in the year 2000 expanded from 47 billion kilowatt-hours and in 2015/16, it reached 90 billion kilowatt-hours (International Energy Agency (IEA) 2016)

Bölük and Mert, (2015) focused on environmental degradation, economic growth, and energy consumption inferred that significant amounts of energy consumption are fundamental for economic development. Simultaneously, it has turned into a critical reason of environmental degradation in developing and developed nations.

Inadequate ecological resources, environmental markets, and administrations facilities have no charge in Pakistan and environmental issues, for example, non-optimal costs are increasing because of scarcity in ecological markets (Zafar et al. 2019). In such a developing economies environment is considered to be an insufficient resource, and it is unachievable to expect to attain such desirable resources (Bakhsh et al., 2017; Baig & Baig 2014).

However, Liu and Sweeney (2012) observed that the big cities are more energy-efficient and reduce energy consumption and that CO_2 discharge from per household reduced. Whereas, Several studies findings reveal that industrialization has a positive relationship with CO_2 emission which focusing on the overall relations at the industry level by ignoring its subdivisions (Chandio et al., 2019). So, further researchers focus on this issue and investigated the industrial sectors across various nations. According to Sözen et al., (2016) , manufacturing industry found to be a big contributor of CO_2 emissions in Turkey .

Environmental pollution is viewed as proportional to the devastation of air, sea creatures, fuel, supplied food, and safety (Hillman and Ramaswami, 2010; Ikram et al., 2019). However, it is important for maintaining the air quality by keeping it clean and fresh in light of the fact that it guarantees purified lakes and supports landscape and wildlife. It gives assets and resources, for example, water, land, forests, and minerals which are the foundation of economic development. Further, it assimilates the economic activities, for example, utilizing unsafe items and can offset them which aids to protect the genetic diversity, ozone layer, and environmental variations (Yuksel and Kaygusuz, 2011; Cloke et al., 2017).

In this study, we have employed mathematically model namely GRA model to compute the weights and Conservative (Maximin) criteria method 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 energy consumption, economic development, population growth as well as high emitting CO_2 emissions sectors of Pakistan.

3. Methodology

This section discusses the approach used within this study for our data collection, along with the grey models used for analysis.

3.1 Data

Pakistan's CO_2 emission and population data were taken from the World Bank website from 2000 to 2018. Whereas the data of GDP per capita was taken from the Ministry of Finance and World Bank collectively. We have investigated the top three major sectors of Pakistan which are the major cause of CO_2 emissions i.e. transport, the industry, and the household. Further, energy consumption data was taken from CEIC database (https://www.ceicdata.com). For these sectors, the CO_2 emission data was abstracted from the Economic Survey of Pakistan 2017-2018. All the factors effecting CO_2 emission used in this study showed the historical inclined trends from 2000 to 2018. Grey system software version 8.0 was used to assess the relation of CO_2 emission between sectors from 2000 to 2018 by a grey relational approach. The current analysis and modeling methodology was used for the first time in this study to assess the sector-wise impact on CO_2 emissions in context of Pakistan.

3.2 Grey Relational Analysis (GRA) models

GRA models are also known as Grey Incidence Analysis (GIA) models and generally regarded as a preliminary part of the new theory of grey systems (Badri & Wang 2017). The theory of the grey system was based on the incredible work performed in 1982 by a Chinese scientist, Professor Julong Deng, which is used from 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 (Javanajdadi 2017)

In 1985, Professor 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 grey incidence model is superior to statistical models of system analysis. The main advantage of the grey incidence model is to overcome the unknown problems in any process which lack's physical details and ambiguous mechanical function and working design (Ikram et al., 2020; Javed & Liu, 2018b). The fundamental idea of Grey Incidence is utilizing the degree of proximity for a geometric curve in an open data structure to assess their associations whether they are close or not (Liu et al., 2017, p.68).

3.2.1 GRA model of Deng's degree

Several GIA models have been developed by various researchers, but Professor Deng's proposed model (1985) tends to be more influential and effective and plays a key role in grey system theory decision-making methodology (Bayramoglu and Hamzacebi, 2016).

Nonetheless, taking the original concept of this model into consideration, several real-life problems in various fields, either related to theoretical or empirical questions, look for consideration to use this approach (Zuo et al., 2016). According to Ikram et al., (2019) below are the two sets of data shown by X_0 and X_1 for the estimation of Deng's gray incidence:

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

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

ii. The second step calculates the difference of sequence X_0' and X_i' i=1, 2,3, …, m, as:

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

iii. The third step includes the difference of maximum and minimum which is written as:

$$M = \max_i \max_l \Delta_i\left(L\right), m = \min_i \min_l \Delta_i\left(L\right).$$

iv. Further, the fourth step calculates the coefficients of grey incidence (sometimes termed as, Grey/Point relation coefficients) by using the following formulae:

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

Where, the distinctive coefficient is represented by ξ and assume to be ξ=0.5 as a distinctive coefficient.While behind this presumption there is no significant reason and attention is still being investigated to be proven wrong among analysts (Javed & Liu 2018a).

v. The last fifth step is estimated the grey relational degree (GRG) also known as Deng's degree of grey incidence as:

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

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

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

Also, 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 & 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. Therefore, the ongoing debate shows that 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 in Pakistan.

3.2.2 *Absolute degree of GIA model*

Xu and Li (2018), Zhicai and Li (2018), demonstrated that the Deng GIA provides insight on the impact of the GIA components (represented through the Grey dataset sequence), and offers a clear insight into the relations between these factors while the absolute degree grey incidence analysis, is also known as the absolute GRA model. In any case, both 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 Incidence in two equal time intervals evenly between X_0 and X_1:

- In the first step, X_0^0 and X_1^0 are the zero starting point which are calculated on the basis of the interval sequence in X_0 and X_1.
- The second step involves the computation of $|s_0|, |s_1|$ & $|s_1 - s_0|$.
- Lastly, the absolute degree of grey incidence (ε_{01}) is estimated through the time interval sequence i.e. X_0 and X_1. For that, the following formula is mentioned below:

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

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

Definitions

Definition I: Deng 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 incidence analysis (DGIA) model. It is presented as:

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

Or

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

Where γ_{0i} (L) denotes the coefficient of grey relational or sometimes, coefficient of grey incidence. The first equation of the DGIA model denotes the weighted form of GRA / DGIA and the second is a non-weighting (or equal weight) scheme.

Definition II: Absolute Degree Grey Incidence Analysis (ADGIA)

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

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

Definition III: Zero-scale point image

Let the system behavior data sequence represent as $X_i = (x_i(1), x_i(2), ..., x_i(n))$ 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

$$X_i C = X_1^0 = (x_i^0(1), x_i^0(2), ...x_i^0(n)).$$

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

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

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

Then

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

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

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

Definition IV: Second Synthetic Degree of Grey Incidence Analysis (SSDGIA) model

The Second Synthetic GRA model or the SSDGIA model proposed by (Javed & Liu 2018a) is given as:

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

Where ρ_{ij} is a Second synthetic degree of grey incidence/grey relation (SSGRG), γij is denoted as Deng's degree of grey incidence (GRG) and ε_{ij} 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, furthermore, the absolute relational model relies on an integrated (comparatively broader) perspective (Liu et. al., 2017b). The SSDGIA determines the overall relationship between two sequence levels and an integral role. The first synthetic grey model methodology (SDGIA) was introduced in conjunction with absolute and relative grey incidence (Javed & Liu 2018a). GRA models have three types of proximities namely partial proximity, integral proximity and inclusive proximity respectively. 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 (Ikram et al., 2020)

The SSDGIA model was developed based on the SDGIA model's working standard. It is recommended to consider θ=0.5 when making decisions with a view to 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.

4 Result and Discussion

The results of the GRA models such as Deng GRG, Absolute GRG and SSGRG between energy consumption, population, GDP Per capita and CO_2 emission of highly emitting sectors of Pakistan for the year 2000 to 2018 are shown in Tables 1 to 3.. The classification of grey models is as follows: Absolute GRG and second synthetic ranges from 0 to 1 and Deng GRG ranges from 0.5 to 1. Also, it is considered to be strongly associated if it is close to one and weak as it deviates from 1.

In the case of the transportation sector, the calculation results show that energy consumption in Pakistan has a great influence on CO_2 emission and ranked 1st among GDP Per capita and population under the Absolute GRG model. Considering the Deng GRG and SSGRG model, the estimates are 0.60172 and 0.73326 which also indicates that the transport sector plays a prominent role in CO_2 emissions. While the ranking is different for GDP Per capita and population factor in Absolute GRG when compared with Deng GRG and SSGRG which can be seen in Table and Figure 1.

The quantity of imported oil in 1990 was nearly 9.96 million tons, and it expanded to 13.87 million tons in the year 2011/2012, and in 2015, it elevated up to 16 million tons (January 1999). The overall impact of the transportation sector on environmental degradation can be confirmed by the facts and figure that the transportation sector contributed nearly 8 million tons of oil which means it participated more than half in the total energy consumption (Danish & Baloch 2018).

Likewise, manufacturing sectors have an increasing proportion of GDP and are economically viable aid in emerging nations such as Pakistan, but at the same moment, they are a hazardous cause of CO_2 emissions and other Greenhouse Gas (GHG) emissions. Consistent energy consumption in both domestic and commercial industries, households and the transport industry is a major factor in Pakistan's environmental degradation and air pollution. Our results endorsed the study of Wang et al. (2017), that also showed the positive effect of energy consumption with CO_2 in transport sector. This result raises the importance of energy consumption as an alternative source and suggests that reduction of CO_2 emission is possible through its extra use.

Table 1. Evaluation of Transport sector in Pakistan through Grey models

Transport Sector	Absolute GRG	Rank	Deng GRG	Rank	Second Synthetic GRG	Rank
Energy Consumption	0.86479	1st	0.60172	1st	0.73326	1st
GDP Per Capita	0.74074	3rd	0.58144	2nd	0.66109	2nd
Population	0.83418	2nd	0.48545	3rd	0.65981	3rd

In Table 2, the estimation results show that in the industrial sector of Pakistan, the population is strongly associated with CO_2 emissions measured by Absolute GRG and SSGRG. It indicates the large influence of this factor on CO_2 emissions. While in the model ofDeng GRG, the population factor in Pakistan is ranked as second and seems to be less influenced when compared with the other two grey models. The estimates for the population are 0.99464, 0.62330 and 0.80897 for Absolute GRG, Deng GRG, and Second Synthetic GRG model respectively.

While the GDP per capita in Deng GRG is 0.65226 for the industrial sector and ranked first. It shows that among the energy consumption and population factor, GDP per capita is showing more association with CO_2 emissions. As a consequence, air quality is decreasing, urban congestion is generated, and circumstances are deteriorating in metropolitan areas, while there are tradeoffs between economic growth and environmental preferences. For example, the shift from organic agriculture to modern agricultural tools has proven to be detrimental to the environment but economically useful.

Table 2. Evaluation in Industrial sector of Pakistan through Grey models

Industrial Sector	Absolute GRG	Rank	Deng GRG	Ranks	Second Synthetic GRG	Ranks
Energy Consumption	0.46229	3rd	0.50890	3rd	0.46059	3rd
GDP Per Capita	0.78061	2nd	0.57966	1st	0.68013	2nd
Population	0.88953	1st	0.50850	2nd	0.68901	1st

Considering the Household sector of Pakistan, the estimation of grey relational models are mentioned in table 3. Now, it can be seen clearly that the population in Pakistan's household sector is strongly associated with the CO_2 emissions measured by the Absolute GRG and SSGRG. And, it shows the significant impact of this factor on CO_2 emissions. Moreover, the energy consumption estimates are 0.46229, 0.50890, and 0.46059 for the Absolute GRG, Deng GRG, and the Second Synthetic GRG, respectively. While in the Deng GRG model, Pakistan's population factor is ranked second and third as energy consumption. It appears to be less affected as compared to the population. For the Absolute GRG, Deng GRG, and Second Synthetic GRG, the population estimates are 0.88953, 0.50850 and 0.68901 respectively.

By and Large, Pakistan would reduce CO_2 with a similar proportion. Consumption of energy per capita expanded to 519 (oil equivalent in kg) in 2015 from figure 280 (kg of oil equal) in the year 1971. Additionally, the population in Pakistan increased from 163.93 million in 2016 to 200 million and this rate of growth is about 2.75 percent per year. In 2015, the proportion of consumption for fossil fuel energy in the total energy consumption combine increased to sixty-four percent while it was 35.60 percent in the year of 1971, which resulted in a higher CO_2 emission rate (Shahbaz & Sinha 2019).

Table 3. Evaluation in Household sector of Pakistan through Grey models

Household sector	Absolute GRG	Ranks	Deng GRG	Ranks	Second Synthetic GRG	Ranks
Energy Consumption	0.69401	3rd	0.51511	3rd	0.60456	3rd
GDP Per Capita	0.86409	2nd	0.65226	1st	0.75817	2nd
Population	0.99464	1st	0.62330	2nd	0.80897	1st

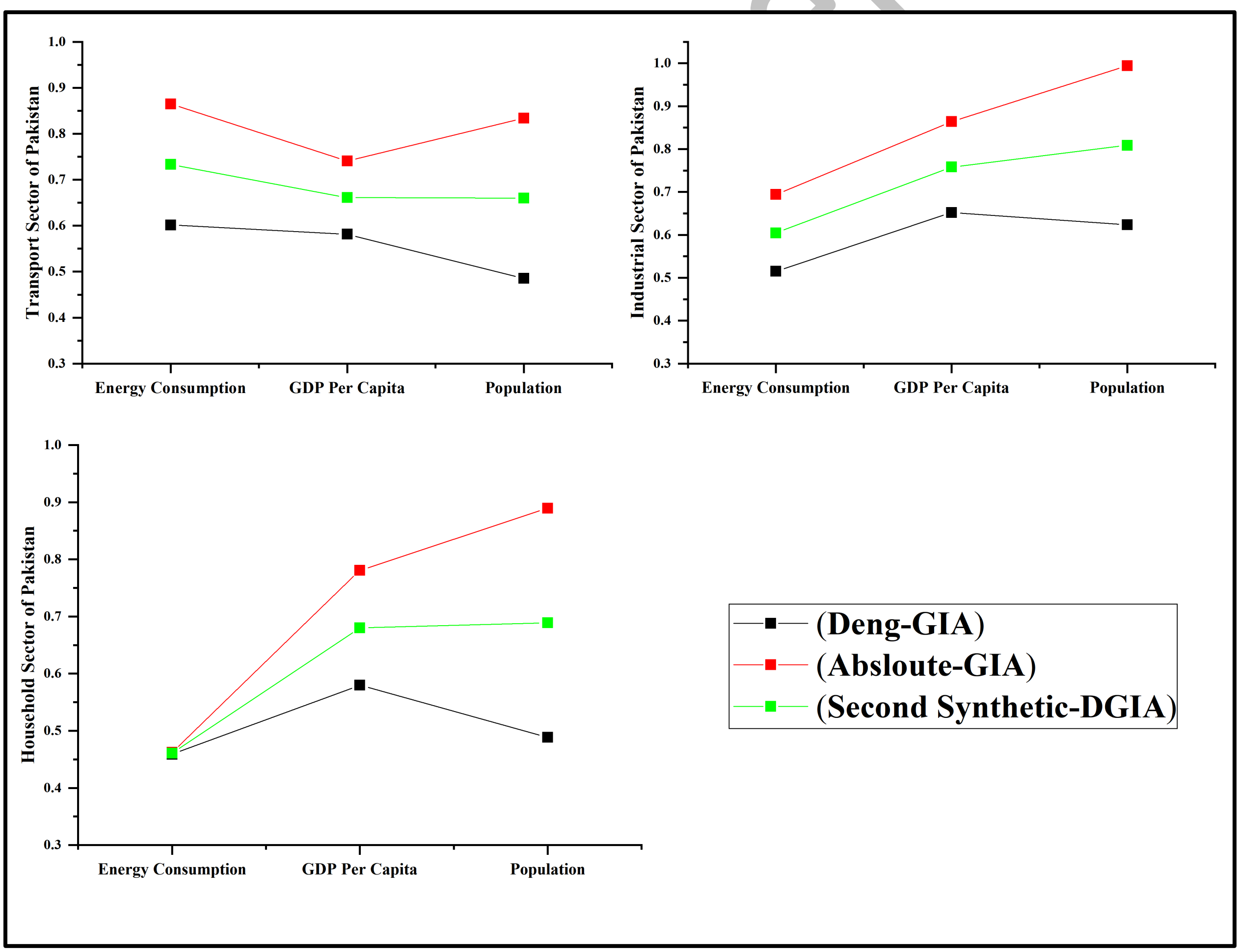

Figure 1: Energy consumption, Population and GDP per capita comparative grey relational evaluation of transport, industrial and household sector.

Table 4 represents the ranking through Grey Relation association between Energy consumption, Population and GDP per capita contributing more to CO_2 emission in three major sectors of Pakistan. To make it simpler, the ranking position for each grey model has been used in every sector with respect to the corresponding variable that has been displayed. In the transportation and household sector, raking criteria is identical for Deng GRG and SSGRG. While in the industrial sector, the ranking position is the same for absolute GRG and SSGRG model which shows that the population is contributing more to CO_2 emissions. After that, CO_2 emission is more influenced by GDP Per capita. The SSGRG comparative analysis of energy consumption, GDP per capita and population of all three sectors is presented in Figure 2.

This massive population increase and rising demand for energy for economic activity have intimidatingly expanded the fuel waste. It increased by 3000 (metric tons of oil equivalent) in the year of 2015 from 10628,916 (metric tons of oil equivalent) in 1971, and still, it accounts for 34 percent of the total consumption of energy. Therefore, the upward trend of the transport, the industrial sector's CO_2 emissions and the rate of population growth indicate a strong and positive relationship (Saidi et al. 2018). The consumption of non-renewable energy like diesel fuel was used in production of electricity for household sector which cause CO_2 emission (Bashir et al., 2018).

Table 4. Sector wise Ranking criteria contributing in CO2 emission

Sectors	Grey Relational Models	Ranking description
Transport Sector	Absolute GRG	Energy Consumption> Population> GDP Per Capita
	Deng GRG	Energy Consumption> GDP Per Capita> Population
	Second Synthetic GRG	Energy Consumption> GDP Per Capita> Population
Industrial Sector	Absolute GRG	Population> GDP Per Capita> Energy Consumption
	Deng GRG	GDP Per Capita> Population> Energy Consumption

	Second Synthetic GRG	Population> GDP Per Capita> Energy Consumption
Household sector	Absolute GRG	Population> GDP Per Capita> Energy Consumption
	Deng GRG	GDP Per Capita> Population> Energy Consumption
	Second Synthetic GRG	Population> GDP Per Capita> Energy Consumption

4.1 *The Hurwicz criteria:*

The Hurwicz Criterion is sometimes termed as Realism Criterion. This methodology is used for making decisions in uncertainty. It is utilized in decision making where we face the number of decision alternatives and uncertain state of nature. This procedure used the steps outlined in Gaspars-Wieloch (2014: p.783-784) and Taha (2007; 2014). Hence, we require to optimize the grey relationship between Pakistan's various sectors and the economic parameters, the decision would be defined as:

$$maxL_k\{\alpha max \mathrm{Cj}\ \mathrm{v}\left(L_p, C_k\right) + (1-\alpha)\mathrm{minCj}\ \mathrm{v}\left(L_p, C_k\right)\}$$

Before applying it, a decision-making scheme must be established, as shown in Table 5.

Table 5. Defines the decision parameters

Goal	**Measuring Grey Relation (Association) between Energy consumption, Population and GDP per capita and CO_2 within Transport sector, Industrial sector and Household sector**
State of Nature/Criteria (Cj); k = 1,2,…,n	Energy Consumption (C_1) GDP Per Capita (C_2) Population (C_3)
Alternative Actions (Li); p=1,2,…,m	Grey Relation was superior in Transport sector (L_1) Grey Relation was superior in Industrial sector (L_2) Grey Relation was superior in Household sector (L_3)

Here, we have n = 3, m = 3, and output =v (L_p, C_k) whereas k = 1, 2, 3 and p = 1, 2, 3. Further, L_1, L_2, and L_3 denotes the grey relation was superior in Transport, industrial and household sectors.

While C_1 is the criteria for energy consumption, C_2 is for Population, and C_3 denotes the criteria for GDP per capita.

Table 6. The Criteria action Matrix

Second Synthetic GRG	C_1	C_2	C_3
L_1	0.73326	0.66109	0.65981
L_2	0.60456	0.75817	0.80897
L_3	0.46059	0.68013	0.68901

The SSDGRG-based Matrix is presented in Table 6. Furthermore, it describes the second synthetic grey relation between decision actions and decision criteria.

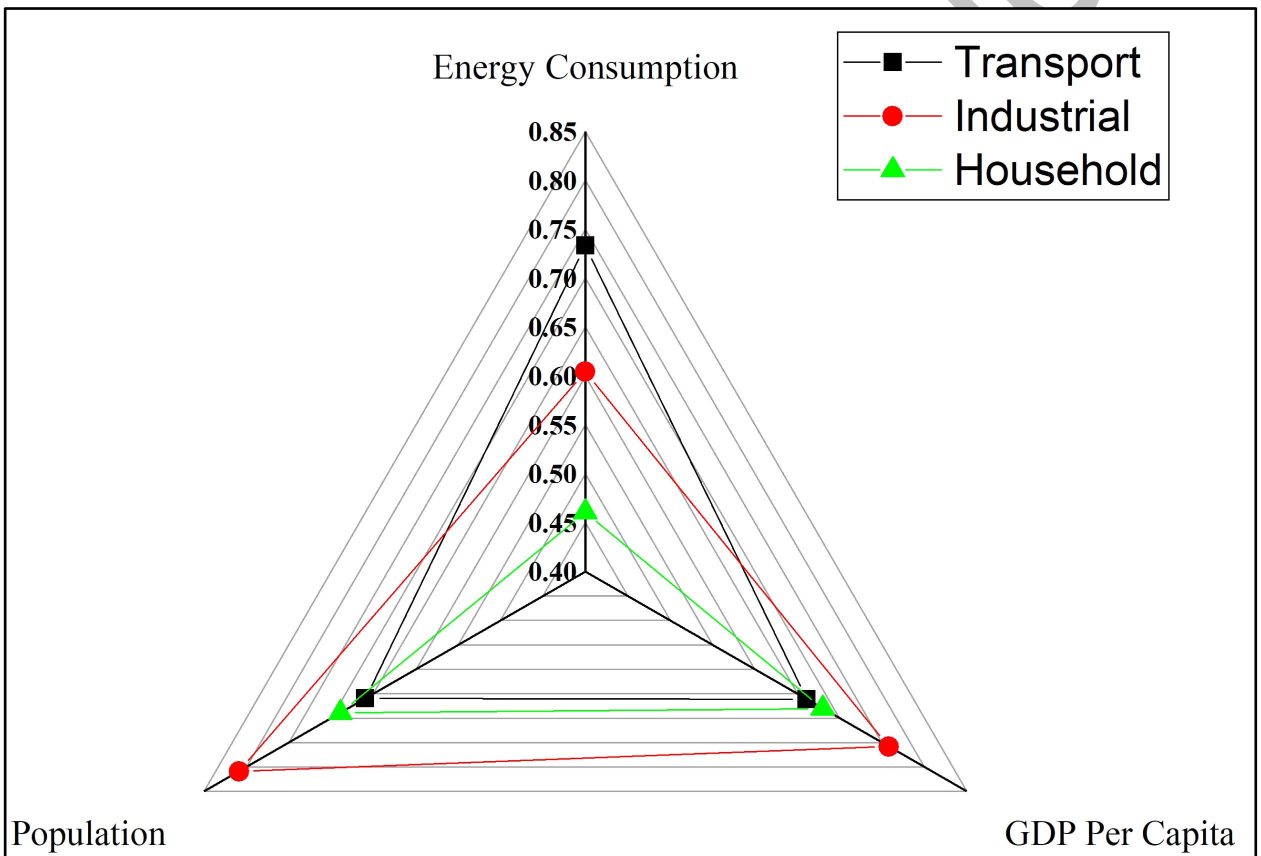

Figure 2: SSGRG comparative analysis of Population, GDP per capita and Energy Consumption

4.2 *The Conservative (Maximin) criteria*

This maximin criterion often referred to as pessimistic criterion, is used to make uncertain decisions. Since the transport, industrial and household sector in Pakistan is to be maximized, a maximin criterion is calculated as:

$$\max L_i \left\{ \min L_k \, v\left(L_p, \mathrm{C}_k\right) \right\} = \max L_p \begin{Bmatrix} 0.65981 \\ 0.60456 \\ 0.46059 \\ \end{Bmatrix} = 0.65981.$$

Based on the result of the maximin criterion, the estimation results provide evidence that there is a strong association between population and CO_2 emissions in the transportation sector of Pakistan. CO_2 emissions in the sector of transport are greatly influenced by the population and play a major role.

The agricultural land in Pakistan has continually increased from 242790 Square Kilometers in 1971 to 265500 Square kilometers (34 percent) in 2011 and is presently 47 percent in 2015 (Pakistan Economic Survey, 2018.). Whereas the elevated growth rate of the population reduces the hectares per individual from 0.31 hectares in the year 1971 to 0.10 hectares per individual in the year of 2015, this enormous demand in Pakistan for food has proven to be a significant reason for environmental degradation and deforestation. The capacity in the environmental system to devour waste released by economic activity is not counterbalanced with the growing population in Pakistan. As a consequence, the increasing growth rate of the population is deteriorating the natural environment due to increased levels of consumption of energy, increasing trends and their adverse effects of population growth on environmental degradation (Mir et al. 2017).

Our findings inferred that an increase in population growth in Pakistan resulted in environmental degradation and emissions from transport. The results found that the environmental impact was negative. It also shows that the growth of the population is a significant cause of economic growth whereas, an adequate plan is required for sustainability conservation. Thus, the alarming growth of population is responsible for the excessive use of natural, non-renewable and renewable resources resulting in ecological and environmental degradation. Growing populations are alarmingly using oxygen, food, and other necessities.

5 Conclusion

The massive growth in CO_2 emissions have provoked a great deal of concern among policymakers. To reduce CO_2 emissions, consideration has been paid extensively, to the part of affluence in CO_2 emissions. This study is taking a step forward to assess the degree of association between Energy consumption, Population, and GDP per capita and CO_2 emission within the transportation sector, Industrial sector and Household sector from 2000 to 2018 in Pakistan. The three grey relation models named Deng GRG, absolute GRG and second synthetic GRG model were applied for our research. This could be used as a viable alternative to conventional data analysis techniques. The estimated outcomes showed that the methodology of grey relational models was adequate and implemented successfully.

Moreover, the decision analysis matrix was used in the second synthetic GRG model which indicated that the CO_2 emission in the transport sector is strongly associated with the population sector in Pakistan. This shows that we need to build up some policies to control that part of the population which heavily relies on the transportation sector. As the population grows, the demand for the transportation sector increase with the passage of time which will eventually causes CO_2 emission.

More investigations can be made on the provincial level to keep checking on a small scale. So that it can be controlled on time which is causing CO_2 emissions and more economic parameters can be added for extensive research. Furthermore, we can add more grey relational approaches to conduct comparative analysis if the variables are extended. This study has proposed the policy as follows:

- Emissions control policies should track the production of coal-fired power, thermal power, and gas-fired power. To reduce their adverse environmental impact, the quality of coal production and other fuels must be enhanced.
- The institutional structure ought to be planned in such a manner that important organizations of government linked to the energy industry should have well-characterized jobs and duties and shared decision-making powers. The effective development of renewable energy policies requires institutional coherence. Coordination and exchanging information between these fundamental organizations will improve effectiveness and can help with gaining ground to renewable energy source plans.
- Capacity-building projects ought to be launched for regulation agencies, ministries, financial establishments, and different utilities due to a broad spectrum of skills and capabilities that are required for policy and decision making, management, and legislative design for project planning, funding, development, execution, and assessment. It is also essential to increase the skill base of the workers through training in moving quickly towards a market for renewable energy.
- The accessibility of data on site-specific demand for renewable energy, potential availability, exploitable level, price and efficiency of renewable techniques is essential for a number of prospective stakeholders including policymakers, regulators, utilities, designers and distributors of renewable technologies, other prospective buyers, researchers to take steps in the growth and advancement of renewable energy technologies.
- Energy efficiency and conservation actions with a reduction in any transmission shortfall should be considered laterally. It is anticipated that energy conservation and effectiveness can be used to preserve about 17 percent of the country's electricity. Electrical applications like fans and lights, which account for 67 percent of local energy use, should be supported as energy-saving equipment.
- Provinces should also have a collective agreement to deal with the issue of energy security and environmental sustainability. In addition, the government should motivate the zero-level emissions policies of the energy infrastructure. If the

government campaigns for the establishment of renewable energy projects, foreign direct investments in the renewables division can also be attracted.

- Potential public transport and transit system should be planned to reduce dependency on personal vehicles like cars and motorcycles, which become helpful to reduce GHG emissions in city areas.
- Some policies should be introduced that boost the return to human capital, promotes gender equality, increase the availability of birth control methods and all have the potential to reduce the rate of fertility. A decrease in population growth leads to an increase in the growth of per capita income and a direct reduction in CO_2 emissions.
- By eradicating trade-offs between long-term benefits and short-term economic expenses, such policies can overcome free-rider effects, which sometimes complicate solutions to environmental problems of a global or international nature.
- It is necessary to produce environmentally friendly and energy-saving electrical appliances that contribute positively to environmental conservation by reducing the impact of electricity on CO_2 and other polluting emissions.

References

Aadil F, Ahsan W, Rehman ZU, Shah PA, Rho S, Mehmood I (2018) Clustering algorithm for internet of vehicles (IoV) based on dragonfly optimizer (CAVDO). J Supercomput 74:4542–4567.

Ahmad, Puppim (2016) Determinants of urban mobility in India: Lessons for promoting sustainable and inclusive urban transportation in developing countries. Transp Policy 50:106–114.

Azomahou (2005) Www.econstor.eu.

Badri, Wang (2017) Integrating sustainability into supplier selection with analytical hierarchy process and improved grey relational analysis: a case of telecom industry. Int J Adv Manuf Technol 90:2413–2427.

Baig MA, Baig MA (2014) Impact of CO2 Emissions: Evidence from Pakistan. Pakistan Bus Rev 15:618–639.

Bakhsh K, Rose S, Ali MF, Ahmad N, Shahbaz M (2017) Economic growth, CO2 emissions, renewable waste and FDI relation in Pakistan: New evidences from 3SLS. J Environ Manage 196:627–632.

Bashir S, Ahmad I, Ahmad SR (2018) Low-emission modeling for energy demand in the household sector: A study of Pakistan as a developing economy. Sustain 10.

Bayramoglu MF, Hamzacebi C (2016) Stock Selection Based on Fundamental Analysis Approach by Grey Relational Analysis: A Case of Turkey. Int J Econ Financ 8:178.

Bhattacharya M, Awaworyi Churchill S, Paramati SR (2017) The dynamic impact of renewable energy and institutions on economic output and CO_2 emissions across regions. Renew Energy 111:157–167.

Bölük G, Mert M (2015) The renewable energy, growth and environmental Kuznets curve in Turkey: An ARDL approach. Renew Sustain Energy Rev 52:587–595.

Chandio AA, Rauf A, Jiang Y, Ozturk I, Ahmad F (2019) Cointegration and causality analysis of dynamic linkage between industrial energy consumption and economic growth in Pakistan. Sustainability 11:4546.

Cherp A, Vinichenko V, Jewell J, Brutschin E, Sovacool B (2018) Integrating techno-economic, socio-technical and political perspectives on national energy transitions: A meta-theoretical framework. Energy Res Soc Sci 37:175–190.

Cloke J, Mohr A, Brown E (2017) Imagining renewable energy: Towards a Social Energy Systems approach to community renewable energy projects in the Global South. Energy Res Soc Sci.

Danish, Baloch MA (2018) Dynamic linkages between road transport energy consumption, economic growth, and environmental quality: evidence from Pakistan. Environ Sci Pollut Res 25:7541–7552.

Dogan E, Seker F (2016) Determinants of CO_2 emissions in the European Union: The role of renewable and non-renewable energy. Renew Energy 94:429–439.

Dong W, Liu S, Fang Z, Yang X, Hu Q, Tao L (2017) Study of a discrete grey forecasting model based on the quality cost characteristic curve. Grey Syst Theory Appl 7:376–384.

Flachsland, Creutzig (2011) Climate policies for road transport revisited (II): Closing the policy gap with cap-and-trade. Energy Policy 39:2100–2110.

Gökmenoğlu K, Taspinar N (2016) The relationship between Co 2 emissions , energy consumption , economic growth and FDI : the case of Turkey. 8199.

Hammond GP, Norman JB (2012) Decomposition analysis of energy-related carbon emissions from UK manufacturing. Energy 41:220–227.

Heede R (2014) Tracing anthropogenic carbon dioxide and methane emissions to fossil fuel and cement producers, 1854-2010. Clim Change 122:229–241.

Hillman T, Ramaswami A (2010) Greenhouse gas emission footprints and energy use benchmarks for eight U.S. cities. Environ Sci Technol 44:1902–1910.

Holmberg K, Erdemir A (2017) Influence of tribology on global energy consumption, costs and emissions. Friction 5:263–284.

Huang Y, Shen L, Liu H (2019) Grey relational analysis, principal component analysis and forecasting of carbon emissions based on long short-term memory in China. J Clean Prod 209:415–423.

Ikram M, Sroufe R, Rehman E, Shah SZA, Mahmoudi A (2020a) Do Quality, Environmental, and Social (QES) Certifications Improve International Trade? A Comparative Grey Relation Analysis of Developing vs. Developed Countries. Phys A Stat Mech its Appl 545:123486.

Ikram M, Zhang Q, Sroufe R, Shah SZA (2020b) Towards a Sustainable Environment: The Nexus between ISO 14001, Renewable Energy Consumption, Access to Electricity, Agriculture and CO_2 Emissions in SAARC Countries. Sustain Prod Consum.

Inglesi-Lotz R, Dogan E (2018) The role of renewable versus non-renewable energy to the level of CO_2 emissions a panel analysis of sub- Saharan Africa's Big 10 electricity generators. Renew Energy 123:36–43.

International Energy Agency (IEA) (2016) Energy and Air Pollution: World Energy Outlook Special Report.

IPCC (2019) Special Report on Climate Change and Land. Ipcc.
January R (1999) Short-Term Energy Outlook Short-Term Energy Outlook.
Javanajdadi (2017) Short-Term Load Forecasting Using Grey Models by Considering Demand Response.
Javed SA, Liu S (2018a) Evaluation of outpatient satisfaction and service quality of Pakistani healthcare projects: Application of a novel synthetic grey incidence analysis model. Grey Syst Theory Appl 8:462–480.
Javed SA, Liu S (2018b) Predicting the research output/growth of selected countries: application of Even GM (1, 1) and NDGM models. Scientometrics 115:395–413.
Khan (2019) Decomposition analysis of carbon dioxide emissions in Pakistan. SN Appl Sci 1:1–8.
Khan MA, Ghouri AM (2011) Environmental Pollution : Its Effects on Life and Its Remedies. Int Ref Res J 2:276–285.
Liu, Xu (2016) Impacts of FDI renewable energy technology spillover on China's energy industry performance. Sustain 8:1–16.
Löffler D, Uhlrich JJ, Baron M, Yang B, Yu X, Lichtenstein L, Heinke L, Büchner C, Heyde M, Shaikhutdinov S, Freund HJ, Włodarczyk R, Sierka M, Sauer J (2010) Growth and structure of crystalline silica sheet on Ru(0001). Phys Rev Lett 105.
Lu Y, Cui P, Li D (2016) Carbon emissions and policies in China's building and construction industry: evidence from 1994 to 2012. Build Environ 95:94–103.
Mallick L, Tandi SM (2015) Energy consumption, economic growth, and CO_2 emissions in SAARC countries: Does environmental Kuznets curve exist? Empir Econom Quant Econ Lett 44:57–69.
Mir KA, Purohit P, Mehmood S (2017) Sectoral assessment of greenhouse gas emissions in Pakistan. Environ Sci Pollut Res 24:27345–27355.
Mohsin M, Abbas Q, Zhang J, Ikram M, Iqbal N (2019a) Integrated effect of energy consumption, economic development, and population growth on CO_2 based environmental degradation: a case of transport sector. Environ Sci Pollut Res 26:32824–32835.
Mohsin M, Abbas Q, Zhang J, Ikram M, Iqbal N (2019b) Integrated effect of energy consumption, economic development, and population growth on CO_2 based environmental degradation: a case of transport sector. Environ Sci Pollut Res 26:32824–32835.
Ouyang X, Lin B (2015) An analysis of the driving forces of energy-related carbon dioxide emissions in China's industrial sector. Renew Sustain Energy Rev 45:838–849.
Pakistan Economic Survey (no date) Statatistical Supplement Pakistan Economic Survey 2017-18.
Qamar U, Saeed A (2016) Contextualizing Privatization in Pakistan: A case study of Pakistan Railway. Pakistan Vis 17:259–291.
Ramanathan R (2006) A multi-factor efficiency perspective to the relationships among world GDP , energy consumption and carbon dioxide emissions. 73:483–494.
Ratti RA, Vespignani JL (2016) Oil prices and global factor macroeconomic variables. Energy Econ 59:198–212.
Rello FJ, Valero A, Adroher FJ (2008) Anisakid parasites of the pouting (Trisopterus luscus) from the Cantabrian Sea coast, Bay of Biscay, Spain. J Helminthol 82:287–291.
Saidi S, Shahbaz M, Akhtar P (2018) The long-run relationships between transport energy consumption, transport infrastructure, and economic growth in MENA countries. Transp Res Part A Policy Pract 111:78–95.
Sarıkaya M, Güllü A (2015) Multi-response optimization of minimum quantity lubrication

parameters using Taguchi-based grey relational analysis in turning of difficult-to-cut alloy Haynes 25. J Clean Prod 91:347–357.

Sarkodie, Owusu (2016) Carbon dioxide emission, electricity consumption, industrialization, and economic growth nexus: The Beninese case. Energy Sources, Part B Econ Plan Policy 11:1089–1096.

Shahbaz, Hussain (2019) The Influencing Factors of CO2 Emissions and the Role of Biomass Energy Consumption: Statistical Experience from G-7 Countries. Environ Model Assess 24:143–161.

Shahbaz M, Mahalik MK, Shah SH, Sato JR (2016) Time-varying analysis of CO2 emissions, energy consumption, and economic growth nexus: Statistical experience in next 11 countries. Energy Policy 98:33–48.

Shahbaz M, Sinha A (2019) Environmental Kuznets curve for CO 2 emissions: a literature survey. J Econ Stud 46:106–168.

Shahbaz M, Yusup S, Inayat A, Patrick DO, Pratama A, Ammar M (2017) Optimization of hydrogen and syngas production from PKS gasification by using coal bottom ash. Bioresour Technol 241:284–295.

Shanthi et al. (2018) Effect of surfactant assisted sonic pretreatment on liquefaction of fruits and vegetable residue: Characterization, acidogenesis, biomethane yield and energy ratio. Bioresour Technol 264:35–41.

Sifeng Liu, Yingjie Yang JF (2016) Grey Data Analysis. Springer Singapore, Singapore.

Solaymani S, Kardooni R, Yusoff SB, Kari F (2015) The impacts of climate change policies on the transportation sector. Energy 81:719–728.

Sözen A, Cakir MT, Cipil F (2016) Sectoral CO 2 emission reductions in Turkey: Preparing for Doha 2020. Energy Sources, Part A Recover Util Environ Eff 38:905–913.

Steffen W, Rockström J, Richardson K, Lenton TM, Folke C, Liverman D, Summerhayes CP, Barnosky AD, Cornell SE, Crucifix M, Donges JF, Fetzer I, Lade SJ, Scheffer M, Winkelmann R, Schellnhuber HJ (2018) Trajectories of the Earth System in the Anthropocene. Proc Natl Acad Sci U S A 115:8252–8259.

Stram BN (2016) Key challenges to expanding renewable energy. Energy Policy 96:728–734.

Tariq S, Ul-Haq Z, Imran A, Mehmood U, Aslam MU, Mahmood K (2017) CO2 emissions from Pakistan and India and their relationship with economic variables. Appl Ecol Environ Res 15:1301–1312.

U.S. Energy Information Administration | International Energy Outlook 2016 (2019) Chapter 8: Transportation sector energy consumption.

Wang H, Ou X, Zhang X (2017) Mode, technology, energy consumption, and resulting CO2 emissions in China's transport sector up to 2050. Energy Policy 109:719–733.

Wang W, Peng W, Xu J, Zhang R, Zhao Y (2018) Driving Factor Analysis and Forecasting of CO2 Emissions from Power Output in China Using Scenario Analysis and CSCWOA-ELM Method. Energies 11:2709.

Wang Z-X, Ye D-J (2017) Forecasting Chinese carbon emissions from fossil energy consumption using non-linear grey multivariable models. J Clean Prod 142:600–612.

Wright VP (1986) World Energy Outlook.

Yuksel I, Kaygusuz K (2011) Renewable energy sources for clean and sustainable energy policies in Turkey. Renew Sustain Energy Rev 15:4132–4144.

Zafar, Saud, Fujun (2019) The impact of globalization and financial development on environmental quality: Evidence from selected countries in the organization for economic co-

operation and development (OECD). Environ Sci Pollut Res 26:13246–13262.
Zeb R, Salar L, Awan U, Zaman K, Shahbaz M (2014) Causal links between renewable energy , environmental degradation and economic growth in selected SAARC countries : Progress towards green economy. Renew Energy 71:123–132.
Zhicai Z, Li C (2018) Analysis on decision-making model of plan evaluation based on grey relation projection and combination weight algorithm. J Syst Eng Electron 29:789.