Review Journal of Social Psychology & Social Works

Volume :2, No:2 **Print ISSN:3006-4716**
http://socialworksreview.com **Online ISSN: 3006-4724**

Influence of Energy Consumption and Ecological Footprints on Emission of CO_2: A Case from Pakistan

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Abstract
The purpose of this research is to examine the influence of traditional energy, ecological footprint and renewable energy on carbon dioxide (CO2) emission in Pakistan. The regression model was used in this study to analyze the connection between the modeled variables using data from 1990 to 2022. The research discovered that although renewable energy had a negative and large effect on CO2 emissions, conventional energy and the ecological footprint had a significant and beneficial impact. According to this study, the government should discourage conventional energy consumption and promote the consumption of renewable energy in the industrial sector. These are only a few examples of the policies that should be developed for the energy sector.

Keywords
Renewable energy, Traditional energy, ecological footprint, CO2, Pakistan

Introduction
According to Mbarek et al. (2018), greenhouse gases (GHGs), especially carbon dioxide (CO2) emissions, are thought to be the primary cause of environmental deterioration. The main causes of carbon dioxide (CO2) emissions in Pakistan include human activities such as deforestation, soil erosion, and burning carbon-based fuels (Ali et al., 2018; Abbas et al., 2020; Ahmed et al. 2020). According to a 2013 research by the Food and Agriculture Organization (FAO), agricultural output will be adversely affected by a 15–30% rise in carbon dioxide emissions until the 21st century. CO2 emissions are caused by a growing ecological footprint, rising energy use, urbanization, inadequate management of water resources, and food scarcity. According to Boko et al. (2018), 68% of the 2010 greenhouse gas emissions came from the energy sector. According to Yousuf et al. (2014), this percentage ratio is composed of 90% carbon

dioxide (CO2) emissions, 9% methane, and the residual gases, including 1% nitrous oxide.

The worldwide community is working to keep the average temperature increase till the 21st century to 20 °C in order to reduce climate danger. The commitments, recognized as Intended Nationally Determined Contributions (INDCs), were agreed upon during the December 2015 Climate Change 21 Conference of Parties (Wirth 2015). However, in order to meet the Intended Nationally Determined Contributions, a thorough analysis of each nation is crucial. This is especially true when it comes to CO2 emissions.

Pakistan was found to have contributed 0.8% of the CO2 emissions, which is less than 1% worldwide. The Pakistani government is committed to mitigating the influences of rainfall and temperature by implementing adaptation strategies and reducing CO2 emissions (Eckstein et al. 2019). For this purpose, the Government presented its Intended Nationally Determined Contributions to the 21st Conference of Parties (COP21). Pakistan's Vision (2025) and the National Climate Change Policy (2012) were the two main sources of this subject that were noted in INDC.

Pakistan has been experiencing a serious energy problem since 2010. In Pakistan, 65.8 million tons of primary energy were recorded in 2018. Hydroelectricity (10.8%), coal (7.5%), gas (47.8%), LPG (0.7%), oil (31.5%), and nuclear power (1.2%) make up this source (Rehman and Deyuan 2018). Since 2000, hydropower has been Pakistan's primary source of energy. Therefore, the Pakistani government creates short-term laws and regulations in response to unplanned urbanization and economic instability. Furthermore, because the 2016 power shortage exceeded 3000 MW, the Pakistani government is also working to limit the decline in energy usage. The government of Pakistan intends to use coal resources to make up for the energy shortages in Pakistan Vision (2025).

The primary focus of the China-Pakistan Economic Corridor (CPEC) is Pakistan's energy consumption. The total cost of this project is $46 billion. According to Hof et al. (2017), this project uses coal (capacity 7570 MW) and initiatives involving the use of renewable energy (capacity 2780 MW) to meet the power need. These two projects have respective costs of $6.4 billion and $8.8 billion. This research makes it easier to link and distinguish between the CO2 emission reduction topics and the goals (INDCs at COP21) by providing a framework of knowledge.

Numerous research has been conducted in many countries throughout the world to examine the impact of energy use using statistical economics-based approaches (Abbas et al. 2018; Samuel et al. 2019; Mohiuddin et al. 2016). Asumadu-Sarkodie and Owusu (2016a) used the autoregressive distributed lag (ARDL) approach to assess the impact of transportation, industry, and energy consumption on CO2 emissions in Benin. Asumadu-Sarkodie and Owusu (2016b) demonstrated the long-term correlation between industrialization, energy consumption, and CO2 emissions. The impacts of energy, transportation, and urbanization on CO2 emissions were also reported by Asumadu-Sarkodie and Owusu (2016c) using ordinary least-squares (OLS) regression and the vector error correction model (VECM). Wang and Feng (2017) also utilized regression-based autoregressive distributed lag (ARDL) as well as vector error correction models (VECM) to examine the effects of GDP, population, and energy consumption on CO2 emissions.

Pakistan's gross domestic product (GDP) has been predicted to be declining since 2000. During the same period, Pakistan's economic strength was negatively impacted by a number of severe causes, including energy shortages, ecological degradation, and CO2 emissions. However, research on the influences of conventional energy, renewable energy, and ecological footprint on CO2 emissions is required. The aim of this work is to use a regression model to examine the link between CO2 emissions and temperature

throughout Pakistan and to estimate the influences of ecological footprint, traditional energy, and renewable energy on CO2 emissions.

Methodology and data

Pakistan is the study region

Pakistan is home to some of the most breathtaking landscapes in all of Asia. The mountain slopes cover it from the southern direction to the northern direction, beginning with the Arabian Sea and expanding in the opposite way. Additionally, there are a number of places that are located on the borders between Egypt and Mesopotamia. The area of South Asia that is bounded by the Arabian Sea, Afghanistan, Iran, and China is known as Pakistan. Pakistan is also the boundary between China and Afghanistan. It is located between 61 and 78 degrees north and 23.6 and 38 degrees east. The whole region has a total area of 796,096 kg2. Pakistan's land is characterized by a diverse terrain, ranging from the Indus plains to the mountains and Plateau in the western region of the country. There is a range of elevations, from 0 to 8611 meters. Pakistan is home to the K2 mountain, which is the country's largest peak. It is anticipated that about 27.87% of the total land area will be arable, with 0.87% of the land for permanent crops and 71.26% for other uses. Twenty-four percent of the total agricultural land is provided, of which eighty percent is irrigated. 4 percent of the land is covered by forests, while 31 percent of the land is not suitable for agricultural use. In Pakistan, there are 97 weather stations in total. There are 28, 19, 05, 27, 09 weather observatories in Punjab, Azad Kashmir, KPK, Sindh, Baluchistan, and the Quetta geophysical center. According to Aslam et al. (2017), Sindh is one of the most sensitive regions in terms of its effects on human health and climate change, However, out of the nine agro-ecological zones, Southern Punjab is the second most vulnerable. This rainfall season's change is based on both a temporal and geographical scale; the late or early beginning of the monsoon also results in significant losses. Because agricultural systems are very sensitive, the climatic extreme has a direct effect on their environmental state. Temperature intensity, water availability, and changes in the climatic system all have a significant impact on food production (Kirby et al. 2017). Higher-than-normal temperatures have drastically decreased yields in semiarid, arid, and sub-humid zones (Sultana et al. 2009).

This research used global hectares (GHA) per person for ecological footprint, fossil fuel energy consumption (as a percentage of total energy) for traditional energy consumption, renewable energy consumption (as a percentage of total final energy), and CO2 emissions for environmental degradation.

Description of the data

This research made use of a number of significant factors. The utilization of conventional energy consumption, renewable energy, and ecological footprint are independent variables, while carbon emissions are the dependent variable. For 33 years (1990 to 2022), yearly statistics on ecological footprint, renewable energy, and traditional energy were gathered from several sources (including the Global Footprint Network and the WDDI).

DATA ANALYSIS

Descriptive Statistic of Pakistan

The primary summary of the data is displayed by descriptive statistics. Table I below shows the descriptive summary used to approximate the impact of traditional energy, renewable energy, ecological footprint on carbon dioxide emission (CO2) in Pakistan.

Table I: Descriptive Summary

Variable	Obs	Mean	SD	Min	Max
CO2	33	10.886	12.501	88.08	118.74
TE	33	57.262	32.896	14.25	93.78
RE	33	65.737	22.167	5.13	75.91
EF	33	70.728	16.885	5.48	77.59

The descriptive statistics associated with the variables are shown in the table.

Correlation matrix

The association relating the dependent and independent variables is shown by the correlation matrix. Its values fall between +1 and -1.

Table II; Correlation matrix

Variable	(1)	(2)	(3)	(4)
CO2	1			
TE	-0.041	1		
RE	0.031	0.378	1	
EF	-0.043	0.237	0.234	1

The table presents the correlation matrix of the variables.

Regression Analysis

The current study investigates the linear link among traditional energy, renewable energy, ecological footprint and carbon dioxide emission (CO2) in Pakistan using a multivariate methodology. In this case, CO2 acts as the study's dependent variable. The renewable energy, Traditional energy, as well as ecological footprint are the independent factors.

$$CO2=\alpha+\beta_1 TE+\beta_2 RE2+\beta_3 EF+\varepsilon_{i,t} \quad (4.1)$$

Equation (4.1) illustrates the association among the independent variable and the dependent variable. The CO2 gauges the carbon dioxide emission, the TE gauges its traditional energy, the RE gauges its renewable energy, the EF ecological footprints. The beta coefficient is the slope, represented by β, and the error term is represented by εi,t.

Table. III; Regression Analysis for Financial Performance

ROA	Coef.	St.Err.	P-value
TE	.011*	.022	.0635
RE	-.03**	.03	.0315
EF	.026**	.038	.0491
FL	3.706***	.533	0
Constant	31.366***	4.629	0
R2	0.446	**observation**	33
F-test	12.874	**P > F**	0.001***

The regression analysis is shown in this table. Traditional Energy (TE), Renewable Energy (RE), Ecological Footprint (EF) are independent variables. *, **, and *** stand for statistically significant at 10%, 5%, and 1%, in that order.

The regression findings are shown in Table III. There are 33 observations in all. The model's fitness is measured by the F-value and the R-squared statistic. The R squared score of 0.446 indicates that 44% of the variance in the CO2 of Pakistan can be ascribed

to the independent variable's causes. According to the F-value results, the entire model is appropriate for additional analysis and is significant at the 1% level. Transitional energy, renewable energy as well as ecological footprints are correlated positively and significantly with CO2. The carbon dioxide emission in Pakistan is increased by Transitional energy, renewable energy and ecological footprints.

Discussion

According to empirically determined statistics, the ecological footprint of conventional energy has an optimistic and significant connection with carbon dioxide emissions (CO2) over the long term, while renewable energy has a negative and significant association with CO2.

Furthermore, prior research has shown a significant correlation between traditional energy and CO2 emissions (Ang 2008; Ahmad et al. 2016; Alkhathlan & Javid 2015; Tiba & Omri 2017; Adewuyi & Awodumi 2017;). Tiba and Omri (2017) explained that although widespread energy consumption contributes to economic progress, it also raises carbon dioxide emissions and the ecological imprint. Similar findings were made by Adewuyi and Awodumi (2017), who found that energy use increases ecological footprint and carbon dioxide emissions (CO2), which in turn increases environmental degradation in the biosphere and ecosystem (Ang 2008; Shahbaz et al. 2013; Apergis & Payne 2009, 2010; Boontome et al. 2017).

In order to fulfill its rapidly increasing energy demand, Pakistan, a rising country that has seen strong industrial expansion in recent decades, is turning to conventional energy sources. Conventional energy is generated by the overuse of oil and natural gas, which are seen to be the main causes of environmental issues since they raise CO2 levels (Singra et al. 2019; O'Ryan et al. 2020; Saleem and Shujah-ur-Rahman 2019). Additionally, the majority of businesses depend on power generation, and conventional energy accounts for 41% of the total energy consumed in power generating (Sadorsky 2009; Shah 2020). Furthermore, large smoke emissions from enterprises have a disastrous effect on the environment, the economy, many economic sectors such as forestry and agriculture, and people in Pakistan (Ahmed et al., 2020).

Likewise, Yang et al. (2017) claimed that environmental deterioration is caused by the release of GHGs such as CO2, nitrous oxide, and methane. Additionally, Anser (2019). According to Shahbaz et al. (2013), using conventional energy sources like wood and fossil fuels in everyday living significantly increases carbon dioxide emissions (Chen et al. 2019).

This research also shows that the usage of renewable energy has a significant and negative correlation with CO2 emissions; the more renewable energy is used, the lower the CO2 emissions will be. We found that our findings align with previous research (Abolhoseini et al. 2014; Hasnisah et al. 2019; Mbarek et al. 2018). According to (Gissh et al. 2019), renewable energy is generated naturally by the wind tides, solar system, and hydropower, all of which significantly lower greenhouse gas emissions (GHGs) such as carbon dioxide, nitrogen oxide, sulfur dioxide, and other ecological pollutants. Furthermore, this research discovered a significant correlation between carbon dioxide emissions and ecological footprint. The findings align with earlier research (Fiala 2008; Szigeti et al., 2017; Vackar 2012). Anthropogenic activity is one of the primary causes of global warming, which may be explained by a rise in the temperature of harmful gases including carbon dioxide, sulfur oxide, and nitrogen oxide. Global warming is caused by human species using 25% more resources than the earth's biocapacity (Fiala 2008). The bulk of the almost 20% of global warming attributed to human activity comes from the first stage of food production, according to the Global Footprints study. According to Szigeti et al. (2017), there was a negligible short-term correlation between

ecological footprint and carbon dioxide emissions (CO2), but a significant long-term effect was seen.

The findings of this study are also supported by the UNFCCC (2007) and the Intended Nationally Determined Contributions to the 21st Conference of Parties (COP21), which show that traditional energy and ecological footprint have a significant positive correlation with carbon dioxide emissions (CO2) in Pakistan, whereas renewable energy has a significant negative correlation. Previous investigations (Shahbaz et al. 2013; Rehman and Deyuan 2018; Ahmed et al. 2015; Saleem & Rahman 2019; Shah 2020) have revealed similar findings.

Conclusion

The current study's goal is to investigate how carbon dioxide emissions are affected by conventional energy, renewable energy, and ecological footprints. The consequences of energy use and environmental impact on carbon dioxide emissions (CO2) between 1990 and 2022 were examined using statistical methods. The findings showed that carbon dioxide (CO2) emissions are favorably impacted by conventional energy and ecological footprint. However, there is no significant correlation between CO2 emissions and renewable energy.

According to this study, the government should discourage conventional energy consumption and promote the use of renewable energy in the industrial sector. These are only a few examples of the policies that should be developed for the energy sector.