

Environmental Intensity in Pakistan: A Projection for Period 2016-2030

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ABSTRACT

This study examines the trend in economic development, energy consumption, CO₂ emissions and ecological footprint, and systematically studies the projection of environmental intensity in Pakistan. To evaluate the trend, the study uses a sample period of 1980-2012, while the environmental intensity projection is undertaken for period 2016-2030 by using the Grey (1,1) model. The rational of the study is that Pakistan as a member of the United Nations (UN) has pledged to meet the Sustainable Development Goals (SDGs), which include the reduction of CO₂ emission to a sustainable level. The result of the study demonstrates that Pakistan's GDP Per Capita shows an increasing trend alongwith energy consumption. The carbon and ecological footprint intensity declines and the annual rates of decline are respectively 8.26% and 8.01%, where the average annual growth rate of GDP is 9.95%, which therefore shows that the impact of economic output on environment is reducing year by year. The projection of environmental intensity based on Grey (1,1) model shows that further increase in economic growth, reduction in CO₂ emissions and material resource consumption will reduce Pakistan's environmental intensity. The study shows that by focusing on renewable energy projects and following China carbon trading markets will achieve upto 20% reduction in carbon emissions and environmental intensity in Pakistan.

Key Words: Environmental Intensity, Economic Growth, Energy Consumption, CO₂ Emissions, Ecological Footprint

JEL Classification: Q51, O40, Q47, Q44, Q57

1. INTRODUCTION

Environmental sustainability due to global climate change and consumption of material resources has become of the daunting challenge the world is facing in the 21st century (Li et al., 2018, Ali et al., 2016). Countries from around the world have been initiating certain measures to slow down global warming and greenhouse gas emissions from resource consumption. CO₂ emission resulting from energy consumption is 90%, which causes a great deal to climate change (Li et al., 2018, IEA, 2015).

In January 2016, the SDGs introduced for the period 2016-2030, not only include the climate change one of the goals – goal 13 (Climate Action) – but also emphasize its protection. The goal stresses to achieve the environmental sustainability. The Kyoto Protocol, an internationally treaty agreement of 192 countries signed in Kyoto Japan in February 2005, recognized to reduce greenhouse gas emissions.

To achieve environmental sustainability the developed countries pledged to provide finance and environmental friendly technology to developing and emerging economies (IEA, 2015, Li et al., 2018). They committed to earn saleable credit based on the certified emissions reduction (Li et al., 2018).

In Pakistan, the economic growth and development process received an increasing concern resulting from the climate change. Whereas, the economic growth over the decade has limited to single digit per annum, yet there has been an increasing trend in energy consumption alongwith the exploitation of natural resources. This led to have an adverse consequence on worsening the air quality and deteriorating the ecological system. Greenhouse gas emissions, climate change and dependency on material resources such as crops, fish and fishery products, forests, grazing and urban land utilization in Pakistan have global significance in environmental challenges. As Pakistan's ecological footprint¹ increased from 0.51gha² in 1961 to 0.73gha in 2015 and biocapacity³ reduced from 0.47gha in 1961 to 0.34gha in 2015, it resulted to the ecological deficit (GFN, 2016). In Pakistan the CO₂ emissions per capita resulting from energy consumption is 0.86 metric tons in 2015, which ranked Pakistan the 7th amongst the most adversely affected countries with respect to climate change and challenges in respect to water, food and energy security. However, for environmental protection Pakistan has passed climate change Act 2017, and set a series of targets and policy measures to combat desertification, geometric centre for climate change and sustainable development.

Given the above background, the following two ways justify the contribution of this work to the existing literature of environmental economics. First, the emphasis of the existing literature on environment is to estimate nexus between economic growth and environmental degradation. In contrast, we assess threats to environmental sustainability by examining the trends in the energy consumption, economic growth, CO₂ emissions and ecological footprint for Pakistan. Second, we have hardly found studies to project the environmental intensity in Pakistan for the period 2016-2030, and the projection of Pakistan's environmental intensity for this period may be considered a novel contribution of this study to the existing literature.

2. LITERATURE REVIEW

The existing literature on environment investigated the nexus between environment, economic growth, energy consumption, trade and economic growth and environmental intensity. These Studies demonstrate different results. Richard et al. (2003); York and Rosa (2003); (Jorgenson and Burns (2007), Al-Mulali et al. (2015)); Ali et al. (2016); Uddin et al. (2017); Salahuddin and Gow (2014) demonstrate that economic growth increases environmental degradation. They argue that economic

¹ Ecological footprint shows human activities impact on environment, expressed in the term of area of land required to support human consumption in form of cropland, forestry, fishing grounds, grazing and built-up land as well as the area of land to absorb CO₂ emissions (GFN, 2014).

² *gha* stands for global hectare and it is the unit measure of ecological footprint and biocapacity. One hectare is approximately equal to 2.47 acres (GFN, 2016, Jorgenson and Burns, 2007).

³ Biocapacity indicates the available productive area required to generate resources as well as to absorb wastage (GFN, 2014).

development demands energy consumption and energy consumption accelerates CO₂ emissions. Li et al. (2018) argue that as an economy becomes more open, it consumes energy in large volume and accelerates environmental degradation. Technological improvement and efficiency in resource utilization enhances energy consumption and environmental degradation. The example of China provides a classic case, where the energy consumption and environmental degradation increased with its economic openness to the world. Mostafa (2010); Shahbaz et al. (2013); Mostafa (2010); Wang et al. (2014); Uddin et al. (2016), however, content that as a country becomes more developed, demands for clean environment would follow suit. Thus, the nexus between economic development and environment degradation becomes negatively correlated. York et al., (2009) test the argument that ecological efficiency reduces resource consumption and threats to environment. They examine the trend in resource consumption and ecological efficiency of two emerging economies, China and India, and two developed economies, Japan and the United States. The ecological footprint uses for environmental degradation. Their findings suggest that ecological efficiency does not reduce resource consumption. It rather escalates the consumption hence accelerates the threats to environmental sustainability.

3. DATA AND METHODOLOGY

In order to contribute to the related literature, this study uses three key sources for data collection. Gross Domestic Product (GDP) and CO₂ emissions data are obtained from the World Bank. The data for Coal, Oil and Gas consumption are obtained from the International Energy Agency. The data for the ecological footprint are obtained from the Global Footprint Network. The examination of threats to environmental sustainability covers the sample period of 1980-2012.

For the environmental intensity projection the study takes a sample period from 2016 to 2030. The rational for the projection is that Pakistan as a member of the United Nations has pledged to the SDGs, in which climate change and environmental protection is one of an overarching goals. To project environmental intensity this study uses the Grey Model proposed by Deng (1982).

The model works on non-negative time series observations. Let $v^0_{(1)}, \dots, v^0_{(m)}$ be non-negative time series observations and V^0 be column vector of observations (Li et al., 2018):

$$V^0 = \begin{bmatrix} v^0_{(1)} \\ v^0_{(2)} \\ v^0_{(3)} \\ \vdots \\ v^0_{(m)} \end{bmatrix} \quad (3.1)$$

Where, $v^0_{(1)}$ is the environmental intensity observation in year 2002 and $v^0_{(m)}$ is the environmental intensity observation in year 2012. The cumulative environmental intensity time series is computed by (Li et al., 2018) as:

$$V^1 = \{v^0_{(1)}, v^0_{(1)} + v^0_{(2)}, \dots, \dots, v^0_{(m)}\} \quad (3.2)$$

$$V^1 = \{v^1_{(1)}, v^1_{(2)}, \dots, v^1_{(m)}\} \quad (3.3)$$

Where

$$v^1_{(1)} = v^0_{(1)}, v^1_{(2)} = \sum_{i=1}^2 v^0_{(i)}, \dots, v^1_{(m)} = \sum_{i=1}^m v^0_{(i)}$$

The Grey Model is use as one of explanatory variables, and first differential equation in form of GM (1, 1) according to (Li et al., 2018) is expressed as:

$$\begin{aligned} \frac{dv^{(1)}}{dt} + av^{(1)} \\ = u \end{aligned} \quad (3.4)$$

It is known as the first order differential equation and projection can be determined as:

$$\begin{aligned} \hat{v}^{(1)}_{(m)} = \left(v^{(0)}_{(1)} - \frac{u}{a} \right) e^{-a(k-1)} + \\ \frac{u}{a} \end{aligned} \quad (3.5)$$

Where k is time period and $\hat{v}^{(1)}_{(m)}$ is forecast cumulative environmental intensity, which depends upon the year 2002 intensity observation, i.e. $v^{(0)}_{(1)}$. The value of $d = [a, u]^T$ by applying the least square estimate is determined by (Akay and Atak, 2007, Chen, 2008) as:

$$\begin{aligned} \hat{d} = \\ (A^T A)^{-1} A^T Y_n \end{aligned} \quad (3.6)$$

$$\text{Where } A = \begin{bmatrix} -1/2\{\sum_{i=1}^2 v^1_{(1)}\} & 1 \\ -1/2\{\sum_{i=2}^3 v^1_{(2)}\} & 1 \\ \vdots & \vdots \\ -1/2\{\sum_{i=k-1}^k v^1_{(k)}\} & 1 \end{bmatrix}$$

$$\text{And the above Matrix can be written as: } A = \begin{bmatrix} -Y^1_{(2)} & 1 \\ -Y^1_{(3)} & 1 \\ \vdots & \vdots \\ -Y^1_{(m)} & 1 \end{bmatrix}$$

Where

$$Y^1_{(2)} = 1/2\{\sum_{i=1}^2 v^1_{(1)}\}, Y^1_{(3)} = 1/2\{\sum_{i=2}^3 v^1_{(2)}\}, \dots, Y^1_{(m)} = 1/2\{\sum_{i=k-1}^k v^1_{(k)}\}$$

And $m \geq 2$

$$X_n = [v^0_{(2)}, v^0_{(3)} \dots, v^0_{(m)}]^T$$

The estimated values of a and u are obtained by applying equations (3.7) and (3.8) and projected observation $\hat{v}^{(0)}_{(m)}$ is computed through equation (3.9) by (Chen, 2008, Li et al., 2018).

$$\hat{a} = \frac{\sum_{i=2}^m [Y^1_{(i)}] \sum_{i=2}^m v^0_{(i)} - (m-1) \sum_{i=2}^m v^0_{(i)} Y^1_{(i)}}{(m-1) \sum_{i=2}^m [Y^1_{(i)}]^2 - \left(\sum_{i=2}^m Y^1_{(i)} \right)^2} \quad (3.7)$$

$$\hat{u} = \frac{\sum_{i=2}^m v^0_{(i)} \sum_{i=2}^m [Y^1_{(i)}]^2 - \sum_{i=2}^m v^0_{(i)} Y^1_{(i)} \cdot \sum_{i=2}^m Y^1_{(i)}}{(m-1) \sum_{i=2}^m [Y^1_{(i)}]^2 - \left(\sum_{i=2}^m Y^1_{(i)} \right)^2} \quad (3.8)$$

$$\hat{v}^{(0)}_{(m)} = \left[\left(v^{(0)}_{(1)} - \frac{u}{a} \right) e^{-a(k-1)} + \frac{u}{a} \right] \quad (3.9)$$

The CO₂ emissions and the ecological footprint use as proxy for environmental degradation and environmental intensity estimate through the following equations respectively.

$$CO_2 Intensity (CO_2 I) = \frac{CO_2 emission}{GDP} \quad (3.10)$$

$$Ecological footprint_{intensity} (EFI) = \frac{Ecological footprint}{GDP} \quad (3.11)$$

The CO₂ emissions and ecological footprint intensity according to (Li et al., 2018) are projected as:

$$\widehat{CO_2 I}^{(0)}_{(m)} = \left[\left(CO_2 I^{(0)}_{(1)} - \frac{u}{a} \right) e^{-a(k-1)} + \frac{u}{a} \right] \quad (3.12)$$

$$\widehat{EFI}^{(0)}_{(m)} = \left[\left(EFI^{(0)}_{(1)} - \frac{u}{a} \right) e^{-a(k-1)} + \frac{u}{a} \right] \quad (3.13)$$

4. RESULTS AND DISCUSSIONS

This research suggests that economic development is positively associated with resource consumption and environmental degradation in Pakistan. It further suggests that the economic development must be accelerated within the boundary of environmental sustainability. In figures 1- 6, we present the trend over time in economic development, resource consumption, ecological footprint and CO₂ emissions of

Pakistan in order to examine the threat to environment. GDP per capita shows an increasing trend and has become steeper from year 2002 onward. Economic development has caused energy consumption and environment degradation. Oil and gas consumption shows relatively an increasing trend than coal. Consumption of coal after 2005 has decreased because of various alternatives sources of energy, resulting to the reduction in CO₂ emissions.

These findings are consistent with the research of Li et al. (2018), where they argue that the growth rate of CO₂ emissions of China has slowed down since 2011 as it has initiated a series of policies to control the consumption of coal. However, year by year the China's GDP per capita is rising owing to a high and sustained economic growth., which outstripped its decline in carbon emissions. For instance, the average annual growth rate (AAGR) of the GDP with 13.79% is higher than the 8.28% average annual decline rate (AADR) of the carbon intensity (Li et al., 2018). It shows that although the growth rate still higher than reduction in carbon emissions in China, yet it has realized to reduce carbon intensity alongwith economic growth. In Pakistan, the increasing trend of economic growth and reduction in CO₂ emissions and ecological footprint explains that Pakistan is also actively participating in environmental sustainability. The findings of this research are consistent with the Economic Survey of Pakistan (2017), which states that the Wind and Solar Power Projects have substantially increased in Pakistan. In the last five years, eighteen wind and six power projects have been established with energy capacity 937.27 MW and 418 MW respectively (Economic Survey of Pakistan, 2017).

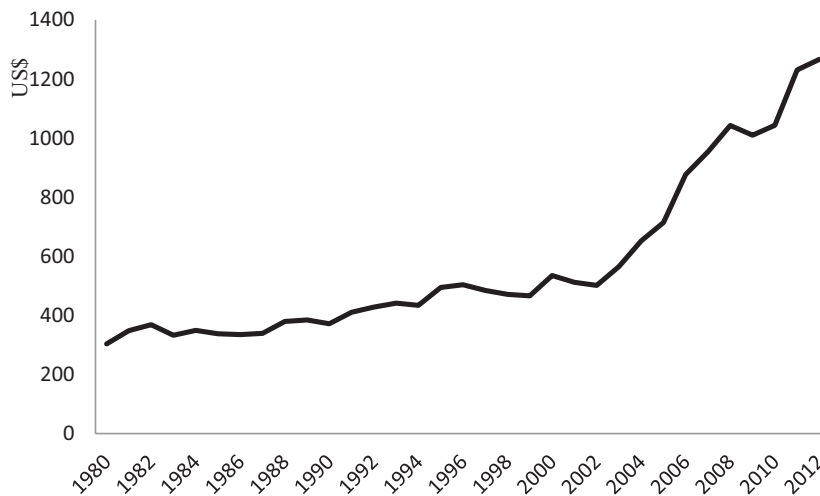


Figure 1. Trend of GDP per capita of Pakistan overtime

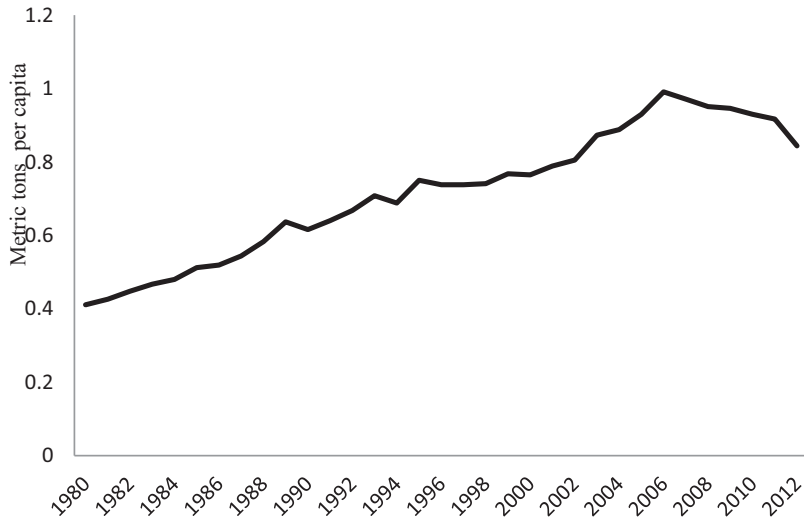


Figure 2. Trend of CO₂ emissions of Pakistan overtime

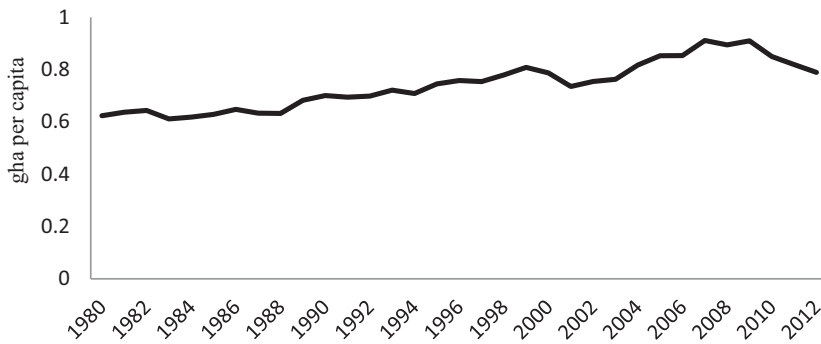


Figure 3. Trend of Ecological Footprint of Pakistan overtime

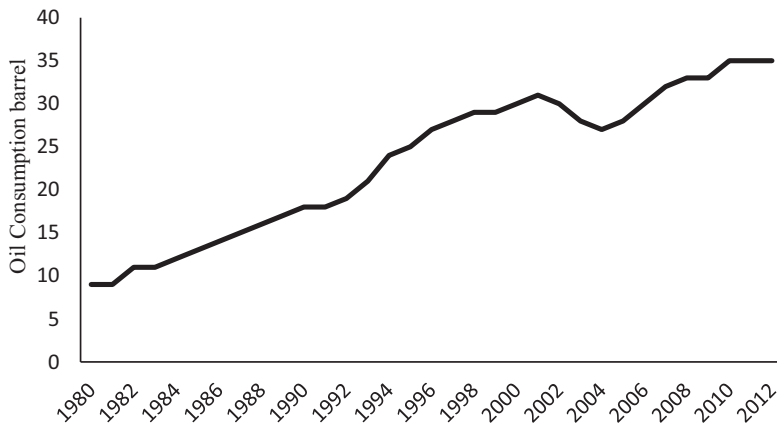


Figure 4. Trend of Oil consumption of Pakistan overtime

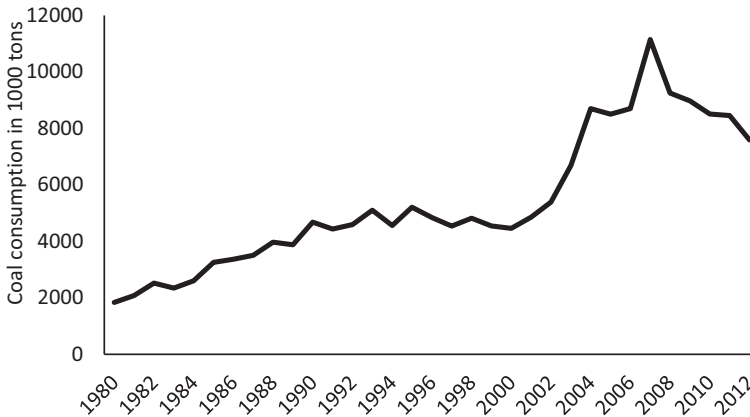


Figure 5. Trend of Coal consumption of Pakistan overtime

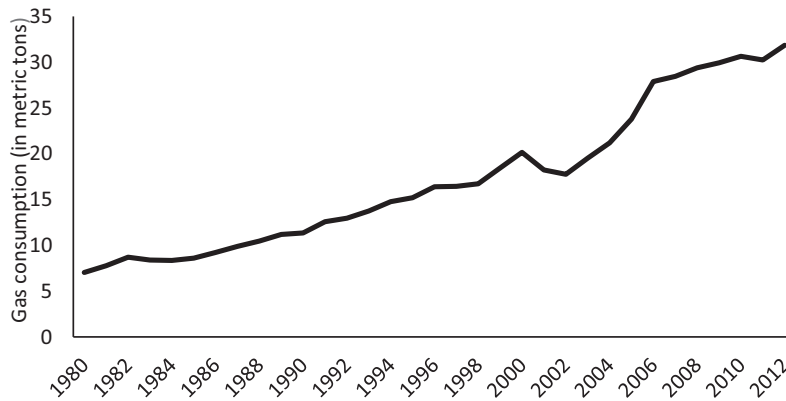


Figure 6. Trend of Gas consumption of Pakistan overtime

Based on increasing trend of GDP per capita and reduction in CO₂ emissions and ecological footprint the environmental intensity has shown a reduction. Average annual growth rate of GDP in Pakistan over the sample period is 9.95%, which is higher than average annual decline rate of CO₂ emissions of 8.26% and ecological footprint intensity 8.01%. Therefore, Pakistan can achieve environmental benefit by initiating various environmental targets in which the impact of economic output on environment is declining year by year.

Table 1. Summary Statistics of variables in Pakistan, 2002-2012

Years	CO ₂ emissions intensity	Ecological footprint intensity
	(metric tons/100US\$)	(global hectare/100US\$)
2002	0.161	0.151
2003	0.154	0.135
2004	0.136	0.125
2005	0.130	0.119
2006	0.113	0.097
2007	0.102	0.096
2008	0.091	0.086
2009	0.094	0.090
2010	0.089	0.081
2011	0.075	0.067
2012	0.067	0.062

Source: author's calculation based on World Bank and Ecological Footprint Network dataset

To project the environmental intensity, the following Grey (1,1) Model for CO₂ emissions and ecological footprint has been estimated.

$$\widehat{CO_2I}^{(1)}_{(k)} = \begin{bmatrix} -2.437 e^{-0.0881(k-1)} \\ + 2.5982 \end{bmatrix} \quad (4.14)$$

And

$$\begin{aligned} \widehat{EFI}^{(1)}_{(k)} \\ = \begin{bmatrix} -1.711 e^{-0.0822(k-1)} \\ + 1.8613 \end{bmatrix} \end{aligned} \quad (4.15)$$

Based on the projected values as shown in table 2, CO₂ emissions and ecological footprint intensity decline steadily year by year. The theoretical debate on the impact of intensity, economic development and energy consumption on environment has a necessary relevance. It is suggested that with technological refinements, advances in material and energy consumption improve the environment. This is consistent with our findings, as intensity reduces alongwith the reduction in CO₂ emission and material consumption. These two indicators show that Pakistan is achieving environmental improvement, which is in line with achiving the goals of the SDGs. For the policy relevance it is suggested that Pakistan must convert energy consumption to renewable energy sources. Thus, increase in Wind and Solar Projects will reduce environmental intensity. Our findings also support the ecological modernization perspective that as economy becomes more developed, it tries to improve environment (Anders and John, 2009). The increasing trend in economic development of Pakistan and reduction in environmental intensity supports the ecological modernization perspective. Overall,

Pakistan can maintain a declining trend in environmental intensity if it follows the economic development under the constraint of reducing material consumption and CO₂ emission. The possible way is to promote renewable energy consumption sources instead of large dependency on non-renewable sources in its different sectors. The finding is consistent with (Li et al., 2018) who show that China has increased the usage of renewable energy in different sectors and hence the environmental intensity is reducing year by year. Li et al. (2018) further argue that China's government is trying to increase investment in carbon trading market and hence has established seven pilot carbon trading markets. Pakistan, if follows investment in carbon trading market, will reduce carbon emissions and ecological footprint which consequently will reduce the environmental intensity.

Table 2. Projecting CO₂ emissions and Ecological Footprint Intensity

Year	Actual Ecological	Forecasting	Actual CO ₂	Forecasting CO ₂
	Footprint Intensity	Ecological Footprint Intensity	emissions Intensity	emissions Intensity
	<i>gha/100 US\$</i>		<i>Metric tons/100 US\$</i>	
2002	0.151	0.151	0.161	0.160
2003	0.135	0.135	0.154	0.153
2004	0.125	0.125	0.136	0.136
2005	0.119	0.115	0.130	0.126
2006	0.097	0.106	0.113	0.115
2007	0.096	0.098	0.102	0.106
2008	0.092	0.090	0.091	0.095
2009	0.090	0.083	0.094	0.090
2010	0.081	0.077	0.089	0.082
2011	0.067	0.071	0.075	0.075
2012	0.062	0.065	0.067	0.069
2013	-	0.060	-	0.063
2014	-	0.056	-	0.058
2015	-	0.051	-	0.054
2016	-	0.047	-	0.049
2017	-	0.044	-	0.045
2018	-	0.040	-	0.041
2019	-	0.037	-	0.038
2020	-	0.034	-	0.035
2021	-	0.032	-	0.032
2022	-	0.029	-	0.029
2023	-	0.027	-	0.027
2024	-	0.025	-	0.025
2025	-	0.023	-	0.023
2026	-	0.021	-	0.021
2027	-	0.019	-	0.019
2028	-	0.018	-	0.018
2029	-	0.017	-	0.016
2030	-	0.015	-	0.015

Source: author's calculation based on Grey (1,1) Model

5. CONCLUSION

From the above discussion it is concluded that Pakistan has taken the issue of climate change and environmental degradation with certain level of seriousness, as the trend analysis of energy consumption, particularly coal, shows a decreasing trend, owing to the implementation of Solar and Wind Power Projects over the decade. Improvement in economic development and reduction in CO₂ emissions and ecological footprint results to reduction in environmental intensity. Projection suggests that further increase in economic development and reduction in CO₂ emissions and material resource consumption will reduce environmental intensity in Pakistan. Thus, focus on renewable energy consumption and also by following China carbon trading markets example, Pakistan can further reduce carbon emissions. The participation of each province of Pakistan in environmental sustainability targets will also reduce environmental intensity, as the government has already delegated the subject of environment to the provinces. Pakistan has targeted to reduce its CO₂ emissions up to 20% in the period 2016-2030. For this, Pakistan has taken some serious steps like the Global Bio-Energy Partnership (GBEP) to support the deployment of biomass and bio-fuels and the Solar and Wind Energy Resource Assessment (SWERA), which seek to make renewable energy data widely available. Policy reforms like energy market reform and reduction of tariff barriers on low-carbon technology transfer are needed to achieve 20% reduction in CO₂ emissions and improve environmental sustainability.

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