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Impact of Industrialization on the Environment: The case study of Pakistan

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ABSTRACT

Industrial development is essential to ensure economic development, but at the same time it can put a significant strain on the environment. This study examines the impact of industrial activities, use of fossil fuels, foreign direct investment (FDI) and integration of clean energy sources on the ecological footprint of Pakistan. Data from national statistical sources over the last two decades is used to estimate the relationship between these variables and environmental health using regression analysis. The findings indicate that industrial production, the use of fossil fuels and FDI have a higher ecological footprint, and the use of clean energy has a lower ecological footprint. The results of these studies stress the economic and environmental costs and benefits that need to be taken into account when designing sustainable industrial policies. The paper offers practical recommendations to the leaders to promote the adoption of renewable energy, attract foreign direct investment (FDI) from those who care about the environment, and develop strategies that balance industrial growth with environmental protection. This study contributes to the literature on sustainable development in emerging economies by analyzing the links between industrialization, energy consumption and FDI flows regarding ecological outcomes, and by providing policy recommendations to mitigate environmental impacts and build economic development.

1. Introduction

The process of industrialization is an integral part of the economic growth and development of a country. But, the concerns of industrialization on the environment are increasing worldwide. Pakistan is a developing country, which has turned into more of an industrialized country over the past few decades. This study aims to thoroughly examine the effects of industrialization on the environment. An example of the relationship between economic growth and environmental quality is the Environmental Kuznets curve hypothesis. Environmental problems of all kinds tend to aggravate as income increases in developing countries. The Environmental Kuznets Curve hypothesis predicts that under a specific level of per capita income, environmental degradation increases in the early stages of economic development, but decreases in the subsequent stages. This indicates that the environmental quality can be better in the rich countries than in middle income countries where pollution levels are higher. We are interested in studying the impact of industry on nature in detail. We are not simply going to be talking about numbers and graphs; we are going to be talking about why it is so and how we can do something about it. To understand the different effects that industry has on the environment in different locations, in order to make things better. The dependence on fossil fuels increases to fuel production growth for both local and global markets are closely tied to their significant carbon emissions. Policymakers are in a conundrum between economic growth and environmental sustainability.

However, there is a relationship between change in the environment and economic expansion. Because the environment is the reservoir of the economy, growth has created degradation in the environment. The role of industrialization, clean energy, fossil fuel energy, FDI, and ecological footprint are all examined in this study. Environmental quality is lowered by the industrialization process and the use of fossil fuels. FDI gradually diminishes the environmental prominence as well. This study shows that the industrial sector is switching from fossil fuels to renewable energy, that foreign investments in fossil fuels are decreasing, and that ecological welfare concepts are being incorporated into development planning.

The aim of this study is to explore the environmental impacts of industrialisation in Pakistan and it focuses on the use of fossil fuel energy resources, foreign direct investment (FDI) and clean energy. It is important to understand the complex interactions between the different factors that shape the course of industrialization and energy consumption, including their effects on economic growth and environmental impacts. Although fossil fuel energy is vital for industry growth, it has also been closely associated with pollutants such as greenhouse gas emissions and air pollution,

demonstrating the need for sustainable alternatives. Also, the nature of the investments undertaken, can potentially stimulate green technologies or cause damage to the environment.

The aim of this study is to provide valuable contributions to those who are trying to balance economic progress and environmental conservation by examining the role of clean energy as a pathway to decreasing industrial pollution. The overall conclusion of the research is that strategies are needed that can support industry growth while balancing ecological systems and ensuring economic stability.

The necessity of solving environmental problems, especially facing climate change issue has been urgent in recent years. The economic growth and industrialization experienced by Pakistan and other Asia-Pacific countries has resulted in increased energy consumption, pollution, and ecological footprint. Understanding the connection between economic activities and their environmental consequences has therefore become crucial. Industrialization and foreign direct investment (FDI) are two key drivers of economic growth in developing countries like Pakistan. FDI contributes to financial development, global trade integration, human capital formation, and the achievement of economies of scale in relevant markets, making it an important engine of economic progress (Gorg and Greenway, 2004). However, while industrialization and FDI have provided significant economic benefits, their reliance on natural resource extraction and intensive production processes also poses serious risks to environmental quality.

According to the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP, 2018), the Asia-Pacific region accounted for 45% of global FDI inflows and is expected to remain a leading destination for such investments in the coming years (Bhujabal et al., 2021). As the region continues to expand economically and technologically, FDI has become an important channel for knowledge transfer and plays a major role in shaping both the environmental and economic landscape of recipient countries (Ahmed et al., 2020; Tang et al., 2014). Therefore, it is essential for developing nations to design policies that encourage FDI and industrial development without compromising public health or environmental sustainability (Tang et al., 2014). Ahmed et al. (2021) further highlighted the deep environmental implications of industrialization, emphasizing its adverse effects on human health and ecological balance. Their findings reinforce the need for detailed research to assess the scale of environmental challenges resulting from industrial expansion.

The link between economic development and environmental degradation has received comparatively little focus in the ever-expanding body of research on the relationship between these

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two concepts at the global level, with the exception of Pakistan and the Asia-Pacific region. This study looks at the impact of industrialization, foreign direct investment (FDI) and use of fossil fuels on Pakistan's ecological footprint, addressing a research void. It provides empirical evidence of the major factors behind environmental degradation in Pakistan through econometric analysis and also provides suggestions to inform policies for sustainable development in Pakistan.

The main objective of this study is to explore the effect of industrialization on an environment from the perspective of environmental quality, which is referred by the indicator of ecological footprint of Pakistan and its related economic issues. The study is particularly focused on measuring the effects of manufacturing value added on the ecological footprint, as an indicator of industrial development. It also aims to examine the correlation between the usage of fossil fuels and environmental damage.

The study also explores the ecological footprint of foreign direct investment (FDI) in Pakistan and its reduction by implementing renewable energy sources. The study aims to contribute to understanding of the factors influencing national environmental sustainability in the context of economic activity and energy choices through these goals.

The main objective of this study is to examine the relationship between the industrialization process, fossil fuel energy, foreign direct investment (FDI) and clean energy and their dual role of contributing to economic development and environmental degradation in the countries. The study aims to improve the existing knowledge on environmental degradation and help policy makers formulate different policy recommendations and approaches to monitoring and mitigating carbon emissions. Moreover, although industrialization is crucial for economic advancement, growth, its rapid expansion has been linked to adverse impacts on the environment and human health.

Extensive research has shown that swift industrial growth disrupts entire ecosystems, impacting air quality, water resources, soil health, and surrounding ecosystems [Ahmed (2021), Magsi (2014)]. Acknowledging the gravity of these challenges, this study is conducted with a dedicated focus and determination to comprehensively understand and address the environmental ramifications of industrialization.

2. Literature Review

Ahmed et al.,(2022) observed that environmental degradation has become a significant concern in recent years due to the profound impacts of climate change. To assess the extent of industrialization and foreign direct investment's influence on environmental degradation, this research analyzed panel data from 55 countries in the Asia-Pacific region spanning from 1995 to 2020.

Bhujabal and Sethi (2021) analyze the effects of ICT and FDI on environmental pollution in major Asia Pacific countries during the years 1990-2018. The findings of the study indicate that FDI and ICT negative effects on environmental pollution or carbon emissions. This suggests that long term pollution of environment decreases significantly with increased ICT infrastructure and FDI inflows.
Kahuthu (2006) examines the long-run and short-run impacts of fossil fuel consumption, foreign direct investment and, economic growth on carbon emissions in fifteen developing Asian countries.
Ahmed and Long (2012) proposed the Environmental Kuznets Curve to explore the connection between CO2 emissions, economic development, energy use, trade liberalization, and population density in Pakistan using annual data from 1971 to 2008.
Sapkota and Bastola (2017) test the Pollution Heaven Hypothesis (PHH) and Environmental Kuznets Curve (EKC) for the Latin American Region.
Abbas (2013) investigates the relationship between Pakistan's economic development and environmental norms. According to the research, pollution may be reduced by efficient management of industrial waste and an environmental fee that is designed to prevent impeding industrial expansion.
Benli and Acar (2021) analyze the effects of FDI inflows on Carbon emissions in low and middle-income OECD countries between 1992 and 2017.
Shahbaz and Sinha (2019) conducted a study of the empirical literature on environmental Kuznets Curve (EKC) estimation of carbon dioxide (CO2) emissions throughout 1991-2017, results showed that EKC estimation for CO2 emissions remained inconclusive.
Hussain and Zhou (2022) The research was carried out to examine how globalization, industrialization, urbanization, and financial growth affect energy consumption and environmental quality. The findings suggest a variety of viable policies from the viewpoint of the Belt and Road Initiative.
Shakeel, (2020) examine the connection between energy consumption, GDP, and exports in the South Asia region using structural break models. Prior to this, perform co-integration tests on the total annual time series data to evaluate their long-term relationship.
Caetano et al.,(2022) conducted the study and the main findings show the lack of statistical significance in the relationship between FDI inflows and CO2 emissions raising the possibility that this effect wasn't contemporaneous.
In summary, the literature highlights the multifaceted and case-specific links between industrial development, energy consumption, foreign direct investment (FDI) and pollution. The following

studies provide some insights into these interactions at different levels and in different locations. The authors of Ahmed et al. (2022) highlights that environmental degradation has been a big issue all over the world and is worsened due to industrial activities and FDI. They analysed 55 countries in the Asia-Pacific region between 1995 and 2020 and found that industrialisation and FDI is a driver of pollution, but also a driver of the adoption of cleaner technologies. Bhujabal and Sethi (2021) find that although at first glance a positive relationship between ICT infrastructure and environmental degradation exists, in the long-term, this seems to be mitigated by the fact that technological development has led to better energy use and lower emissions. The Environmental Kuznets Curve (EKC) hypothesis, which has been extensively explored by researchers like Ahmed and Long (2012) and Sapkota and Bastola (2017), depicts a non-linear relationship between economic growth and the adverse environmental impacts. This approach proposes that environmental degradation would rise with economic growth in the early stages, but drop after a certain point. But Shahbaz and Sinha (2019) reveal that empirical evidence for EKC is still inconclusive, so there is a need for research to further illuminate the various regional factors and pollutant types. Abbas (2013) has pointed out that industrialization is one of the major causes of environmental degradation in the context of Pakistan. The consequences of this are suggested to be counteracted by the implementation of environmental taxes, better waste management methods. In the context of the South Asian region, Shakeel (2020) further explores the intertwinement of GDP, exports and energy use by applying structural break models. In the international literature, Benli and Acar (2021) and Caetano et al. (2022) explore the impact of FDI inflows on carbon emissions in middle-income and OECD countries, respectively.

However, FDI effects on emissions remain controversial given that Benli and Acar find evidence that it tends to increase emissions while Caetano et al. do not. This indicates that FDI's environmental consequences can differ based on national policies and economic conditions. Hussain and Zhou (2022) consider the implications of globalization, industrialization, urbanization and call for synergy in the policy context, including the Belt and Road. In general, the results from these reviews indicate that the relationship of industrialization, FDI and environmental degradation is complex and a function of the economic, policy and technological environment. Although the EKC hypothesis offers a theoretical underpinning, the empirical findings are divergent, and further studies are needed to find strategies that can promote a balance between industrial development and environmental protection. The study aims at addressing the gaps in existing literature in the context

of Pakistan, where industrialization and FDI have continued to influence economic policies, and their long-term effects on ecological footprint.

3. Methodology and Data

With an emphasis on Pakistan, this analysis uses secondary time series data from the Global Footprint Network (GFN) and the World Development Indicators (WDI) for the years 1990 to 2021. The study explores the relationship between the dependent variable, namely the ecological footprint, and the independent variables: industrial production, fossil fuel energy consumption, clean energy and foreign direct investment (FDI).

The ecological footprint is given by the Global Footprint Network (GFN) and is measured in global hectares per person. The amount of energy consumed from fossil fuel energy use and clean energy is presented as a percentage of total energy use, while industrial production is represented by the manufacturing value added as a share of GDP. Net inflows as reported in the World Development Indicators (WDI) are used to quantify FDI. These elements collectively offer a holistic perspective on the impact of economic activities and energy use on Pakistan's environmental sustainability.

Table: 1 Variables and Data Sources

Dependent Variable	**Independent Variables**	**Econometric Model** **Data period**	**Data Source**
Ecological footprint	Industrial Production Fossil fuel energy. Clean energy Foreign Direct Investment (FDI)	Johansen Cointegration 1990-2023	World Development Indicators Global footprint Network

4. 3.1 Econometric Model

In order to determine the relationships between the study's independent and dependent variables, a co-integration technique and linear regression analysis will be used. Ecological footprint (EFP) is

the explained/dependent variable in this study. Fossil fuel energy (FFE), clean energy production (CEP), industrial GDP (INDUS), and foreign direct investment (FDI) are the independent variables. Therefore, the econometric model used in this study is represented by the Equation:

For the evaluation, we take the natural logarithm form. The EFP function will be:

…...…2

The ecological footprint, clean energy production, industrial production, fossil fuel energy, and foreign direct investment are represented by LEFP, LCEP, LINDUS, LFFE, and LFDI, respectively, after taking the natural logarithm. The constant term is denoted by σ_0. The coefficients for expected elasticity in the model are denoted by the words σ_1 to σ_4, whereas the error terms are denoted by μ.

5. Estimation results and discussion

In this section, we analyze the key characteristics of my dataset using descriptive statistics, focusing on measures of central tendency, dispersion, skewness, and kurtosis. This analysis provides a clear overview of the distribution of each variable and helps to identify any issues, such as outliers or asymmetry, that may affect the results. The ecological footprint is the dependent variable in this study, while industrial production, clean energy consumption, fossil fuel energy consumption, and foreign direct investment (FDI) are the independent factors.

Table 2: Descriptive Statistics

	lnEFP	lnFDI	lnFFE	lnINDUS	lnRE
Mean	*18.29*	*-0.248*	*4.061*	*3.00*	*3.88*
Median	*18.24*	*-0.362*	*4.087*	*3.024*	*3.870*
Maximum	*18.75*	*1.110*	*4.034*	*3.132*	*4.062*
Minimum	*17.83*	*-1.172*	*3.95*	*2.842*	*3.728*
Std. Dev.	*0.279*	*0.553*	*0.049*	*0.087*	*0.088*
Skewness	*0.201*	*0.816*	*-0.996*	*-0.442*	*0.144*
Kurtosis	*1.657*	*3.406*	*3.102*	*2.043*	*2.307*
Jarque-Bera	*2.786*	*4.015*	*5.308*	*2.407*	*0.750*
Probability	*0.248*	*0.134*	*0.070*	*0.300*	*0.687*

Observations	*34*	*34*	*34*	*34*	*34*

To ascertain the time series properties of each variable in our model, standard ADF test is applied on each series. The null hypothesis of ADF test is that a given variable has a unit root or non-8 stationary, while alternative hypothesis is that the variable under consideration is stationary at levels. The results of test are provided by Table 3. The values of ADF statistics for all variables imply that all variables are non-stationary at level but become stationary at 1st difference, indicating that all variables are integrated of order one.

Table 3: Unit root test

Variable	**ADF Statistic**	**Critical value (1%)**	**Critical value (5%)**	**Critical value (10%)**	**Decision**
lnEFP	-4.446	-3.66161	-2.960411	-2.619160	I(1)
lnFDI	-5.687	-3.653730	-2.957110	-2.617434	I(1)
lnINDUS	-5.266	-3.653730	-2.957110	-2.617434	I(1)
lnFFE	-5.565	-3.670170	-2.963972	-2.621007	I(1)
lnRE	-5.438	-3.670170	-2.963972	-2.621007	I(1)

Most of the lag selection criteria (LR, FPE, AIC, and HQ) in Table 4 point to a lag length of 2 as the optimal choice. Therefore, a lag structure of 2 will be used in the subsequent analysis, as it effectively captures the dynamics of the total ecological footprint while ensuring model accuracy.

Table 4: Lag Length Criteria

Lags	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	123.05	NA	2.63e-10	-7.87	-7.63	-7.79
1	243.76	193.14	4.57e-13	-14.25	-12.85	-13.80
2	282.33	48.85*	2.5E-e3*	-15.15	-12.58*	-14.33*

*Indicates lag order selected by the criterion

The majority of the criteria (LR, FPE, AIC, and HQ) point to a lag length of 2 as the optimal choice. Therefore, a lag structure of 2 will be used in the subsequent analysis, as it effectively captures the dynamics of the total ecological footprint while ensuring model accuracy.

Table 5: Trace and Max-Eigenvalue Tests

Hypothesis	**Eigenvalue**	**Trace Stat**	**5% Critical value (Trace)**	**Max-Eigenvalue**	**5% Critical value (Max)**
r = 0*	0.948	205.71	69.818	82.992	33.876
r ≤ 1*	0.811	122.71	47.856	46.723	27.584
r ≤ 2*	0.770	75.99	29.797	41.257	21.131
r ≤ 3*	0.701	34.73	15.494	33.893	14.264
r ≤ 4	0.029	0.843	3.841	0.844	3.831

In this study, the target variable selected as the dependent variable is lnEFP (ecological footprint), while lnFFE, lnFDI, lnINDUS, and lnRE are the independent variables. Therefore, the VECM model will be specified as follows:

$lnEFPt = \beta 0 + \beta 1 ECTt{-}1 + \beta 2 \Delta lnEFPt{-}1 + \beta 3 \Delta lnEFPt{-}2 + \beta 4 \Delta lnFDIt{-}1 + \beta 5 \Delta lnFDIt{-}2 + \beta 6 \Delta lnFFEt{-}1 + \beta 7 \Delta lnFFEt{-}2 + \beta 8 \Delta lnINDUSt{-}1 + \beta 9 \Delta lnINDUSt{-}2 + \beta 10 \Delta LN_REt{-}1 + \beta 11 \Delta LN_REt{-}2 + et$ (3)

β0 is the constant or intercept, while $\beta 1 - \beta 11$ are the short-run coefficients associated with lagged difference of variables to be estimated. β1 is the coefficient of the Error Correction Term. ECTt-1 represents the speed at which deviations from the long-term equilibrium are corrected. The Error Correction Term ECTt-1 is derived from the residuals of the long-run model, defined as:

$ECTt{-}1 = lnEFPt{-}1 - \alpha - \beta FDI.\ lnFDIt{-}1 + \beta FFE.\ lnFFEt{-}1 + \beta INDUS.\ lnINDUSt{-}1 + \beta RE.\ lnREt{-}1$ (4)

where α is the constant term, and βFDI, βFFE, βINDUS, and βRE represent the long-run coefficients for foreign direct investment, fossil fuel energy, industrial production, and renewable energy, respectively. When we reverse the sign of coefficients of the Co-integrating Equation, we derive the long-run co-efficients and the results are shown in Table 6:

The coefficient of renewable energy is -0.562197 (after reversing the sign). The t-value is 2.75431, which is greater than 2.36, making the coefficient significant at a 1% level of significance. It can also be interpreted as the 1% increase in renewable energy consumption decreases the ecological

footprint by 0.56%, ceteris paribus. However, the coefficient of fossil fuel energy is 1.396085 (after reversing the sign). The t-value is 3.36947, which is greater than 1.96, indicating significance. The 1% increase in fossil fuel energy consumption increases the ecological footprint by 1.39%, ceteris paribus. Similarly, the coefficient of FDI is -0.084588 (after reversing the sign). The t-value is 4.90647, which is significant. The 1% increase in foreign direct investment decreases the ecological footprint by 0.084%, ceteris paribus. Moreover, the coefficient of industrial production is 0.394659 (after reversing the sign). The t-value is 4.08899, making it significant. The 1% increase in industrial production increases the ecological footprint by 0.39%, ceteris paribus.

Table 6: Long-run Johansen co-integration results

Variables	**Co-efficients**	**Standard Error**	**T-value**
lnFDI	-0.0845***	0.0172	4.906
lnFFE	1.396***	0.414	3.369
lnINDUS	0.394***	0.0962	4.088
lnRE	-0.562***	0.204	2.754
constant	-13.5993	-	-

*** Represents significance at 1% level of significance

On similar lines, the results of short run vector error correction model are placed in Table 7. The coefficient of the error correction term (ECT) is -0.099, which is negative and In-significant. The t-value is 0.31095, which is less than the critical value of 1.96 (in absolute terms). This indicates that the coefficient is not statistically significant, implying no short-run adjustments toward equilibrium. This highlights that the correction is not significant but can be significant after passing few years. The short run co-efficient ΔlnFDIt-1 is 0.037 with a t-value: 1.314 is positive but In-significant as t-value is less than 1.96. Therefore, The Foreign direct investment has an insignificant short-run effect on the ecological footprint. The short run co-efficient ΔlnFFEt-1 is 0.115944 with a t-value: 0.84737 is positive but Insignificant as t-value is less than 1.96. Therefore, Fossil fuel energy consumption has an insignificant short-run effect on the ecological footprint. The short run co-efficient ΔlnINDUSt-1 is -0.289887 with a t-value: -1.91176 is close to 1.96 but slightly insignificant as t-value is less than 1.96. Therefore, industrial production has a marginally insignificant negative effect on the ecological footprint in the short run. The short run co-efficient ΔlnREt-1 is -0.212 with a t-value -1.12 is negative but insignificant as t-value is less than 1.96.

Therefore, The Renewable energy consumption has an insignificant short-run effect on the ecological footprint. Some diagnostic tests are also performed to check the estimated model's reliability. For Autocorrelation Residual LM test, the p-values are above 0.05. Therefore, we conclude that there is no significant autocorrelation in the residuals of our model at the tested lags. This indicates that the residuals are independent and satisfy the assumption of no serial correlation, which is essential for reliable VECM results. We perform Residual Heteroskedasticity test (Joint) test to determine if the residuals have constant variance, indicating no heteroscedasticity. The joint test p-value is 0.2105, which is above the 0.05 significance level. This means we fail to reject the null hypothesis of homoscedasticity, indicating that the residuals have constant variance. Thus, there is no evidence of heteroscedasticity in the residuals, satisfying one of the assumptions for reliable VECM estimates. Likewise, the p value associated with the Jarque-Bera test (0.9778) is high as well when compared to the typical significance value of 0.05. This means that the null hypothesis that the data were normally distributed is not rejected. Goodness of fit for the residuals: Normal distribution is good for the reliability and robustness of the VECM results.

The results demonstrate a clear long-run relationship between the ecological footprint and its determinants (renewable energy, fossil fuel energy, foreign direct investment, and industrial production). Renewable energy and FDI contribute to reducing the ecological footprint, while fossil fuel energy and industrial production increase it. The short-run dynamics are mostly insignificant, indicating that changes in these variables take time to impact the ecological footprint.

6. Vector Error Correction Model (VECM)

Table 7: Results of Error correction model

Variables	Co-efficients	Standard Error	T-value
ΔlnEFPt-1	-0.791*	0.410	-1.92
ΔlnEFPt-2	0.171	0.306	0.560
ΔlnFDIt-1	0.035	0.026	1.314
ΔlnFDIt-2	0.004	0.029	0.139
ΔlnFFEt-1	0.353	1.089	0.324
ΔlnFFEt-2	-0.396	0.905	-0.437
ΔlnINDUSt-1	-0.289*	0.151	-1.91

ΔlnINDUSt-2	0.146	0.360	0.404
ΔlnREt-1	-0.212	0.188	-1.127
Constant	0.019	0.010	1.840
ECTt-1	-0.099	0.310	-0.318
Diagnostic Tests			
Autocorrelation Residual LM test			
lag	LRE*stat	df	Prob.
1	22.66	25	0.597
2	25.81	25	0.417
3	22.07	25	0.631
VEC Residual Heteroskedasticity test (Joint)			
Chi-sq	df	Prob.	
350.41	330	0.210	
VEC Residual Normality Test: Jarque Bera (Joint			
component	Jarque-Bera	df	Prob.
Joint	3.145	10	0.977

* Represents significance at 10% level of significance

The long-term results show a significant association between ecological footprint and its major variables after the signs of the coefficients of the co-integrating equation are reversed. With a t-value of 2.75431 and a negative and statistically significant coefficient of −0.562197, renewable energy (LN_RE) shows that, ceteris paribus, a 1% increase in renewable energy consumption lowers the ecological footprint by roughly 0.56%. Fossil fuel energy (LN_FFE), on the other hand, shows a positive and significant coefficient of 1.396085, backed by a t-value of 3.36947, suggesting that the ecological footprint increases by roughly 1.39% for every 1% rise in fossil fuel use. Additionally, the ecological footprint is negatively and significantly impacted by foreign direct investment (LN_FDI).

Having a t-value of 4.90647 and a coefficient of −0.084588, indicating that increased FDI eventually improves the environment. With a t-value of 4.08899 and a positive and significant coefficient of 0.394659, industrial production (LN_INDUS) shows that greater industrial activity results in a larger ecological footprint. The statistical insignificance of the error correction term (ECT) (−0.099008; t-value = 0.31095) suggests a poor and sluggish short-term adjustment towards long-

term equilibrium. Every short-run coefficient is consistently statistically insignificant: D(LN_FFE(−1)) is likewise positive (0.115944; t-value = 0.84737), while D(LN_FDI(−1)) is positive (0.037443; t-value = 1.31452).

While D(LN_RE(−1)) is positive but negligible (0.146000; t-value = 0.40462), D(LN_INDUS(−1)) is negative but marginally insignificant (−0.289887; t-value = −1.91176). The overall results indicate that there is a general long-run relationship between ecological footprint and renewable energy, fossil fuel energy, foreign direct investment, and industrial production, as renewable energy and FDI have a negative impact on the environment, but fossil fuel energy and industrial production have a positive impact, while the short-run dynamics are not significant.

To find causality in this model, we utilize the concept of Granger causality to determine if there is predictive influence from the independent variables (FDI, Fossil Fuel Energy, Industrial Production, and Renewable Energy) on the dependent variable, Ecological Footprint.

A statistical technique called Granger causality is used to determine if historical values of one variable may be used to forecast changes in another. In this research, the VEC Granger Causality/Block Exogeneity Wald tests are applied to examine if both short-run and long-run coefficients Granger-cause the dependent variable, Ecological Footprint.

Table 8: VECM Granager Causality/Block Exogeneity Wald Test

Dependent variable: (ΔlnEFP)			
Excluded	Chi-sq	df	Prob.
ΔlnFDI	1.796	2	0.407
ΔlnFFE	0.616	2	0.734
ΔlnINDUS	3.906	2	0.141
ΔlnRE	0.349	2	0.839
All	6.441	8	0.597
Dependent variable: (ΔlnFDI)			
ΔlnEFP	2.033	2	0.361
ΔlnFFE	2.154	2	0.340
ΔlnINDUS	1.736	2	0.419
ΔlnRE	0.270	2	0.873

All	4.147	8	0.843
Dependent variable: (ΔlnFFE)			
ΔlnEFP	8.900	2	0.011
ΔlnFDI	8.070	2	0.017
ΔlnINDUS	0.710	2	0.700
ΔlnRE	0.133	2	0.9350
All	14.836	8	0.0624
Dependent variable: (ΔlnINDUS)			
ΔlnEFP	4.026	2	0.133
ΔlnFDI	2.293	2	0.317
ΔlnFFE	0.817	2	0.664
ΔlnRE	0.963	2	0.617
All	7.844	8	0.448
Dependent variable: (ΔlnRE)			
ΔlnEFP	3.873	2	0.144
ΔlnFDI	5.944	2	0.051
ΔlnFFE	1.846	2	0.397
ΔlnINDUS	1.808	2	0.667
All	13.072	8	0.109

The Granger causality results show mixed short-run relationships between ecological footprint and the selected variables. The p-value for foreign direct investment (FDI) is 0.3618, which is higher than the 5% significance level, indicating that ecological footprint (D(LN_EFP)) does not Granger-cause FDI in the short run, and past ecological footprint values cannot predict future FDI. In contrast, the p-value for fossil fuel energy consumption (FFE) is 0.0117, which is below 0.05, leading to rejection of the null hypothesis and suggesting that ecological footprint Granger-causes fossil fuel energy consumption in the short term; thus, past ecological footprint values can be used to predict future fossil fuel energy use. For industrial production (INDUS), the p-value of 0.1336 exceeds the 5% level, implying that ecological footprint does not Granger-cause industrial production in the short run. Similarly, the p-value for renewable energy (RE) is 0.1442, which is also greater than 0.05, indicating no short-run Granger causality from ecological footprint to renewable energy consumption.

7. Conclusion and policy implications

This study looks at the short-term relationships between Pakistan's ecological footprint and industrial production, fossil fuel energy use, FDI, and renewable energy. According to the Vector Error Correction Model (VECM) results, none of these factors have a statistically significant short-term effect on the ecological footprint. In particular, there is no immediate impact of foreign direct investment on the quality of the environment, indicating that its impacts take time to manifest. Similar to this, industrial activity and the use of fossil fuels for energy do not have a major short-term impact on the ecosystem, suggesting that changes in these areas take time to have noticeable ecological repercussions.

Additionally, there is little obvious short-term impact from renewable energy usage, suggesting that the environmental advantages of adopting clean energy are mostly realized over the long term. Additionally, weak short-term adaptations towards long-term equilibrium are suggested by the error correction term's insignificance. Overall, the short-term results show that although investment, energy use, and industrial activity are significant factors that determine environmental quality, their effects on the ecological footprint mostly manifest over time rather than right away.

Several policy recommendations to promote sustainable development in Pakistan can be made in light of these findings. First, by increasing investments and offering incentives for the production and use of clean energy, the government should bolster its commitment to renewable energy. Long-term environmental pressure can be lessened by encouraging businesses and people to switch to renewable energy sources. Second, as green FDI has the ability to reduce the ecological imprint, it should be selectively allocated to environmentally favorable initiatives. Therefore, attracting investors who support environmentally friendly industrial practices and sustainable technologies should be a top priority for policymakers.

Third, considering the unfavorable environmental repercussions linked with fossil fuel consumption, tighter laws are needed to limit its use. Carbon taxes, emissions controls, and subsidies for greener energy sources are a few examples of such policies. Last but not least, encouraging sustainable industrial methods is crucial to reducing the negative environmental effects of industrialization. It is important to promote the adoption of energy-efficient technology, waste reduction, and resource management. Pakistan can pursue economic development while preserving environmental quality by focusing on renewable energy, green FDI, less reliance on fossil fuels, and sustainable industrial expansion.

Although this study has its positive points, it has also a few drawbacks. The research is based on time-series data from 1990 to 2023 – which may not be representative of recent changes in policy, structures or environment. In addition, the study does not consider other factors that may be relevant to the ecological outcomes, such as technological innovations, institutional reforms, or environmental legislation, and focuses on a limited number of variables such as industrial production, fossil fuel energy, foreign direct investment, and renewable energy.

Further, the findings are limited to Pakistan, and may not readily be extrapolated to other industrialization and environmental control levels. Another disadvantage of the analysis is its focus on the short-term; the results do not reveal any significant short-term effects. Thus, it would be useful to conduct further research that explores longer-term dynamics to enable more comprehensive policy recommendations. This book, however, contributes to the existing literature on the complex interconnection between industrialization, energy use, and sustainable development in developing countries.

References:

Ahmed, F., Ali, I., Kousar, S., & Ahmed, S. (2022). The environmental impact of industrialization and foreign direct investment: empirical evidence from Asia-Pacific region. Environmental Science and Pollution Research International, 29(20), 29778–29792. https://doi.org/10.1007/s11356-021-17560-w

Bhujabal, P., Sethi, N., & Padhan, P. C. (2021). ICT, foreign direct investment and environmental pollution in major Asia Pacific countries. Environmental Science and Pollution Research International, 28(31), 42649–42669.

Kahuthu, A. (2006). Economic growth and environmental degradation in a global context. Environment, Development and Sustainability, 8(1), 55–68. https://doi.org/10.1007/s10668-005-0785-3

Ahmed, K., & Wei, L. (2012). Environmental Kuznets Curve and Pakistan: an Empirical analysis. Procedia Economics and Finance, 1, 4–13. https://doi.org/10.1016/s2212-5671(12)00003-2

Sapkota, P. &. B. U. (2017). Foreign direct investment, income, and environmental pollution in developing countries: Panel data analysis of Latin America. ideas.repec.org. https://ideas.repec.org/a/eee/eneeco/v64y2017icp206-212.html

Benli, M., & Acar, Y. (2021). Foreign Direct Investment and Pollution: Evidence from Middle Income and Oecd Countries. https://www.semanticscholar.org/paper/Foreign-Direct-Investment-and-Pollution%3A-Evidence-Benli-Acar/6762f84f309d6ee02abc68648ea6fe992e0b3416

Abbas, S. (2020). Impact of industrialization and economic reforms on environmental quality in Pakistan.Iiupk.https://www.academia.edu/42989906/Impact_of_Industrialization_and_Economic_Reforms_on_Environmental_Quality_in_Pakistan

Shahbaz, M., & Sinha, A. (2019). Environmental Kuznets curve for CO2 emissions: a literature survey. Journal of Economic Studies, 46(1), 106–168. https://doi.org/10.1108/jes-09-2017-0249

Hussain, J., & Zhou, K. (2022). Globalization, industrialization, and urbanization in Belt and Road Initiative countries: implications for environmental sustainability and energy demand. Environmental Science and Pollution Research International, 29(53), 80549–80567. https://doi.org/10.1007/s11356-022-21520-3

Shakeel, M. (2020). Economic output, export, fossil fuels, non-fossil fuels and energy conservation: evidence from structural break models with VECMs in South Asia. Environmental Science and Pollution Research International, 28(3), 3162–3171. https://doi.org/10.1007/s11356-020-10729-9

Caetano, R. V., Marques, A. C., Afonso, T. L., & Vieira, I. (2022). A sectoral analysis of the role of Foreign Direct Investment in pollution and energy transition in OECD countries. Journal of Environmental Management, 302, 114018. https://doi.org/10.1016/j.jenvman.2021.114018

Gorg, H., & Greenaway, D. (2012). Much ado about nothing? Do domestic firms really benefit from foreign direct investment?. World Bank Research Observer.

Bhujabal, P., Sethi, N., & Padhan, P. C. (2021b). ICT, foreign direct investment and environmental pollution in major Asia Pacific countries. Environmental Science and Pollution Research International, 28(31), 42649–42669. https://doi.org/10.1007/s11356-021-13619-w

Hussain, M., Butt, A. R., Uzma, F., Ahmed, R., Irshad, S., Rehman, A., & Yousaf, B. (2020). A comprehensive review of climate change impacts, adaptation, and mitigation on environmental and natural calamities in Pakistan. Environmental monitoring and assessment, 192(1), 48.

Qureshi, A., & Jamil, M. (2021). The footprint of industrialization on climate change. Journal of Business and Economics, 13(1), 95-112.

Khan, S., & Majeed, M. T. (2023). Toward economic growth without emissions growth: the role of urbanization & industrialization in Pakistan. Journal of Environmental Studies and Sciences, 13(1), 43-58.

Rehman, A., Ma, H., & Ozturk, I. (2021). Do industrialization, energy importations, and economic progress influence carbon emission in Pakistan. Environmental Science and Pollution Research, 28(33), 45840-45852.

Rasul, G., & Ahmad, B. (2012). Climate change in Pakistan. Pakistan Meteorological Department.