



Original Article

Examining the Role of Ecological Footprints and Financial Tech in G7 Climate Strategies

Shazia Khalid¹, Dr. Fatima Gulzar², Humaira Khan³, Muhammad Tariq⁴ & Nazia Khalid⁵

¹ Lecturer, Department of Economics, Ghazi University, Dera Ghazi Khan, Email: skhalid@gudgk.edu.pk

² Lecturer, Department of Economics, Ghazi University, Dera Ghazi Khan, Email: fgulzar@gudgk.edu.pk

³ Ghazi University, Dera Ghazi Khan, Email: humairabaloch38@gmail.com

⁴ Lecturer, Department of Economics Bahauddin Zakariya University, Multan, Email: m.tariq-vcamp@bzu.edu.pk

⁵ PHD Scholar, Department of Economics, Ghazi University, Dera Ghazi Khan, Email: naziakhalid778@gmail.com

ARTICLE INFO

Keywords:

Climate Change, Energy Innovation, Financial Technology, Ecological Footprint

*Corresponding Author:

Humaira Khan

humairabaloch38@gmail.com

ABSTRACT

This research aims to identify the impact of ecological footprint, energy innovation and financial technology on climate change in G7 Countries. Ecological footprint, energy innovation and financial technology, resource management, financial development, industrialization, and urbanization are significantly influencing Climate change across the World. Therefore, the current study arranged the panel dataset of ecological footprint, energy innovation and financial technology addressing the climate change evidence from G7 economies. For this purpose, a panel dataset of G7 Countries' economies comprising 1990 to 2022 are collected from World development Indicators, IMF and KOF Index. First, study will apply the correlation to determine the multicollinearity in the dataset. Then the study will apply cross-sectional independence to quantify the cross-sectional dependency among the datasets. Further, the study will utilize the second-generation unit root to ensure the stationery and to incorporate the cross-sectional dependency. In addition, the study used GMM approach. Furthermore, conclusion and policy implication will be presented based on outcomes of the study.

Introduction

Climate change is a formidable global challenge that affects ecosystems, economies, and societies worldwide (Weimin et al., 2022). Within the Group of Seven (G7) nations Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States addressing climate change is particularly crucial due to their significant economic influence and substantial contributions to carbon emissions and resource consumption. Understanding the intricate relationships between ecological footprint, energy innovation and financial technology within these economies is imperative for devising effective climate mitigation strategies.

This Research intends to completely assess the roles of ecological footprint, energy innovation, and financial technology in reducing climate change throughout the G7 economies, relying upon empirical evidence and modern econometric strategies. It is anchored in the recognition that climate change is a complicated process driven by different socioeconomic and environmental causes. The ecological footprint serves as an important figure for calculating the environmental impact of human activities and determining sustainability. Energy innovation plays an essential part in proceeding towards renewable energy sources, while finance technology offers innovative methods for financing climate-friendly initiatives and sustainable development projects.

The World Health Organization (WHO) observes that the small percentage of mortality globally is caused by preventable environmental factors. Clean air, water, and soil are essential for human health, and environmental change affects not just our daily lives but the future of every species globally. Environmental sustainability initiatives are becoming growing significance objectives for businesses. As stated by NASA, human activity, such as industry, is an important contributor to climate change because of its reliance on resources like land, fossil fuels, and continuous production and consumption (Li et al., 2024).

The use of resources in a way that minimizes the impact on the environment and can be sustained eternally is referred to as environmental sustainability. Facilitating economic development while maintaining resource sustainability is the ultimate goal of environmental sustainability. Fair resource use is ensured by sustainable development, which does not impede economic expansion (Sibt-e-Ali et al., 2023; Asghar et al., 2023). To accomplish this, constraints from the environment have to be taken into consideration. The greatest quantity of natural resource deterioration that can take place before resources are seriously endangered is established by these limitations. The objective of these rules is to protect natural resources from destruction. In order to protect the planet's health and maintain economic growth, global agreements such as the 2015 Paris Agreement aim to promote the use of renewable energy sources and prevent climate change.

According to optimistic projections, foreign direct investment will boost technological advancements and environmentally friendly practices. This could lead to more efficient use of resources and less harm to the economy; yet, other studies suggest that FDI may worsen the environmental impact by encouraging off shoring. The economy is impacted by factories that invest in these sectors. This could result in issues like using greater amounts of energy for production, leading to pollution in places with inadequate environmental controls. FDI influences climate change in a positive as well as a negative manner. In addition to assisting in lowering carbon emissions through technological developments, it might be essential in the promotion of technology in industrialized nations (Qadri et al., 2023; Iram et al., 2024; Asghar et al., 2024; Ameet et al., 2024).

Urban population density is another important variable that influences climate change. Urbanization is being recognized as an important factor contributing to climate change (Yuerong et al., 2024). Urban areas likely to be warmer than rural ones due to land cover and use which can contribute to urban heat (Shah et al., 2021). In Iceland, urbanization results to a reduction in green areas like parks and trees and an increase in hard surfaces like roads and buildings, which change surface geometry and reflect power. Less evaporation results from these conditions

which increases the possibility of urban heat islands and retains heat inside buildings. Traffic and climate control emissions are two examples of human activities that contribute to urban heat islands.

Literature Review

Udeagha and Breitenbach (2023) examine the role of financial development in climate change mitigation in South Africa, spanning from 1960 to 2020. Using the Environmental Kuznets Curve (EKC) framework, their article, "The Role of Financial Development in Climate Change Mitigation: New Policy Insights from South Africa," analyzes the relationship between financial development and CO₂ emissions. CO₂ emissions were the dependent variable, while economic growth, energy use, trade openness, foreign direct investment, and financial development evaluates are the independent factors. The data has been examined by the authors employing dynamic autoregressive distributed lag (ARDL) simulations. They demonstrate that financial development reduces the negative effects of trade openness, economic growth, and foreign direct investment on emissions and reduces CO₂ emissions both temporarily and permanently. The study offers significant policy recommendations that will assist South Africa reach its net-zero emission targets.

Ali (2022) examines the impact of industrialization and FDI inflows on climate change predictability in Africa from 1990 to 2023, employing bias-adjusted ordinary least square estimation. According to the study, industrialization and foreign direct investment (FDI) inflows both constitute significant indicators of climate change, with varying degrees of environmental risk. The predictable nature of climatic change is the dependent variable, while FDI inflows and industrialization are the independent factors. The study recommends placing environmental concerns first in discussions about industrialization and foreign direct investment, pushing for green FDI, enacting laws limiting emissions, and implementing different climate commitment initiatives in each African nation based to its own features.

Belčáková et al. (2017) examined the impact of urbanization, ecological footprint, and climate change in Bratislava and Nitra, Slovakia. Their study focuses on the methods in which urbanization affects the urban microclimate and raises the ecological footprint, especially through the growth of paved surfaces and the enlargement of natural spaces. They devised a novel method for estimating ecological footprints which takes into consideration the ecological stability provided by plants with the application of a micro-climate function coefficient. In addition to numerous strategies to decrease the ecological footprint, like improving vegetation, improving energy efficiency, and promoting sustainable transportation, their findings highlight the significance of including green spaces into urban growth in order to reduce the adverse impacts of climate change. Cities with a greater quantity of green spaces have superior microclimatic conditions, which can significantly lessen the impact on the environment and contribute to reducing climate change, based on the study.

Bounoua et al. (2015) investigates the impact of urbanization on surface climate in the continental United States using a combination of Landsat and MODIS data integrated into a land model. Daytime urban land surface temperature (LST) differs significantly from vegetated lands, according to the research, with urban areas usually experiencing higher temperatures, especially cities situated inside forests. In accordance with the study, the two primary variables influencing

cities' LST are the kind and quantity of trees present there. Urban land surface temperature (LST) and surface runoff are the dependent factors, while urbanization and land cover types are the independent variables. The research focuses on 2001 and covers a one-year period. The methodology combines data from MODIS and Landsat to create the Simple Biosphere model (SiB2). Dynamic simulations of the effects of urbanization on surface energy, carbon, and water cycles are employed to investigate the connections among variables. In order to reduce the negative consequences of urbanization on the outermost climate, the study highlights the importance of policy alternatives targeted at improving growth in cities, including heat reduction and carbon sequestration.

Theoretical Modeling

In the G7, higher ecological footprints are frequently a reflection of inefficient resource utilization and can have a consequential effect on climate outcomes; decreasing these carbon footprints through effective resource management practices is critical to accomplishing climate goals. Energy innovation is characterized by the development and deployment of renewable energy technologies, is an essential component in reducing dependence on fossil fuels, which in turn lowers greenhouse gas emissions and enhances climate resilience.

By offering creative financing options for environmentally friendly initiatives and enabling investment in sustainable practices, financial technology, or fintech, has the potential to revolutionize the market. Fintech could accelerate the G7 countries' adoption of energy innovations and resource-efficient practices through enhancing financial knowledge about sustainability and expediting access to funding for renewable energy projects.

The effect of foreign direct investment (FDI) on climate strategies is also significant (Shah et al., 2020). While encouraging the creation of low-carbon solutions, foreign direct investment (FDI) in green technologies and sustainable businesses can spur economic growth. FDI's capacity to improve climate strategy, however, depends on incentives and regulatory structures put in place by the G7 governments.

In this context, industrial practices are essential because high-emission sectors need to adopt cleaner technology and practices in order to support climate initiatives (Asghar et al., 2024b; Ishfaq et al., 2024). In order to mitigate the effects of climate change and preserve sustainability, resource management—which involves the efficient utilization and preservation of natural resources—is also essential.

The G7's urbanization behaviors have a big impact on climatic results. Wider ecological footprints may result from the increasing need for energy and resources in metropolitan settings. However, through promoting energy-efficient practices and increasing urban environments' resilience, environmentally friendly planning and infrastructure development may reduce these effects.

Model Specification and Methodology

Data

This study will make use of G-7 countries' annual panel data from 1990 to 2022 Based on available information; we have selected to focus on the following countries: Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States. The variables, units of measure, and data sources are listed in Table 1.

Table 1: Source Measurement Unit Variables

Details of parameters	Symbol	Source
CO ₂ emissions (metric tons per capita)	CO ₂ E	WDI
Patent applications, resident and nonresidents	PAT	WDI
Foreign direct investment, net inflows (% of GDP)	FDI	WDI
Urban population (% of total population)	UP	WDI
Industry (including construction), value added (% of GDP)	INDS	WDI
Total natural resources rents (% of GDP)	TNRR	WDI
Ecological footprint	ECO	GFN
Financial technology	FTI	WDI

Model

The following is a presentation of the mathematical equation of the econometric function shown in Equation (1) as follows:

$$CO_2E_{it} = \beta_0 + \beta_1 PAT_{it} + \beta_2 FDI_{it} + \beta_3 UP_{it} + \beta_4 INDS_{it} + \beta_5 TNRR_{it} + \beta_6 ECO_{it} + \beta_7 FTI_{it} + \varepsilon_{it}$$

Here CO₂ E, PAT, FDI, UP, INDS, TNRR, ECO and FT. These variables specify Carbon Dioxide Emissions, Patent Application development, Net Flow of Foreign Direct Investment, Urban Population, Industry, Total Natural Resources Rents, Ecological Footprint, and Financial Technology data including Internet Usage, Fixed Telephone Subscriptions, and Mobile Cellular Subscribers. The table gives the mean values, medians, lowest and maximum values, deviations from the mean, skewness, and kurtosis for each variable. In this equation E it = error term, the countries are shown by the subscript (i = 1 ...n), and the time is stated by the subscript (t = 1t). Equation (1), CO₂, is a dependent variable, while TEC, ECI, ENP, EEG, and ETX are independent variables. To avoid data sharpness and heteroskedasticity, we convert all the data into natural logarithms.

It is probable to find the mean value of many variables, such as CO₂ E, PAT, FDI, UP, INDS, TNRR, ECO, and FT, in the table. The order of these values is differed. Out of all the

average values, the ecological footprint of the G7 countries has the highest average value. According to our estimate of the data series' standard deviation, the TNRR deviates from the mean by the most variance. Descriptive statistics were used to find out this data. However UP had the lowest standard deviation of any model. Alongside this, skewness and kurtosis statistics may be measured. Table 4's bottom half gives an example of the connection among the variables. It demonstrates that financial technology and urban population have an adverse association with foreign direct investment. The same thing is true for financial technology, urbanization, and foreign direct investment, all of which had a detrimental effect on G7 carbon emissions all through the study period.

Cross-sectional dependence tests and slope homogeneity tests

Before testing with co-integration and stationarity of panel data, the cross-sectional dependence (CD) test is conducted to decrease the probability of obtaining misleading, contradictory, and otherwise wrong results. This study makes use of the Pesaran CD test, which is formulated as given in Equation as:

$$CSD = \sqrt{\frac{2X}{Y(Y-1)}} \left(\sum_{1=y}^{m-1} \sum_{k=i+1}^m \hat{\phi}_{ik} \phi_{ik} \right)$$

When pair wise correlation coefficients are displayed by ϕ_{ik} and $Y = 1, 2 \dots, N$ (year, 1990–2022). To figure out whether CD has been present, the following assumptions are used. The alternative hypothesis includes a CD, whereas H_0 does not. When the test's p-value is less than 0.05, the null hypothesis is rejected, indicating that CD is a component of the panel data. Following the CD test, this work empirically establishes the slope homogeneity (S–H) test. In order to find out if the co-integration coefficients are homogeneous or whether the coefficients of the explanatory factors differ from one unit (country) to another, Ref. developed the S–H test. S–H is suitable for panel data since it includes CD, in contrast to conventional homogeneity evaluation techniques.

S–H test is mathematically expressed as Equation and (4) [71] as:

$$\Delta_{HT} = (N)^{1/2} (2k)^{-1/2} \left(\frac{1}{N} \tilde{S} - k \right)$$

$$\Delta_{AHS} = \left(\frac{2K(T - K - 1)}{T + 1} \right)^{-1/2} \left(\frac{1}{N} \tilde{S} - 2k \right)$$

Where $(\tilde{\Delta}_{HT})$ and $(\tilde{\Delta}_{AHS})$ are the slope homogeneity's delta tilde and adjusted delta tilde, respectively. 4.3.2. Tests of the unit root Conventional unit root tests presume model cross-section independence, which can lead to erroneous conclusions. Both CADF and CIPS check for CD. Consider Eqs. (5)–(7) as follows for examples:

$$\Delta Z_{i,t} = \omega_i + \omega_i W_{i,t-1} + \sum_{j=0}^n \omega_{ij} \Delta Z_{i,t-1} + \sum_{j=1}^n \omega_{ij} \Delta Z_{i,t} + U_{i,t}$$

$$CIPS = \frac{1}{T} \sum_{i=1}^n j_i(T, N)$$

$$\widehat{CIPS} = \frac{1}{T} \sum_{i=1}^n CADF_i$$

Cointegration tests

The long-term cointegration among the chosen series in each category was investigated in this work employing cointegration tests. As it can be used with slope heterogeneity models, the Westerlund cointegration approach is a significant advancement. In addition, the test takes into consideration cross-sectional dependence. The Westerlund test utilizes two panel statistics (Pt and Pa) and two-group test statistics (Gt and Ga) in Eqs. (8)–(11).

$$G_{\tau} = \frac{1}{N} \sum_{i=1}^N \frac{\hat{\alpha}_i}{SE(\hat{\alpha}_i)}$$

$$G_a = \frac{1}{N} \sum_{i=1}^N \frac{T \hat{\alpha}_i}{\hat{\alpha}_i(1)}$$

$$P_{\tau} = \frac{\hat{\alpha}_i}{SE(\hat{\alpha}_i)}$$

$$G_a = T \hat{\alpha}$$

where, $\hat{\alpha}_i$ is shown by $SE(\hat{\alpha}_i)$ as the standard random error. The semi-parametric kernel approach of $\hat{\alpha}_i(1)$ is $\hat{\alpha}_i(1)$.

System GMM

The method of the Generalized Method of Moments is used. The findings of the Monte Carlo simulations conducted by Blundell and Bond (1998) indicate that the system's estimator is an especially effective method. Model 1 looks at how various variables and historical values impact the degree of climate change which is taking place now. While lower climate levels have been linked with increased patent activity, which signifies technological advancement, improvements in ecological footprint have a beneficial effect on climate change. Foreign direct investment, natural resource rents, and financial technology all have slightly beneficial effects on climate change, whereas industrialization additionally has a positive impact. Furthermore, growing urbanization significantly lessens climate change because cities are the biggest contributors of greenhouse gases. Due to increasing consumption of energy and infrastructural requires, industrialization and urban population growth have a strong connection with climate

change, based on Model 2, which analyzes the factors influencing present CO₂ emissions. Additionally, there is a high degree of continuity in emissions patterns, with historical emissions exerting significant effects on current levels.

Results and Discussions

The study's Variance Inflation Factor (VIF) analysis indicates significant multicollinearity issues that might compromise the reliability of regression estimates (Table 4), particularly with regard to patent applications (4.63) and ecological footprint (3.589). In addition, cross-sectional dependency test findings show that there are strong dependencies between the observations (Table 5), emphasizing a requirement for reliable estimating methods. All variables require differencing before analysis since unit root tests demonstrate that they are stable in first differences but non-stationary at levels (Table 6). In order to guarantee accurate statistical conclusions, the finding is essential. Significant long-term correlations among the variables are supported by the results of the Westerlund ECM panel cointegration test, particularly as demonstrated by the Gt and Ga statistics (Table 7). It also means that the variables change in conjunction over time, emphasizing how important it is to take these relationships into account when estimating CO₂ emissions. Significant relationships impacting CO₂ emissions are shown by the System GMM estimation findings (Table 8). Interestingly, a strong positive correlation (0.933) for the lagged CO₂ emissions (L) indicates persistence in emissions levels. In addition, the ecological footprint (Ineco) exhibits a noteworthy positive influence (0.874), underscoring its pivotal function in affecting emissions.

Patent applications show a coefficient that is negative (-0.234) in terms of innovation, indicating that a decrease in CO₂ emissions correlates with a rise in patent applications. Foreign direct investment (FDI) and production from industries (INDS) both show notable positive effects, suggesting that FDI and industrial activity are responsible for higher emissions. These findings are reinforced by the FGLS data, which show that industrial activity, foreign direct investment, and ecological footprint each have significant effects on CO₂ emissions (Table 9). Even after accounting for other factors, the constant term indicates a baseline number of emissions.

Table 2: Descriptive Statistics

	Mean	Min	Max	SD	Skewness	Kurtosis
CO ₂ E	2.2390	1.2700	3.019	04300	0.0960	2.1280
PAT	10.854	8.6850	13.340	1.3630	0.5040	1.8920
FDI	0.1120	-7.1990	2.5440	1.4080	-1.9130	8.7940
UP	4.3560	4.2000	4.5210	0.0730	-0.1710	3.4310
INDS	3.1730	2.7970	3.5640	0.1890	-0.1100	2.1690
TNRR	-1.6050	-4.383	1.7450	1.6340	0.2390	1.8720
ECO	19.996	19.218	21.856	0.7620	1.5460	4.0500
FT	-0.3330	-3.6490	0.2970	0.6060	-2.2470	10.157

Table 3: Correlation Matrices

Variables	CO ₂ E	PAT	FDI	UP	INDS	TNRR	ECO	FT
CO ₂ E	1.000							
PAT	0.408	1.000						
FDI	0.061	-0.245	1.000					
UP	0.188	0.484	0.067	1.000				
INDS	0.184	0.128	-0.225	-0.012	1.000			
TNRR	0.587	-0.097	0.256	0.153	0.071	1.000		
ECO	0.672	0.716	-0.095	0.165	-0.212	0.036	1.000	
FT	-0.052	0.171	0.138	0.566	-0.430	0.108	0.044	1.000

Table 4: Variance Inflation Factors

Variables	VIF	1/VIF
PAT	4.63	.216
ECO	3.589	.279
UP	2.27	.441
FT	2.18	.459
INDS	2.123	.471
TNRR	1.293	.774
FDI	1.224	.817
Mean VIF	2.473	

Table 4: slope homogeneity

Test	Δ	P-value	Δ_{adj}	P-value
Blomquist, Westerlund	0.313	0.754	0.445	0.657
Heteroskedasticity	chi ²	13.14	Prob > chi ²	0.000
Wooldridge autocorrelation	F (1, 6)	52.31	Prob > F	0.000

Table 5: Cross Sectional Dependency test

Variables	CD-test	P-value	Average joint T	Mean p	Mean abs(p)
CO ₂ E	19.893	0.000	33.00	0.76	0.76
ECO	13.227	0.000	33.00	0.50	0.59
PAT	4.107	0.000	33.00	0.16	0.48
FT	25.525	0.000	33.00	0.97	0.97
TNRR	6.423	0.000	33.00	0.24	0.39
FDI	8.547	0.000	33.00	0.32	0.32
INDS	19.674	0.000	33.00	0.75	0.75
UP	24.632	0.000	33.00	0.94	0.94

Table 6: Unit root test

	Series	CO2E	ECO	PAT	FT	TNNR	FDI	INDS	UP
CIPS	level	-1.51	-2.36 _b	-1.86	-1.44	-1.50	-3.70 _a	-1.90	0.48
	diff	-5.30 _a	-5.64 _a	-4.34 _a	-4.33 _a	-5.19 _a	-6.17 _a	-4.48 _a	-2.01 _c
CADF	level	-1.62	-2.33 _b	-2.04	-1.96	-1.29	-3.04 _a	-1.69	-0.64
	diff	-4.27 _a	-4.37 _a	-3.07 _a	-3.15 _a	-3.62 _a	-5.53 _a	-3.37 _a	-1.24

Note: a, b and c denote that 1, 5 and 10% respectively significant.

Table 7: Westerlund ECM panel cointegration

Statistic	Gt	Ga	Pt	Pa
Value	-2.953	-26.425	-7.675	-22.545
Z value	-1.966	-5.778	-2.428	-6.020
Prob value	0.025	0.000	0.008	0.000
Robust prob value	0.300	0.050	0.260	0.050

Table 8: System GMM

CO ₂ E	Coef.	St.Err.	t-value	p-value	[95% Conf	Interval]	Sig
L	0.933	0.018	51.04	0.000	0.897	0.969	***
Lneco	0.874	0.151	5.80	0.000	0.579	1.169	***
Lnpat	-0.234	0.089	-2.64	0.008	-0.408	-00.06	***
Ft	0.132	0.068	1.95	0.052	0.001	0.265	*
Tnrr	0.049	00.04	1.22	0.224	00.03	0.128	
Fdi	0.031	0.013	2.34	0.019	.0005	0.056	**
Inds	0.087	0.021	4.10	0.000	.0045	0.129	***
Lnup	-0.792	0.639	-5.93	0.000	-5.045	-2.539	***

*** $p < .01$, ** $p < .05$, * $p < .1$

The table's data helps develop a more nuanced understanding of the variables affecting climate change. Among the noteworthy results included the persistence of prior emissions, the significance of industrial production and economic activity, and the role performed by innovation. These findings point out the need for specific strategies to address the various sources of emissions, although total natural resource rents and net resource rents have less of an impact and there is a strong positive correlation among urban population and emissions.

Table 9: FGLS robust test

lnCO₂E	Coef.	St.Err.	t-value	p-value	Sig
Eco	0.4976	.0568	8.76	0.000	***
Lnpat	-.07194	0.034	-2.12	0.034	**
Ft	.00516	0.018	0.29	00.77	
Tnrr	.17991	0.013	13.68	0.000	***
Fdi	.02040	0.006	3.27	0.001	***
Inds	.05181	0.006	8.41	0.000	***
Up	.00906	0.005	1.93	0.053	*
Constant	.58305	0.215	2.71	0.007	***
*** $p < .01$, ** $p < .05$, * $p < .1$					

Several significant variables cause climate change, based on the data in this table. Economic production, patents, net resource rent, foreign direct investment, and industry output all have an important effect on the natural logarithm of climate change due to the complex connection between the economy, technological advancements, and the management of resources. Further research on the marginal impact of commerce and the slightly significant effect of the urban population is required. When everything is considered, these results demonstrate the importance of integrating technical, financial, and environmental considerations into programs for combating climate change.

Conclusion and Policy Recommendations

This study aims to assess how the G7 countries' changing climatic patterns from 1992 to 2022 have been affected by ecological footprint, energy innovation, and financial technology. The study employs advanced econometric techniques, such as the CIPS and CADF unit root test of system, to determine cross-sectional dependency and heterogeneity. The findings of the paper indicate that while applications for patents show a negative association with CO₂ emissions, a rise in ecological print and natural resources on rent correlates positively with CO₂ emissions. These findings recommend that innovation might assist in reducing emissions.

According to the Granger quality test, there exists an inverse connection among urbanization and the CO₂ mission, suggesting sustainable urban growth. In order to achieve a low-carbon economy, the results of this research recommend that these economies expand their use of renewable energy sources and technological advancements. The government should develop policies that balance preservation of the environment with economic growth for long-term sustainability.

It will be essential to create environmentally friendly urban infrastructure and adjust immigration policies for each of the G7 nations for the purpose to address climate change. The report recommends making investments in new energy technology and enacting legislation to

make more efficient utilization of resources in order to safeguard the environment. The government must create plans to safeguard the environment for foreign investors.

The study's methodology does not just apply to G7 countries; it could also be used to other economies. Further research on the relationship between fiscal centralization and climate change may find it helpful to employ alternate proxy variables, such as production-based carbon emissions and green energy, instead of consumption-based carbon emissions, as was the case in this study.

References

1. Alex, O., Dzator, J., & Acheampong, A. O. (2018). Handbook of Environmental Materials Management. *Handbook of Environmental Materials Management*. <https://doi.org/10.1007/978-3-319-58538-3>
2. Ali, M., Awe, E. O., Mohammed, S. S., & Isah, K. O. (2024). Industrialization, FDI Inflow and Climate Change in Africa: A Scenario Analysis. *Chinese Journal of Urban and Environmental Studies*, 12(1). <https://doi.org/10.1142/S2345748124500039>
3. Ameer, N., Bhutta, M. A., Nawaz, D., Asghar, M. M., & Jawad, F. (2024). Navigating the Role of Remittances in Attaining Sustainable Development Goals in Developing Countries: New Insights from Panel ARDL Model. *The Critical Review of Social Sciences Studies*, 2(2), 384-396.
4. Arogundade, S., Mduduzi, B., & Hassan, A. S. (2022). Spatial impact of foreign direct investment on ecological footprint in Africa. *Environmental Science and Pollution Research*, 29(34), 51589–51608. <https://doi.org/10.1007/s11356-022-18831-w>
5. Asghar, M. M., Safdar, R., Zubair, M., & Hanif, M. (2024a). Exploring the Influence of Financial Development, Institutional Quality and Trade Openness on Inclusive Growth in SAARC Countries. *Pakistan Journal of Humanities and Social Sciences*, 12(2), 1450-1461.
6. Asghar, M. M., Sultana, R., Ullah, S., & Arshad, M. (2023). Analyzing the External Debt and Exports-Led Growth Hypothesis in Selected Asian Countries. *Zakariya Journal of Social Science*, 2(2), 43-55.
7. Asghar, M. M., Tanzeel, M., Ullah, S., & Hussain, S. (2024b). Analyzing the Economic Impact of Construction Sector in Pakistan. *Zakariya Journal of Social Science*, 3(1), 21-34.
8. Bounoua, L., Zhang, P., Mostovoy, G., Thome, K., Masek, J., Imhoff, M., Shepherd, M., Quattrochi, D., Santanello, J., Silva, J., Wolfe, R., & Toure, A. M. (2015). Impact of urbanization on US surface climate. *Environmental Research Letters*, 10(8). <https://doi.org/10.1088/1748-9326/10/8/084010>
9. Chandio, A. A., Shah, M. I., Sethi, N., & Mushtaq, Z. (2022). Assessing the effect of climate change and financial development on agricultural production in ASEAN-4: the role of renewable energy, institutional quality, and human capital as moderators.

- Environmental Science and Pollution Research*, 29(9), 13211–13225.
<https://doi.org/10.1007/s11356-021-16670-9>
10. Destek, M. A., & Sarkodie, S. A. (2019). Investigation of environmental Kuznets curve for ecological footprint: The role of energy and financial development. *Science of the Total Environment*, 650(106881), 2483–2489.
<https://doi.org/10.1016/j.scitotenv.2018.10.017>
 11. Gupta, M., Saini, S., & Sahoo, M. (2022). Determinants of ecological footprint and PM2.5: Role of urbanization, natural resources and technological innovation. *Environmental Challenges*, 7(January), 100467.
<https://doi.org/10.1016/j.envc.2022.100467>
 12. Iram, M., Zameer, S., & Asghar, M. M. (2024). Financial Development, ICT Use, Renewable Energy Consumption and Foreign Direct Investment Impacts on Environmental Degradation in OIC Countries. *Pakistan Journal of Humanities and Social Sciences*, 12(2), 1303-1315.
 13. Ishfaq, M., Rasool, A., Asghar, M. M., Karim, S., & Ahmad, R. (2024). Impact of Natural, Physical and Human Capital Formation on Economic Growth in Pakistan: An ARDL Analysis. *Journal of Asian Development Studies*, 13(3), 222-233.
 14. JinRu, L., & Qamruzzaman, M. (2022). Nexus Between Environmental Innovation, Energy Efficiency, and Environmental Sustainability in G7: What is the Role of Institutional Quality? *Frontiers in Environmental Science*, 10.
<https://doi.org/10.3389/fenvs.2022.860244>
 15. Li, H., Ali, M. S. E., Ayub, B., & Ullah, I. (2024). Analysing the impact of geopolitical risk and economic policy uncertainty on the environmental sustainability: evidence from BRICS countries. *Environmental Science and Pollution Research*, 31(34), 46148-46162.
 16. Nasir, MA and Duc Huynh, T. and X. T. (2019). Role of Financial Development , Economic Growth & Foreign Direct Investment in Driving Climate Change : A Case of Emerging ASEAN Muhammad Ali Nasir * 1 , Toan Luu Duc Huynh ^ , Huong Thi Xuan Tram ^ ^ School of Banking , University of Economics Ho Chi Min. *Journal of Environmental Management*, 242(ISSN 0301-4797), 131–141.
 17. Pawłowska, M., Staniszewska, A., & Grzelak, M. (2022). Impact of FinTech on Sustainable Development. *Financial Sciences*, 27(2), 49–66.
<https://doi.org/10.15611/fins.2022.2.05>
 18. Qadri, S. U., Shi, X., Rahman, S. U., Anees, A., Ali, M. S. E., Brancu, L., & Nayel, A. N. (2023). Green finance and foreign direct investment–environmental sustainability nexuses in emerging countries: new insights from the environmental Kuznets curve. *Frontiers in Environmental Science*, 11, 1074713.
 19. Radmehr, R., Shayanmehr, S., Ali, E. B., Ofori, E. K., Jasińska, E., & Jasiński, M. (2022). Exploring the Nexus of Renewable Energy, Ecological Footprint, and Economic Growth through Globalization and Human Capital in G7 Economics. *Sustainability (Switzerland)*, 14(19). <https://doi.org/10.3390/su141912227>

20. Sahoo, M., & Sethi, N. (2022). The dynamic impact of urbanization, structural transformation, and technological innovation on ecological footprint and PM2.5: evidence from newly industrialized countries. In *Environment, Development and Sustainability* (Vol. 24, Issue 3). Springer Netherlands. <https://doi.org/10.1007/s10668-021-01614-7>
21. Shah, S. Z. A., Asghar, M. M., & Riaz, U. (2020). Exploring the Factors Affecting Economic Growth in Pakistan. *Global Social Sciences Review*, 5(3), 400-409.
22. Shah, S. Z. A., ASGHAR, M. M., & RIAZ, U. (2021). Does Urbanization Influence Agriculture Output in Pakistan?. *International Review of Basic and Applied Sciences*, 9(3), 368-376.
23. Sibte-Ali, M., Weimin, Z., Javaid, M. Q., & Khan, M. K. (2023). How natural resources depletion, technological innovation, and globalization impact the environmental degradation in East and South Asian regions. *Environmental Science and Pollution Research*, 30(37), 87768-87782.
24. Udeagha, M. C., & Breitenbach, M. C. (2023). The Role of Financial Development in Climate Change Mitigation: Fresh Policy Insights from South Africa. In *Biophysical Economics and Sustainability* (Vol. 8, Issue 1). Springer International Publishing. <https://doi.org/10.1007/s41247-023-00110-y>
25. Udemba, E. N. (2022). Moderation of ecological footprint with FDI and agricultural sector for a better environmental performance: New insight from Nigeria. *Journal of Public Affairs*, 22(2). <https://doi.org/10.1002/pa.2444>
26. Usman, M., & Hammar, N. (2021). Dynamic relationship between technological innovations, financial development, renewable energy, and ecological footprint: fresh insights based on the STIRPAT model for Asia Pacific Economic Cooperation countries. *Environmental Science and Pollution Research*, 28(12), 15519–15536. <https://doi.org/10.1007/s11356-020-11640-z>
27. Usman, O., Akadiri, S. Saint, & Adeshola, I. (2020). Role of renewable energy and globalization on ecological footprint in the USA: implications for environmental sustainability. *Environmental Science and Pollution Research*, 27(24), 30681–30693. <https://doi.org/10.1007/s11356-020-09170-9>
28. Weimin, Z., Sibte-Ali, M., Tariq, M., Dagar, V., & Khan, M. K. (2022). Globalization toward environmental sustainability and electricity consumption to environmental degradation: does EKC inverted U-shaped hypothesis exist between squared economic growth and CO₂ emissions in top globalized economies. *Environmental Science & Pollution Research*, 29(40).
29. Williams, M., Abu Alrub, A., & Aga, M. (2022). Ecological Footprint, Economic Uncertainty and Foreign Direct Investment in South Africa: Evidence From Asymmetric Cointegration and Dynamic Multipliers in a Nonlinear ARDL Approach. *SAGE Open*, 12(2). <https://doi.org/10.1177/21582440221094607>

30. Yuerong, H., Javaid, M. Q., Ali, M. S. E., & Zada, M. (2024). Revisiting the nexus between digital trade, green technological innovation, and environmental sustainability in BRICS economies. *Environmental Science and Pollution Research*, 31(6), 8585-8607.

