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Analyzing Ecological Footprint through the Lens of Globalization, Financial Development, Natural Resources, Human Capital and Urbanization

Arzoo Abid
School of Economics, Quaid-i-Azam University, Islamabad, Pakistan
Email: arzooabid999@gmail.com

Muhammad Tariq Majeed (Corresponding author)
School of Economics, Quaid-i-Azam University, Islamabad, Pakistan
Email: tariq@qau.edu.pk

Tania Luni
School of Economics, Quaid-i-Azam University, Islamabad, Pakistan
Email: tania_luni@yahoo.com

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Abstract

This study aims to analyze the relationships of globalization, financial development, natural resources, human capital, and urbanization with ecological footprint employing a panel of 118 countries from 1971 to 2018. Further, for deeper insights, the analysis is extended for the panels of heterogeneous income groups namely high income (45), upper-middle-income (27), lower-middle-income (30), and low-income (10) panels. For empirical analysis fully modified ordinary least squares (FMOLS), dynamic ordinary least squares (DOLS) methods are employed. The results show that economic growth improves environmental quality by lowering ecological footprint (EF). However, economic growth increases the ecological footprint in lower-middle-income countries. Globalization increases ecological footprints. Human capital increases environmental degradation by increasing EF footprint across all panels. Energy use increases EF in all income groups except the low-income group. Natural resources exert a positive influence on ecological footprint across all income groups except global and upper-middle-income countries. Urbanization increases the ecological footprint for all income panels except high-income economies. Financial development increases ecological footprint across all panels except lower-middle-income economies. The robustness analysis also validated our findings. The findings also hold for Belt and road, BRICS, G7, MENA, and OECD economies.

Keywords: ecological footprint, energy consumption, environmental quality, financial development, globalization, human capital, natural resources, urbanization.

1. Introduction

Climate change exerts an adverse influence on the terrestrial ecosystem, food availability, land quality, and human life (IPCC, 2019). Climate change is mainly attributed to increasing carbon emissions in the atmosphere. These emissions result from the use of conventional energy sources (fossil fuels) which occupy 80% share in energy generation. Moreover, excessive resource exploitation increases environmental stress and ecological footprint (EF) across the globe (Alola, 2019; Alola et al., 2019b; Bekun et al., 2019). Environmental issues are largely linked with economic growth (EG), energy consumption (EC), urbanization (UP), globalization (GL), and financial development (FD).

Recently, the literature has also highlighted the importance of natural resources (NR) and human capital (HC) in influencing environmental quality. The present research is motivated by the following facts. First, the leading causes of environmental changes do not provide conclusive results. Second, the new avenues of environmental changes are not well explored. This research emphasizes global evidence along with heterogenous income groups for a better understanding of environmental factors. Third, this study emphasizes that environmental factors need to be explored using a comprehensive measure of environmental quality unlike past studies focusing on a single aspect of environmental quality.

Among environmental factors, EG is a key indicator of the prosperity of a country as it supports poverty reduction, social welfare, and the use of efficient technologies that result in lower EF (Zafar et al., 2019; Usman et al., 2020). EG associated with innovations, the use of clean technology, and modern techniques in the production process can enhance environmental quality. However, EG can hurt the environmental quality by escalating pressure on EF (Yasmeen et al., 2020) (Danish et al., 2019b; Ahmad et al., 2020). The impact of EC on environmental quality depends on the sources of its generation. Energy generated from fossil fuels adversely affects environmental quality, however, if it’s generated from renewable resources, it improves environmental quality. The past studies suggest both negative (Nathaniel et al., 2019; Zafar et al., 2019) and positive (Al-Mulali et al., 2015b; Charfeddine, 2017; Ibrahiem and Hanafy, 2020; Balsalobre-Lorente and Carlos, 2020) effects of EC on environmental quality.

Planned urbanization can contribute to environmental enhancement, by using public facilities (public transport) while unplanned and unsystematic urbanization promotes land insecurity, waste management problems (Uttara et al., 2012), loss of biodiversity, air pollution, and deforestation. The studies of Al-Mulali et al. (2015b), Charfeddine, (2017), Ahmed et al. (2020a), and Ahmed et al. (2020b) reported an increase in ecological footprint resulting from urbanization while Luni and Majeed (2020), Majeed and Mazhar (2019b), and Charfeddine and Mrabet (2017) reported a decline in environmental degradation resulting from urbanization. The findings of Hossain (2011) and Behera and Dash (2017) provide mixed results regarding the impact of urbanization on environmental degradation.

GL and FD as environmental factors have been intensively debated. GL affects the environment through trade and foreign direct investment (FDI), which lead to an increase in economic activities, technological transfer, and energy demand. Trade (exports) has increased 200 folds between 1970 to 2017 and led to an increase in the demand for goods and services mostly by the developed countries and boosted imports of natural resources (to fulfil demands) from the developing world (WWF, 2020). GL can affect the environment both positively and negatively. Some researchers suggest adverse effects of GL on the environment due to increased energy demand, natural resource extraction, and infrastructure development (Majeed and Mazhar, 2019a; Al-Mulali et al., 2015b), while other researchers are of the view that GL improves environmental quality through innovations, use of green technologies, energy efficiency, improved management skills and shift from industrial to service-based economies (Figge et al., 2017; Rudolph and Figge, 2017; Sharif et al., 2019; Ahmed et al., 2019; Sabir and Gorus 2019; Godil et al., 2020).

The FD determines environmental quality through the availability of credit facilities within the economy. On one hand, FD promotes research and development, the use of clean technologies, and attracts projects that are environmentally friendly, thereby improving environmental quality (Uddin et al., 2017; Majeed and Mazhar, 2019b; Destek and Sarkodie, 2019). On the other hand, FD leads to the availability of credit that results in the purchase of durable goods, the industrial expansion that promotes the use of obsolete technologies to avoid costs (Charfeddine, 2017; Baloch et al., 2019; Rehman et al., 2019; Godil et al., 2020) and lead to adverse environmental impact in the form of higher land, water, and air degradation. Furthermore, financial institutions are not concerned about the possibilities and impact of credit usage which also leads to environmental deterioration (Tahir et al., 2021).

The extraction and use of NR also determine the environmental quality of a country. The global consumption of natural resources is 50% higher than the biological capacity of the earth, therefore, two planets earth will be required to meet the increasing demand of resources and waste generation by humanity (WWF, 2008). The global stock of natural capital has declined by 40% since the 1990s (WWF, 2020). With economic prosperity, the rate of natural resource depletion and waste generation increases due to the over-extraction of resources as these resources are used as a primary input in the production process (Danish et al., 2019a). Furthermore, the unsustainable use of natural resources leads to deforestation, and water insecurity (Dong et al., 2017) and is associated with a decline in biocapacity thereby increasing environmental deficit and ecological footprints respectively (Destek and Sarkodie, 2019). On the contrary, the availability of natural resources may attract FDI that promotes the use of energy-efficient technologies in the production process and improves environmental quality in industrialized economies (Shahabadi and Feyzi, 2016).

HC is also an important factor affecting environment quality, as education changes individual behavior by increasing awareness regarding environmental concerns, it leads to a decline in deforestation (Godoy et al., 1998), promote the use of clean energy (Yao et al., 2019), support innovation and use of abatement technologies, the use energy-efficient appliances, a decline in energy consumption (Yao et al., 2020), and an increase in recycling activities (Zen et al., 2014) thereby decreasing emissions (Iqbal et al., 2021). Kwon (2009) stated that with the creation of energy efficiency, environmental quality will be improved by human capital. The favorable and effective use of energy and NR depends on HC (Zallé, 2019). Saleem et al. (2019) support positive relation between HC and EF while Zafar et al. (2019) provided opposite results.

Environmental quality has been measured by several indicators. Carbon emissions (CO2) have been extensively used as a measure of environmental quality (Tahir et al., 2021; Bekun et al., 2019; Charfeddine and Kahia, 2019; Behera and Dash, 2017) and measure environmental degradation partially (Al-Mulali et al., 2015a). EF, on the other hand, is a comprehensive indicator that includes the impact of human activities on the environment by incorporating carbon footprint, ocean, grazing land, forest products, land use for crops, and infrastructure.

Although some studies used EF to measure environmental quality (Destek and Sinha, 2020; Majeed and Mazhar, 2019b; Zafar et al. 2019; Al-Mulali et al. 2015a) however they lack the channels explaining the contribution of HC and NR towards ecological quality (Destek and Sinha, 2020; Majeed and Mazhar, 2019b). Furthermore, the studies that examined the impact of GL on EF consider trade (Destek and Sinha, 2020; Al-Mulali et al., 2015b) and FDI (Zafar et al., 2019) as an indicator of globalization. However, the globalization index (Dreher, 2006) is a better measure of interconnectedness among the countries. Furthermore, the difference in techniques yields different results because of endogeneity therefore the study used the generalized method of moments (GMM) to overcome this problem. As environmental quality is a long-term phenomenon therefore long-run relationships are assessed with the help of FMOLS and DOLS. With the limitations discussed above the objective of this study is to examine the effects of GI, FD, HC, and NR on EF while controlling for the effects of EG, EC, and UP. The research questions of the study can be postulated as 1) How do GI, HC, NR, and FD influence EF in a global economy? 2) Do the global relationships between the variables remain the same across heterogenous income groups?

The remaining study is organized as follows: section 2 incorporates literature. Section 3 is based on data description and methodology. Section 4 provides results and their discussion. Section 5 provides the conclusion and policy recommendations.

2. Literature Review

Environmental deterioration is the outcome of human activities that result in spoliation of environmental quality by extinction of species, variations in weather, ecosystem loss, and natural resources depletion highlighted by Majeed and Mumtaz (2017) and Majeed and Mazhar (2019b). Environmental degradation impacts all aspects of human life, therefore, emerged as a key area of academic research.

2.1 Economic Growth and Ecological Footprint

There is a trade-off between EG and the quality of the environment. EG increases the standard of living decreases poverty and is regarded as a key indicator of growth and prosperity of a country but there is also a counter side of growth that is its harmful effects on nature (Yasmeen et al., 2020). Destek and Sarkodie (2019), and Sabir and Gorus (2019) showed inverted U-Shaped relation among EG and EF. Zafar et al. (2019) and Usman et al. (2020) stated that EG decreases EF the reason is that with an addition in income people want more and more of a safe environment and they want to give more money to protect the environment. Danish et al. (2019b) and Ahmad et al. (2020) stated that economic progress increases EF because when there is an increase in income it means more consumption, more production, more industries and consumers waste, and more extraction of natural resources, so this all puts pressure on nature.

2.2 Energy Consumption and Ecological Footprint

Energy is necessary and it plays a key role in the production process. Too much use of energy (fossil fuels) results in environmental degradation. Inter generation equity theory states that it is our moral and ethical responsibility to save the environment for future generations. So, we should take care of the natural environment and make it available for our future generations as well.

Al-Mulali et al. (2015b), Charfeddine (2017), Ibrahiem and Hanafy (2020), and Balsalobre-Lorente and Carlos (2020) analyzed that EC (non-renewable) increase EF. Nathaniel et al. (2019), Zafar et al. (2019), and Usman et al. (2021) showed that EC results in decreasing EF by using renewable energy. Alola et al. (2019a), Rehman et al. (2019), Destek and Sinha (2020), and Balsalobre-Lorente and Carlos (2020) showed that renewable energy usage decline EF while non-renewable energy usage increases EF.

2.3 Urbanization and Ecological Footprint

Urbanization (UP) is increasing in both developing and developed nations and many rich countries have entered the third stage of UP. Urbanization refers to the structural transformation of the agriculture economy to an industrialized and serviced-based economy. Poumanyvong and Kaneko, (2010) highlighted three theories including ecological modernization, urban environmental transition, and compact city theory to explain the linkages of urbanization and environmental quality. The ecological modernization theory posits that urbanization represents transformation and is modernization that results in environmental degradation initially however with the increase in modernization the awareness regarding environmental sustainability increases along with technological advancements which result in improved environmental quality. The urban environmental transition theory discusses problems associated with different stages of development at early stages environmental problems are greater however with the increase in income these problems are resolved through the availability of modern technologies. The compact city theory explains the benefits of an increase in urban density including scale economies and urban public transportation (Poumanyvong and Kaneko, 2010). However, according to Kasman and Duman (2015), rural-urban migration increases air pollution. Thus, disagreement exists among researchers on the impact of urbanization on environmental quality. Literature regarding the effect of UP on EF shows positive effects of UP on EF suggesting an increase in environmental deterioration because of unplanned UP as supported by Al-Mulali et al. (2015b), Charfeddine (2017), Ahmed et al. (2020a), and Ahmed et al. (2020b). Other studies highlight the inverse effect of UP on EF suggesting improved environmental quality due to economies of scale and planned urbanization like Hossain (2011), Behera and Dash (2017), and Charfeddine and Mrabet (2017).

2.4 Globalization and Ecological Footprint

We can interpret GI as an increase in the social, economic, and political interconnectedness of countries (Saud et al., 2020; Shahbaz et al., 2019). GI can both positively and negatively affects the environment. On one side environmental quality can be improved by trade innovations, FDI, and clean technologies (Ahmed et al. 2019). On the other side as consumption and production increase by GI so demand for energy and natural resources also increases which increases pressure on the environment (Sharif et al., 2019). Usman et al. (2022), Ahmad et al. (2021), and Al-Mulali et al. (2015b) confirmed that GI decreases EF. Figge et al. (2017), Rudolph and Figge (2017), Sharif et al. (2019), Ahmed et al. (2019), Sabir and Gorus (2019), Godil et al. (2020), and Kirikkaleli et al. (2021) showed that overall GI has a positive impact on EF. Saud et al. (2020) showed mixed outcomes regarding the impact of GI on EF.

2.5 Financial Development and Ecological Footprint

Literature shows the powerful effect of FD on the quality of the environment. On one side some studies show a negative effect of FD on EF (Zhang, 2011; Uddin et al., 2017; Majeed and Mazhar, 2019b; Sarkodie and Strezov, 2019) using environmentally friendly technologies including renewable energy. On the other side Charfeddine (2017), Baloch et al. (2019), Rehman et al. (2019), Godil et al. (2020), and Usman et al. (2022) stated that FD results in an increase in EF by increasing credit facilities that will increase the use of machinery and hence an increase in EF. Saud et al. (2020) showed mixed results regarding the impact of FD on EF.

2.6 Natural Resources and Ecological Footprint

Gas, coal, minerals, and forests are included in natural resources and natural resource rent is used to quantify it. As natural resources are finite and generated over thousands of year their excessive use, more than their regeneration causes depletion (Majeed et al. 2022), deforestation, and global warming (Dong et al., 2017). Literature shows mixed results regarding the relation between NR and EF. On one side Hassan et al. (2019), Ahmed et al. (2020a), Ahmad et al. (2020) and Ahmed et al. (2020b), and Usman et al. (2022) stated the favorable effect of NR on EF due to inefficient use of the natural resource, weak energy strategies and dependence on standard sources of energy that increases EF while on the other side Zafar et al. (2019) show a negative effect of NR on EF because of increase in the natural capacity of the land, and water quality. Therefore, the impact of NR on the environment depends on the way resources are used and managed as sustainable use supports sustainability of the resource and improved environmental quality however overuse undermines regeneration and results in ecological degradation respectively.

2.7 Human Capital and Ecological Footprint

Human capital refers to an increase in the abilities and productivity of humans. HC increases energy efficiency that results in reducing emissions (Kwon, 2009). As HC is equipped with knowledge and education, they promote environmentally friendly practices including recycling of products in contrast to people with limited education (Zen et al. 2014). HC also leads to a decline in deforestation and promotes conservation due to a decline in dependence on income from the forest and relying on the job market (Godoy et al., 1998). The literature has recommended that HC results in an improvement of environmental quality by decreasing the use of fossil fuels, promote use of green technologies (Yao et al., 2019), and energy efficiency (Yao et al., 2020), promoting the recycling activities (Zen et al., 2014). HC helps in innovation and use of modern technologies to combat emissions. Furthermore, HC leads to a decline in costs of implementing advanced pollution control technologies (Iqbal et al., 2021). Zafar et al. (2019) and Ahmed et al. (2020a) reported a negative relationship between HC and EF suggesting that environmental deterioration decreases by HC. Saleem et al. (2019) stated that HC has a positive effect on EF in some models and country-specific cases but the overall impact is negative on EF.

The above discussion of literature can be summarized as; there is a shortage of literature on the connection between our concerning independent variables and dependent variable ecological footprint. There are only a few studies that are conducted on this topic and are reporting different results; the reason behind dissimilar results probably is the diversity of characteristics of countries, regions, and different practices regarding management and extraction of natural resources.

3. Data and Methodology

3.1 Data Description:

This research used panel data of 118 countries, 45 high income, 33 upper-middle-income, 30 lower-middle-income, and 10 low-income countries from 1971 to 2018. The study conducted panel time series and panel analysis therefore classification of World Bank (2020) has been used to differentiate between countries according to income level (high income, upper middle-income, lower middle-income, and low-income). EF has been taken as a regressand and data of EF has been taken from the Global footprint network (2019). Data of globalization has been extracted from the KOF globalization index, while data of human capital has been obtained from Penn world tables Version 9 (Feenstra et al., 2015). The Penn world table measures human capital by the comparison and combination of data sets of Barro and Lee (2013) and Cohen and Leker (2014). Furthermore, the data of natural resource rent, financial development, urbanization, and economic growth has been taken from World Bank (2020). The study also examines the association in case of 25 Belt and Road (B&R), Brazil, Russia, India, China, and South Africa (BRICS), Group of Seven countries (G7), Middle East and North Africa (MENA), and Organization for Economic Co-operation and Development (OECD). Table 1 presents the detailed information of the variables (and their sources) analyzed in this study.

Table 1: Data, Variables and Measurement

Variable Description	Symbol	Unit of Measurement	Data Source
Ecological Footprint	LEF	Ecological footprint (Global hectares per person)	Global Footprint Network (2019)
Economic Growth	LEG	GDP per capita (constant 2010 US$)	World Bank (2020)
Energy Consumption	LEC	Energy use (kg of oil equivalent per capita)	World Bank (2020)
Urbanization	LUP	Urban population (% of total population)	World Bank (2020)
Globalization	LGI	Globalization index	KOF Globalization Index (Dreher 2006)
Financial Development	LFD	Domestic credit to the private sector (% of GDP)	World Bank (2020)
Natural Resources	LNR	Total natural resources rents (% of GDP)	World Bank (2020)
Human Capital	LHC	Human capital index	Penn World Tables

3.2 Model and Methodology:

The objective of the research is to investigate the linkage among G, FD, NR, HC, UP, and EF by controlling the effect of EG and energy consumption at the global level and across different income groups from 1971 to 2018. The model used can be written as

$$EF_{it}=\beta_0+\beta_1 EG_{it}+\beta_2 EC_{it}+\beta_3 UP_{it}+\beta_4 GI_{it}+\beta_5 FD_{it}+\beta_6 NR_{it}+\beta_7 HC_{it}+\mu_{it} \quad (1)$$

Where EF refers to ecological footprint, EG is economic growth, EC is energy consumption, UP is urban population, GI is globalization index, FD is financial development, NR is natural resources, and HC is the human capital index, β_0 is the intercept, i is for the countries while t is the period from 1971-2020 respectively. Normality problems are detected when the above model is being used. To make data normal and to limit the issues of heteroscedasticity and autocorrelation, the logarithm of all variables is used therefore $\beta_1, \beta_2, \ldots, \beta_7$ presents elasticity with respect to EG, EC, UP, GI, FD, NR, and HC, μ_{it} is the error term.

The fully Modified Ordinary Least Square (FMOLS) method is a panel time-series estimation technique that is used to see long-run relationships between variables. FMOLS technique is proposed by Phillips and Hansen (1990) and this method is appropriate as it controls the problems of endogeneity and serial correlation in values of predictors. Furthermore, Dynamic Ordinary Least Square (DOLS) is also used to validate the results. Panel techniques including Pooled Ordinary Least Square (POLS), Random effects (RE), Fixed effects (FE), and GMM are used to examine the sensitivity of the results.

4. Results and Discussion

4.1 Summary Statistics

Table 2 presents summary statistics. For the global panel, the maximum values of EF, EG, EC, UP, GI, FD, NR, and HC are taken by China, Bahrain, Burundi, Faroe Island, Bhutan, Bahrain, Estonia, and Isle of Man respectively. The minimum values of EF, EG, EC, UP, GI, FD, NR, and HC are taken by Brunei Darussalam, Brazil, Belarus, Poland, Netherlands, Bermuda, Italy, and Liberia respectively.

Table 2: Descriptive Statistics

Global Panel								
	EF	**EG**	**EC**	**UP**	**GI**	**FD**	**NR**	**HC**
Mean	1.49E+08	3.688766	7.260869	47.14953	56.43106	12918.74	57.04950	2127.769
Med	30195791	3.675526	2.805624	31.82158	54.93861	4895.468	58.53050	1025.904
Max	5.26E+09	196061.4	40710.12	100.0000	91.31335	368.9784	89.12039	3.974200
Min.	2.909782	161.7345	9.548031	2.970000	14.27918	0.007726	0.000000	1.008087
S.D.	4.49E+08	0.664339	10.77845	41.89393	17.19776	17567.23	23.51645	2547.804
Obs.	3008	3008	3008	3008	3008	3008	3008	3008
High Income Panel								
	EF	**EG**	**EC**	**UP**	**GI**	**FD**	**NR**	**HC**
Mean	2.08E+08	30072.03	4398.202	75.77936	71.92599	78.10339	4.452265	2.963489
Med	45163810	27077.12	3675.435	78.14000	75.42797	68.46720	0.506192	3.042929
Max	3.06E+09	196061.4	40710.12	100.0000	91.31335	308.9784	89.12039	3.974210
Min.	2.909782	1943.877	112.0547	14.30300	32.64028	0.186170	0.000000	1.315220
S.D.	5.10E+08	19873.00	3059.265	14.33521	12.61586	47.66577	10.36467	0.497080
Obs.	1109	1109	1109	1109	1109	1109	1109	1109
Upper Middle-Income Panel								
	EF	**EG**	**EC**	**UP**	**GI**	**FD**	**NR**	**HC**
Mean	2.32E+08	6105.946	1399.983	63.32137	53.93122	41.02604	8.871967	2.223426
Med	50243244	5151.887	1101.247	64.55100	53.36253	28.53423	4.107676	2.224304

Max	5.26E+09	20532.95	5941.586	91.99100	81.4084	164.6643	86.25231	3.529136
Min.	62920.9	238.0147	228.0758	8.998000	22.2330	1.266927	0.000000	1.102233
S.D.	6.44E+08	3256.244	815.5369	15.87547	12.10581	33.86400	10.64736	0.463659
Obs.	743	743	743	743	743	743	743	743
Lower Middle-Income Panel								
	EF	**EG**	**EC**	**UP**	**GI**	**FD**	**NR**	**HC**
Mean	76296628	1397.055	500.7361	35.59563	45.19852	24.92934	6.575596	1.765217
Med	23604282	1151.988	429.6687	34.58750	44.10575	20.87487	4.161952	1.673175
Max	1.55E+09	4830.197	4856.642	77.91500	74.90000	137.9121	59.60435	3.453346
Min.	52336.54	161.7345	9.548031	35.00871	15.27918	0.007726	0.00000	1.018196
S.D.	1.78E+08	895.7657	309.5108	14.96950	11.72598	18.33557	6.893941	0.514666
Obs.	928	928	928	928	928	928	928	743
Low-Income Panel								
	EF	**EG**	**EC**	**UP**	**GI**	**FD**	**NR**	**HC**
Mean	13385056	681.3389	327.3602	28.76994	37.86728	12.04438	12.97835	1.394167
Med	5446796.	638.2364	327.6095	28.51000	37.68252	11.12189	9.966816	1.275924
Max	1.09E+08	1900.093	1907.013	62.13400	54.88209	46.47665	62.73409	3.169026
Min.	524216.8	164.1919	63.66971	2.97000	14.3000	0.402581	0.00000	1.008087
S.D.	17513711	329.0091	96.85158	8.622102	8.445161	7.809772	10.95355	0.370499
Obs.	223	223	223	223	223	223	223	223

4.2 Correlation Analysis

Table 3 presents the correlation analysis. A positive correlation exists among GI, EC, FD, and EF across all income groups. HC has a positive correlation with EF in all groups besides low-income groups. NR has a positive correlation with EF in upper middle-income, lower middle-income, and low-income groups except for the global panel and high-income group. A positive correlation exists between UP and EF in all income groups besides low-income groups. A positive correlation exists between EG and EF in the global panel, and the high-income group while a negative correlation exists in other income groups.

Table 3: Correlation Analysis

	LEF	LEG	LEC	LUP	LGI	LFD	LNR	LHC
Global panel								
LEF	1							
LEG	0.2120	1						
LEC	0.2309	0.9030	1					
LUP	0.17589	0.8257	0.7442	1				
LGI	0.24768	0.7936	0.7173	0.7458	1			
LFD	0.3466	0.6673	0.6071	0.5208	0.6723	1		
LNR	-0.0816	-0.4049	-0.2447	-0.2558	-0.3972	-0.4666	1	
LHC	0.28077	0.7790	0.7423	0.6825	0.8452	0.6052	-0.4114	1
High-income panel								
LEF	1							
LEG	0.2467	1						
LEC	0.1490	0.6573	1					
LUP	0.1477	0.5094	0.3932	1				
LGI	0.2643	0.6874	0.3080	0.2482	1			
LFD	0.3379	0.5530	0.1179	0.1679	0.4792	1		
LNR	-0.2149	0.0347	0.3844	0.1538	-0.2644	-0.2740	1	
LHC	0.4385	0.5475	0.2828	0.06183	0.6821	0.4546	-0.3860	1
Upper middle-income panel								
LEF	1							
LEG	-0.0453	1						
LEC	0.2098	0.6164	1					
LUP	0.0218	0.7071	0.2963	1				
LGI	0.0250	0.3682	0.3260	0.4643	1			
LFD	0.3993	-0.1273	0.2142	-0.1883	0.2885	1		
LNR	0.1143	0.2434	0.2922	-0.0455	-0.2184	-0.2185	1	
LHC	0.0991	0.1780	0.2850	0.3907	0.7845	0.1330	-0.1664	1
Lower middle-income panel								
LEF	1							
LEG	-0.0161	1						
LEC	0.1134	0.6394	1					
LUP	0.0007	0.7350	0.4756	1				
LGI	0.1741	0.6454	0.4609	0.6820	1			
LFD	0.1551	0.4468	0.2760	0.3238	0.4732	1		
LNR	0.0616	0.2973	0.3707	0.3636	0.0942	-0.1136	1	
LHC	0.0993	0.3824	0.4069	0.3518	0.6560	0.2223	-0.1046	1
Low-income panel								
LEF	1							
LEG	-0.3856	1						
LEC	0.1744	-0.2620	1					

LUP	-0.4561	0.2320	0.0534	1				
LGI	0.3541	0.0231	0.0075	0.4257	1			
LFD	0.2233	0.0148	0.2396	-0.0591	0.3219	1		
LNR	0.3227	-0.2930	0.2318	-0.2177	0.1252	-0.3310	1	
LHC	-0.1657	0.0929	0.1357	0.4802	0.4958	0.1852	-0.2723	1

4.3 Unit root analysis

We have applied four-panel unit root tests to test the stationarity properties of our variables. Table 4 shows outcomes obtained from unit root analysis. The result reveals that most of the variables are stationary at first difference as supported by all the tests at a 1% level of significance respectively.

Table 4: Unit Root Analysis

Variables	**LLC**		**IPS**		**ADF**		**PP**	
	Intercept	Intercept & trend	Intercept	Intercept & trend	Intercept	Intercept & trend	Intercept	Intercept & trend
Global panel								
LEF	-1.9***	-6.3***	4.62	-5.8***	367.1	644***	373.6	947.9***
ΔLEF	-80.5***	-75.8***	-79***	-69***	4812***	4944***	5229***	10050***
LEG	-6.0***	-7.0***	4.51	-1.93**	472.3***	759.8***	488.1***	516.9***
ΔLEG	-50.2***	-47.2***	-51***	-47***	3385***	3129***	3538***	3756***
LEC	-10.2***	578.67	-10***	1.91	538***	302.2	595.5***	347.9***
ΔLEC	-53.9***	-108***	-55***	-54***	2962***	3030***	3110***	4596***
LUP	-11.6***	1791***	-5.5***	1285***	816.9***	-11.7***	2752***	-7.7***
ΔLUP	-7.2***	19.2	-10***	0.14	869.4***	602.1***	838.9***	462.5**
LGI	-10.4***	-3.6***	4.81	-0.18	440.6**	439.7**	523.1***	502.3***
ΔLGI	-68.2***	-66.6***	-67***	-62***	4357***	3981***	4692***	6017***
LFD	-7.3***	-1.37**	-3.8***	-2.2***	535.2***	518.6***	534.1***	523.8***
ΔLFD	-72.9***	-68.4***	-48***	-33***	2782***	2335***	3060***	2977***
LNR	-10.2***	-9.9***	-12***	-9.4***	818***	746***	777.9***	684.9***
ΔLNR	-72.8***	-65.7***	-72***	-61***	4525***	3949***	5098***	6908***
LHC	-8.6***	-8.1***	7.00	1.72	305.96	332.9**	1015***	350.8***
ΔLHC	-1.1	0.85	-0.20	-1.84**	271.7	338***	332.2	263.1
High-income panel								
LEF	-7.7***	-3.1***	-4.4***	-2.9***	198***	169***	210***	175***
ΔLEF	-46***	-43.5***	-45***	-43***	1532***	1544***	1659***	2708***
LEG	-11***	-2.2***	-1.17	-0.358	200***	158.9	265***	115.0
ΔLEG	-27***	24***	-28***	-24***	1024***	842***	1038***	988***
LEC	-7.6***	-0.567	-5.3***	2.064	183***	98.74	215***	124.58
ΔLEC	-38***	-490***	-38***	-38***	1233***	1302***	1284***	2166***
LUP	-5.3***	-6.0***	-4.2***	-7.0***	345***	340***	889***	796***
ΔLUP	-9.0***	9.74	-7.7***	1.73	345***	152.9	331***	171*
LGI	-8.4***	-0.27	0.482	1.84	170**	122.6	180***	193***
ΔLGI	-40***	-39***	-37***	-31***	1429***	1296***	1493***	2121***
LFD	-5.6***	4.06	-2.6***	1.23	172***	115.4	154***	129.7

ΔLFD	-56***	453	-27***	-21***	774***	671***	846***	805***
LNR	-4.2***	-4.7***	-4.8***	-5.0***	211***	221***	212***	198***
ΔLNR	-39***	-35***	-37***	-31***	1344***	1124***	1550***	2164***
LHC	-7.1***	-5.9***	0.208	0.652	138***	120.1	700***	174***
ΔLHC	-1.7**	0.020	-0.420	-0.141	103.50	88.27	135.9***	115.35
Upper middle-income panel								
LEF	3.8***	-2.9***	0.342	-3.8***	100.67	178***	93.92	213***
ΔLEF	-41***	-39***	-40***	-34***	1252***	1279***	1392***	2272***
LEG	-3.7***	-3.2***	1.205	-3.2***	154***	181***	129.25	243***
ΔLEG	-27***	-25***	-28***	-25***	1088***	759***	1092***	911***
LEC	-5.9***	-1.98**	-8.5***	-1.92**	181***	120***	212***	150***
ΔLEC	-27***	-181***	-28***	-26***	811***	785***	826***	856***
LUP	-7.5***	-9.5***	-4.7***	-6.7***	231***	333***	925***	411***
ΔLUP	-7.0***	11.026	-3.5***	1.364	182***	135.1**	186***	110.75
LGI	-6.8***	1.7**	1.442	-0.69	143***	107.5	179***	101.7
ΔLGI	-35***	-35***	-35***	-35***	1161***	1110***	1248***	1602***
LFD	-5.7***	0.97	-4.4***	-2.0**	204***	182***	189***	185***
ΔLFD	-21***	-5841***	-20***	-14***	633***	497***	762***	731***
LNR	-6.3***	-5.7***	-7.9***	-5.7***	252***	201***	243***	198***
ΔLNR	-40***	-34***	-40***	-36***	1301***	1123***	1497***	2010***
LHC	-3.1***	-2.8***	3.973	1.294	57.9	82.8***	156***	35.76
ΔLHC	1.744	0.528	0.247	-3.1***	59.22	121***	70.32	57.00
Lower middle-income panel								
LEF	3.248	-3.7***	8.081	3.9***	50.277	189***	42.116	209***
ΔLEF	-40***	-39***	-40***	-40***	1224***	1239***	1346***	3194***
LEG	3.237	-1.70**	7.189	0.483	70.502	108.6	47.489	113.6
ΔLEG	-25***	-27***	-26***	-28***	743***	1087***	876***	1331***
LEC	-3.3***	0.085	-4.2***	3.885	119**	44.604	131***	48.49
ΔLEC	-26***	-19***	-27***	-27***	711***	725***	730***	831***
LUP	-3.1***	2.334	0.182	-4.3***	135**	251***	617***	342***
ΔLUP	6.319	17.187	-3.4***	0.575	195***	119.3*	184***	93.34
LGI	-3.1***	-3.4***	3.823	-1.7***	101.39	125**	126**	149***
ΔLGI	-33***	-32***	-34***	-32***	1088***	976***	1209***	1388***
LFD	1.28*	-1.101	0.027	-1.435*	110.54	142***	136***	128**
ΔLFD	-24***	-23***	-24***	-16***	825***	708***	888***	843***
LNR	-6.7***	-6.3***	-7.0***	-5.2***	243***	231***	214***	189***
ΔLNR	-37***	-33***	-37***	-34***	1172***	1059***	1315***	1942***
LHC	-4.7***	-4.9***	4.466	-0.9***	70.92	95**	121***	70.28
ΔLHC	-0.133	1.533	-0.726	-0.043	80.185	80.370	92.21*	55.655
Low-income panel								
LEF	2.408	2.9***	6.671	-1.49*	22.441	110***	32.882	353***
ΔLEF	-31***	-28***	-31***	-22***	784***	861***	813***	1857***
LEG	2.976	-8.5***	2.869	-0.702	47.62	311***	46.24	45.33

ΔLEG	-20***	17***	-20***	-14***	530***	441***	532***	526***
LEC	-4.5***	527.4	-1.40*	-0.244	55***	39.08**	36.82	24.502
ΔLEC	-11***	57.421	-12***	-14***	-206***	217***	269***	743***
LUP	-7.3***	0.543	-1.65**	-5.3***	105***	362***	322***	242***
ΔLUP	-2.8***	-1.87**	-5.3***	-5.0***	147***	195***	138***	88***
LGI	0.060	-2.4***	5.059	-2.5***	27.250	84***	37.521	57.362
ΔLGI	-27***	-25***	-28***	-26***	666***	591***	731***	898***
LFD	-1.06	-6.5***	-0.031	-2.5***	47.79	79.4**	54.07	80.64**
ΔLFD	-35***	-21***	-26***	-17***	549***	458***	562***	597***
LNR	-3.9***	-3.4***	-4.4***	-2.6***	112***	94***	108***	99***
ΔLNR	-31***	-29***	-28***	-22***	707***	643***	735***	793***
LHC	-0.379	-1.74**	7.278	2.608	33.91	35.344	26.03	71***
ΔLHC	-1.4*	-0.458	-0.672	-0.435	28.183	45.39	33.043	32.123

4.4 Cointegration results

Cointegration means a long-run relationship among variables. Table 5 presents cointegration results obtained from Pedroni and Kao panel cointegration tests. Both tests confirm the presence of cointegration among the variables as H0 of no cointegration is rejected at a 1% level of significance in most of the cases. So, we conclude that EG, EC, UP, GI, FD, NR, HC, and EF have a long-run relation.

Table 5: Cointegration Results

Estimates	**Statistics**				
	GP	**HIP**	**UMIP**	**LMIP**	**LIP**
Pedroni cointegration test H_0: No cointegration					
Panel v-Statistic	3.47***	1.92**	1.85**	0.836	2.94***
Panel rho-Statistic	-7.85***	-3.63***	-4.40***	-2.14**	-6.67***
Panel PP-Statistic	-10.10***	-4.33***	-6.26***	-3.24***	-7.39***
Panel ADF-Statistic	-10.23***	-4.55***	-6.16***	-3.26***	-7.29***
Group rho-Statistic	-1.46*	-0.551	-0.411	-0.327	-2.14**
Group PP-Statistic	-13.88***	-6.10***	-9.76***	-5.58***	-6.88***
Group ADF-Statistic	-13.12***	-6.79***	-7.03***	-6.85***	-5.94***
Kao cointegration test H_0: No cointegration					
ADF	-1.2143*	2.0932**	-4.2882***	-1.7390**	-2.5442***
Probabilities * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$					

4.4 Causality Results

Table 6 shows pairwise causality results from the global panel and different income groups. One lag is selected as suggested by Jones (1989) that Ad-Hoc lag selection method is more suitable in Granger causality than any other method. For a global and high-income group of countries two-way causality is found between GI, HC, FD, EG, and EF while one-way causality is observed from EC and NR to EF, and from EF to UP, respectively. For the upper middle-income group, two-way causality was found between EC and EF. One-way causality is observed from EF to EG, UP, and GI, and from HC to EF. No causality is observed between NR, FD, and EF. For the lower middle-income group of countries, two ways causality is presented among HC, EC, and EF respectively. Unidirectional causality is observed from NR to EF and no causality is present between EG, UP, GI, and EF. For the low-income group of countries, unidirectional causality was found from GI, NR to EF, and from EF to EG, UP, FD and HC. No causality is present between EC and EF.

Table 6: Causality Results

Null Hypothesis	Global Panel		High-Income Panel		Upper Middle-Income Panel		Lower Middle-Income Panel		Low-Income Panel	
	Probability	Conclusion	Probability	Conclusion	Probability	Conclusion	Probability	Conclusion	Probability	Conclusion
LEG doesn't Cause LEF	0.0004	LEG↔LEF	0.0244	LEG↔LEF	0.5455	LEG←LEF	0.2646	No Causality	0.7517	LEG←LEF
LEF doesn't Cause LEG	0.0008		0.0003		0.0583		0.1840		0.0091	
LEC doesn't Cause LEF	0.0000	LEC→LEF	0.5499	LEC←LEF	0.0020	LEC↔LEF	0.0000	LEC↔LEF	0.1393	No Causality
LEF doesn't Cause LEC	0.4513		0.0943		0.0385		0.0018		0.1365	
LUP doesn't Cause LEF	0.4872	LUP←LEF	0.5064	LUP←LEF	0.5092	LUP←LEF	0.2231	No Causality	0.5284	LUP←LEF
LEF doesn't Cause LUP	0.0423		0.0011		0.0000		0.1125		0.0000	
LGI doesn't Cause LEF	0.0033	LGI↔LEF	0.00006	LGI↔LEF	0.2519	LGI←LEF	0.2393	No Causality	0.0480	LGI→LEF
LEF doesn't Cause LGI	0.0014		0.0088		0.0191		0.1574		0.1331	
LFD doesn't Cause LEF	0.0001	LFD↔LEF	0.0003	FD↔LEF	0.1860	No Causality	0.5087	No Causality	0.2020	LFD←LEF
LEF doesn't Cause LFD	0.0016		0.0112		0.3792		0.9615		0.0272	
LNR doesn't Cause LEF	0.0000	LNR→LEF	0.0000	NR→LEF	0.5724	No Causality	0.0354	LNR→LEF	0.0524	LNR→LEF
LEF doesn't Cause LNR	0.6497		0.2240		0.1070		0.9388		0.6579	
LHC doesn't Cause LEF	0.0000	LHC↔LEF	0.0000	HC↔LEF	0.0001	LHC→LEF	0.0461	LHC↔LEF	0.2358	LHC←LEF
LEF doesn't Cause LHC	0.0002		0.0068		0.9113		0.0000		0.0008	

↔ = bidirectional causality; ←,→ = unidirectional c.2ausality

4.5 Results and discussion

Table 7 provides the result obtained from FMOLS and DOLS. The results reveal that EG results in a decrease in EF at global, high, and upper middle income, while increases EF in lower middle-income panel however it has insignificant impact in low -income group. A 1 percent addition in EG results in addition in EF by 0.1352 percent in the lower middle-income group while a decline in EF at global, high, and upper middle-income groups by

0.1345, 0.44084, and 0.1681 percent. These findings of an increase in EF resulting from EG are consistent with Danish et al. (2019b) and Ahmad et al. (2020) who supported deteriorated environmental quality resulting from EG. The inefficient and over usage of resources in consumption and production and dependence on non-renewable energy increases EF. The decline in EF from EG can be attributed to the use of clean methods of production, awareness, and healthy competition that decrease EF. These findings are consistent with Zafar et al. (2019) and Usman et al. (2020).

EC leads to a decline in EF in low-income countries while increasing EF in global and other income groups (high income, upper middle-income, and lower middle-income). A 1 percent addition in EC increases EF by 0.48714, 0.802529, 0.56387, and 0.18122 percent at global level, high income, upper middle-income, and lower middle-income groups while a decline in EF in low-income group by 0.14902 percent. These findings of an increase in EF resulting from EC are in line with Al-Mulali et al. (2015b), Charfeddine (2017), Ibrahiem and Hanafy (2020), and Balsalobre-Lorente and Carlos (2020) who supported deteriorated environmental quality resulting from EC. The increase in non-renewable energy puts higher pressure on the environment. The decline in EF from EC can be attributed to a higher share of renewable energy in total energy and the usage of clean energy sources. These results are consistent with Nathaniel et al. (2019) and Zafar et al. (2019).

UP leads to a decline in EF in the high income group while increasing EF at global, upper middle-income, and lower middle-income. UP has an insignificant impact on EF in low-income economies. A 1 percent rise in UP results in addition in EF by 0.1681, 0.38607, and 0.1948 percent at global, upper middle-income, and lower middle-income panels. UP declines EF in the high income group by 0.00547 percent. These findings of an increase in EF resulting from UP are in line with Al-Mulali et al. (2015b), Charfeddine (2017), Ahmed et al. (2020a) and Ahmed et al. (2020b), and Iqbal et al. (2021) who supported deteriorated environmental quality resulting from UP. The increase in unplanned UP puts pressure on the environment. The decline in EF from UP can be attributed to the planned UP and with an increase in UP the economies of scale decrease EF. These findings are similar to Hossain (2011), Behera and Dash (2017), and Charfeddine and Mrabet (2017).

Gl leads to an increase in ecological footprint at the global level and all income groups except upper middle-income group where its impact is insignificant. A 1% addition in GI increases EF by 0.34426, 0.703367, 0.22563, and 0.77556 percent in global, high income, lower middle-income, and low-income groups. These findings are in line with Figge et al. (2017), Rudolph and Figge (2017), Sharif et al. (2019), Ahmed et al. (2019), Sabir and Gorus (2019), and Godil et al. (2020) who supported deterioration in environmental quality because of GI. GI leads to an increase in production and consumption activities and withdrawal of NR thereby causing pressure on biodiversity. The extraction of resources more than their production leads to an increase in EF. However, our findings are different from Majeed et al. (2022) and Tahir et al. (2021) who supported improved environmental quality from GI. GI supports the flow of green technologies and hence technological advancements enhance environmental quality and decrease EF.

FD increases EF at global and upper middle-income panels while it has an insignificant impact on other panels. A 1% increase in FD leads to an increase in EF by 0.022065, and 0.06156 percent at global and upper middle-income groups. These findings are in line with Charfeddine (2017), Baloch et al. (2019), Rehman et al. (2019), and Godil et al. (2020) who supported deteriorated environmental quality resulting from FD. The increase in credit facilities, new businesses, and usage of machinery in the production process puts pressure on the environment. However, our findings are different from Uddin et al. (2017), Majeed and Mazhar (2019b), and Destek and Sarkodie (2019) who supported that FD leads to progress of research, clean and new technologies, and by attracting more projects that are more environmentally friendly and leads to decrease in environmental deterioration.

NR leads to an increase in EF in high income, lower middle-income, and low-income panels. A 1 percent addition in NR results in an increase in EF by 0.010489, 0.03586, and 0.08365 percent in high income, lower middle-income, and low-income groups while the insignificant impact of NR on EF at global level and upper middle-income group. These findings of an increase in EF resulting from NR are consistent with Hassan et al. (2019), Ahmed et al. (2020a), Ahmad et al. (2020), Ahmed et al. (2020b), and Majeed et al. (2022) who supported deteriorated environmental quality resulting from NR. The expansion in withdrawal of natural resources, weak energy strategies, and dependence on conventional sources of energy puts pressure on the environment. NR increases EF in high income as resources are required for developmental changes. Furthermore, in the case of lower middle-income and low-income panels, the inefficient use of resources is the cause behind the increase in EF. The use of natural resources more than their regeneration causes depletion (Majeed et al. 2022), deforestation, and global warming (Dong et al., 2017). However, our findings contrast with Zafar et al. (2019) who supported a decline in EF from NR because of an increase in natural capacity resulting from efficient use of resources that support improved land and water quality. Therefore, the impact of NR on the environment depends on the way resources are used and managed as sustainable use supports sustainability of the resource and improved environmental quality however overuse undermines regeneration and results in ecological degradation respectively.

HC results in addition to EF at the global level and all income groups. An increase of 1 percent in HC increase EF by 1.25529, 0.208659, 1.18898, 1.48042, and 1.21295 percent in global, high income, upper middle-income, lower middle-income, and low-income groups. These findings are in line with Saleem et al. (2019) who supported environmental deterioration because of HC. The HC has favorable effects on EG and that becomes the reason for overconsumption of resources and deterioration of the environment. Our finding contrasts with Iqbal et al. (2021) who reported improvement in environmental quality across different income groups due to HC as HC increases knowledge and skills and helps in innovation and use of modern technologies to combat emissions. Furthermore, they also reported that HC leads to a decline in costs of implementing advanced pollution control technologies. Yao et al. (2019, 2020) also reported that HC support the use of green technologies and energy efficiency which leads to a decline in energy consumption thereby enhancing environmental quality. Zen et al. (2014) also reported that HC promote recycling activities thus supporting environmental sustainability. The findings obtained from DOLS are similar to FMOLS.

Table 7: FMOLS and DOLS Results

FMOLS	Variablee	**GP (118)**	**HIP (45)**	**UMIP**	**LMIP**	**LIP (10)**
	LEG	-0.1345*** (0.028617)	-0.44084*** (0.089847)	-0.1681*** (0.045355)	0.13529*** (0.046753)	-0.060499 (0.065838)
	LEC	0.48714*** (0.032025)	0.802529*** (0.066474)	0.56387*** (0.040585)	0.18122*** (0.049576)	-0.14902* (0.093247)
	LUP	0.1681*** (0.055051)	-0.00547*** (0.001729)	0.38607*** (0.102050)	0.1948*** (0.064339)	0.001127 (0.145417)
	LGI	0.34426*** (0.062681)	0.703367*** (0.201003)	0.092705 (0.074393)	0.22563*** (0.082012)	0.77556*** (0.136151)
	LFD	0.022065* (0.012632)	0.0000028	0.06156*** (0.018770)	-0.0178 (0.015035)	0.019519 (0.031028)
	LNR	-0.00004 (0.007182)	0.010489*** (0.001419)	-0.003025 (0.009880)	0.03586*** (0.012200)	0.08365*** (0.027774)
	LHC	1.25529*** (0.078057)	0.208659*** (0.050681)	1.18898*** (0.106725)	1.48042*** (0.103039)	1.21295*** (0.265306)
	Obs	2777	997	692	874	200
DOLS	**LEG**	-0.053255 (0.048268)	-0.166791* (0.126833)	-0.20776** (0.103848)	0.2017*** (0.073237)	-0.43545** (0.192825)
	LEC	0.5326*** (0.053094)	0.768115*** (0.127247)	0.48248*** (0.070244)	0.18604** (0.072234)	0.332954* (0.193338)
	LUP	-0.056868 (0.103648)	-0.002873* (0.002127)	0.255029 (0.343860)	0.43972*** (0.114490)	0.164015 (0.215910)
	LGI	0.4497*** (0.129686)	1.054956*** (0.219936)	0.288680* (0.202754)	-0.02023 (0.152563)	-0.014676 (0.350425)
	LFD	0.014989 (0.019159)	-3.27E-05 (0.000292)	0.109017** (0.043922)	-0.014088 (0.020501)	0.126564* (0.066949)
	LNR	0.020215 (0.013541)	0.014851*** (0.001664)	0.004921 (0.022491)	0.04195** (0.018095)	0.045265 (0.049218)
	LHC	1.2905*** (0.143259)	-0.025233 (0.078090)	1.30919*** (0.276904)	1.5241*** (0.165191)	0.826159* (0.443879)
	Obs	1973	641	524	692	116
Probabilities * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$; GP = global panel, HIP = high income						

Furthermore, panel techniques are used to verify the robustness of the results. The results are reported in table 8. The results obtained from POLS, RE, FE, and SGMM reveal consistent results. EG decreases EF across all income groups, EC, FD, and HC increase EF, GI, NR, and UP, providing heterogenous results across different panels respectively.

Table 8: Robustness Analysis

	Variable	GP (118)	HIP (45)	UMIP (27)
POLS	**LEG**	-0.25869*** (0.063751)	-0.78136*** (0.164967)	-1.00414*** (0.192432)
	LEC	0.115299* (0.069430)	0.485837*** (0.132444)	0.601557*** (0.163314)
	LUP	0.006253 (0.110458)	0.012619*** (0.002107)	2.510046*** (0.329703)
	LGI	-0.456792** (0.206965)	-1.0457** (0.488527)	-2.68862*** (0.473790)
	LFD	0.72134*** (0.046651)	0.005175*** (0.000696)	1.220786*** (0.090714)
	LNR	0.09133*** (0.017444)	-0.006682** (0.003157)	0.323697*** (0.050650)
	LHC	1.46460*** (0.182232)	0.861889*** (0.077484)	1.643724*** (0.480794)
	Constant	7.327427*** (0.275456)	7.388201*** (0.687525)	7.093345*** (0.650416)
	Observations	3008	1109	743
RE	**LEG**	-0.08697*** (0.016540)	-0.23107*** (0.053469)	-0.1499*** (0.032973)
	LEC	0.48089*** (0.018764)	0.781913*** (0.039147)	0.59128*** (0.029413)
	LUP	0.08471*** (0.031367)	-0.00845*** (0.000935)	0.26100*** (0.071811)
	LGI	0.29928*** (0.036106)	0.335859*** (0.108840)	0.102638** (0.053789)
	LFD	0.008738 (0.007239)	-0.00024** (0.000118)	0.06022*** (0.013632)
	LNR	-0.004658 (0.004270)	0.007078*** (0.000871)	-0.003611 (0.007139)
	LHC	1.38256*** (0.044421)	0.282966*** (0.023958)	1.22833*** (0.078210)
	Constant	5.100236*** (0.096465)	4.814586*** (0.196370)	5.1768*** (0.174565)
	Observations	3008	1109	743
FE	**LEG**	-0.0818*** (0.016603)	-0.2306*** (0.053642)	-0.14820*** (0.032988)
	LEC	0.48319*** (0.018815)	0.787945*** (0.039215)	0.589484*** (0.029431)

	LUP	0.091065** (0.031474)	-0.00857*** (0.000940)	0.257635*** (0.071871)
	LGI	0.29061*** (0.036177)	0.331496*** (0.108989)	0.102118** (0.053801)
	LFD	0.007893 (0.007243)	-0.00024** (0.000118)	0.059711*** (0.013637)
	LNR	-0.004458 (0.004276)	0.007289*** (0.000873)	-0.003941 (0.007142)
	LHC	1.38224*** (0.044498)	0.282182*** (0.024035)	1.232839*** (0.078263)
	Constant	5.22613*** (0.068864)	5.046833*** (0.149041)	5.239206*** (0.106136)
	Observations	3008	1109	743
GMM	**LEG**	-1.768*** (0.593)	-0.111 (0.553)	-2.610*** (0.901)
	LEC	3.464*** (0.906)	-0.2696 (0.750)	1.732** (0.816)
	LUP	-0.732 (0.850)	2.781** (1.469)	5.408*** (2.084)
	LGI	-3.342* (1.748)	2.304 (2.214)	-3.867** (1.893)
	LFD	1.946*** (0.610)	0.823*** (0.2479)	2.208*** (0.495)
	LNR	0.178** (0.0776)	0.1504 (0.091)	0.453* (0.256)
	LHC	2.689* (1.520)	0.8818 (2.4406)	2.212 (3.070)
	Constant	6.429*** (2.082)	2.256** (3.59)	4.692 (3.052)
	Observations	3008	1058	743
	Hausman Test	0.0006	0.0018	0.4142
	Variable	**LMIP (30)**	**LIP (10)**	
POLS	**LEG**	-0.60519*** (0.104467)	-0.38099*** (0.077836)	
	LEC	0.31952*** (0.094382)	0.810429*** (0.124852)	
	LUP	-0.42528*** (0.126275)	-2.43391*** (0.167980)	
	LGI	1.54056*** (0.243907)	4.220411*** (0.270600)	
	LFD	0.246185*** (0.056464)	-0.23842*** (0.062735)	
	LNR	0.147245***	-0.19831***	

		(0.038706)	(0.047628)	
	LHC	-0.15919 (0.189815)	-1.59417^{***} (0.245310)	
	Constant	6.24824^{***} (0.332086	3.411987^{***} (0.543468)	
	Observations	928	2230	
RE	**LEG**	0.16511^{***} (0.027032)	-0.08169^{**} (0.040726)	
	LEC	0.19572^{***} (0.028456)	-0.01587 (0.059709)	
	LUP	0.20162^{***} (0.036934)	-0.036649 (0.093309)	
	LGI	0.19191^{***} (0.047524)	0.77869^{***} (0.086637)	
	LFD	-0.0241^{***} (0.008778)	0.015991 (0.019498)	
	LNR	0.03297^{***} (0.007101)	0.042382^{**} (0.017070)	
	LHC	1.46724^{***} (0.060777)	1.19175^{***} (0.168841)	
	Constant	5.37019^{***} (0.134729)	5.83666^{***} (0.221223)	
	Observations	928	223	
FE	**LEG**	0.168564^{***} (0.027089)	-0.070163^{*} (0.041019)	
	LEC	0.193352^{***} (0.028587)	-0.03125 (0.060121)	
	LUP	0.204782^{***} (0.037049)	-0.026902 (0.094132)	
	LGI	0.185716^{***} (0.047569)	0.762757^{***} (0.086919)	
	LFD	-0.024362^{**} (0.008785)	0.015656 (0.019541)	
	LNR	0.032824^{***} (0.007105)	0.043907^{**} (0.017128)	
	LHC	1.472353^{***} (0.060953)	1.225326^{***} (0.170786)	
	Constant	5.519856^{***} (0.096329)	5.766073^{***} (0.181075)	
	Observations	928	223	
GMM	**LEG**	-1.829^{*} (1.079)	-0.569 (1.991)	
	LEC	1.432	-1.750^{***}	

		(0.890)	(0.549)	
	LUP	-1.449 (1.571)	5.649 (10.55)	
	LGI	3.349 (2.042)	7.621*** (0.618)	
	LFD	-1.449 (1.571)	1.071 (1.692)	
	LNR	0.324** (0.152)	-0.339 (0.274)	
	LHC	-1.074 (1.428)	-28.60 (37.83)	
	Constant	-1.829* (1.079)	-4.158 (18.92)	
	Observations	928	223	
	Hausman Test	0.0155	0.0383	

Probabilities * p < 0.1, ** p < 0.05, *** p < 0.01
Standard error in parenthesis
GP = global panel, HIP = high income panel
UMIP = upper middle-income panel
LMIP = lower middle-income panel
LIP = low-income panel

4.6 Expanded analysis

Table 9 presents the result obtained from the expanded analysis. The result shows that EG has a positive effect on EF in B&R and G7 countries while decreasing EF in ,OECD countries. EG has an insignificant effect on EF in BRICS and MENA EC has a positive effect on EF for all panels, while the effect is more profound in the case of OECD economies. UP has a a positive effect on EF, B&R and BRICS countries while UP has a a negative impact on EF in G7, OECD countries. The impact of UP on EF is insignificant in MENA. GI increases EF across all panels. FD increases EF in BRICS, G7, and MENA while in the case of B&R and OECD countries the effect of FD on EF is insignificant. NR results in higher EF in B&R countries while an insignificant effect of NR is observed in other panels. HC increases EF across all panels except G7 economies where HC declines EF.

Table 9: Expanded Analysis Results

FMOLS	Variable	B & R (25)	BRICS (5)	G7 (7)	MENA (13)	OECD (37)
	LEG	0.097202* (0.065914)	-0.066521 (0.057764)	0.458625*** (0.093335)	-0.176824 (0.181433)	-0.145094* (0.077687)
	LEC	0.489226*** (0.060233)	0.657419*** (0.107147)	0.241001*** (0.074111)	0.360050*** (0.153882)	0.766778*** (0.052280)
	LUP	0.468602*** (0.088415)	0.313346** (0.142600)	-0.854949** (0.369423)	-0.083275 (0.410291)	-0.581937*** (0.187242)
	LGI	0.236506** (0.116949)	0.179307** (0.086600)	0.558937*** (0.222582)	1.583407*** (0.311075)	0.474250*** (0.145053)
	LFD	-0.010849 (0.023108)	0.113354*** (0.027065)	0.090367*** (0.036138)	0.111646** (0.049139)	-0.026074 (0.021893)
	LNR	0.027244** (0.012167)	0.015039 (0.018007)	0.006657 (0.009729)	-0.007137 (0.021464)	0.007190 (0.007096)
	LHC	0.928398*** (0.126674)	0.515100*** (0.109137)	-1.815550*** (0.306885)	0.779056** (0.358487)	0.868903*** (0.242395)
	Observ	594	174	211	369	804
DOLS						
	LEG	0.280014*** (0.078402)	-0.088245 (0.167348)	0.514861*** (0.170919)	-1.233248*** (0.215621)	0.111403 (0.179584)
	LEC	0.175411*** (0.072304)	0.669564*** (0.183927)	0.435985*** (0.132072)	0.729225*** (0.210364)	0.611296*** (0.112441)
	LUP	0.372649*** (0.118728)	0.187556 (0.289163)	0.132485 (0.544691)	-0.199816 (0.378629)	0.161672 (0.280398)
	LGI	0.074668 (0.151085)	0.355652** (0.158050)	0.681362** (0.320409)	1.954898*** (0.356314)	0.923786*** (0.215936)
	LFD	0.037356* (0.026100)	0.070060* (0.045010)	0.104106** (0.051594)	0.213973*** (0.037796)	0.034334 (0.041186)
	LNR	0.020301 (0.017853)	-0.008140 (0.024894)	0.020918 (0.015585)	0.052142*** (0.026334)	0.010162 (0.012850)
	LHC	1.108024*** (0.171219)	0.393251* (0.220832)	-2.637608*** (0.523934)	0.926821*** (0.364593)	-1.252206*** (0.452938)
	Observ	475	149	161	287	492

Probabilities * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Standard error in parenthesis

B&R = Belt and road countries

BRICS = Brazil, Russia, India, China, and South Africa

G7 = Group of Seven countries

MENA = Middle East and North Africa

OECD = Organization for Economic Co-operation and Development

5. Conclusion

This study addressed the gap in the literature on investigating the relation among EF, EG, EC, UP, GL, FD, NR, and HC for the global panel and across different income groups for the period 1971 to 2018. EG results in a decrease in EF and hence improves the environment for all panels other than the lower-middle-income panel. EC increases EF and exerts pressure on environmental quality across all panels except low-income countries where EC does not cause environmental degradation. For the high-income group, UP supports improved environmental quality through a decline in EF due to planned UP while unplanned UP degrades the environment by an increase in EF as in other panels. GL has a favorable effect on EF. GL boosts consumption and production, thereby increasing use for energy and NR and causing pressure on the environment by increasing EF (Sharif et al., 2019). FD increases EF and hence degrade the environment because credit availability boosts industrial expansion and production thus causing environmental degradation for all panels except lower-middle-income economies where FD increases research and development, promotes clean technologies thereby improving the environment. NR increases EF and hence compromises environmental quality in high-income panels, low-income panels, and lower-middle-income panels due to inefficient use. For global and upper-middle-income countries NR improves environmental quality by decreasing EF through an increase in the natural capacity of land and water quality. HC increases EF and degrades the environment due to the higher use of technologies and financial capital.

5.1 Contribution of the Study:

Due to global warming and degrading environmental quality, the economies around the globe are taking measures and devising policies to support environmental sustainability. In this regard, the present study provides insight into the impact of globalization, financial development, natural resources, and human capital on ecological footprint while controlling for economic growth, energy consumption, and urbanization. To the best of our knowledge literature lacks evidence regarding the impact of globalization, natural resource, and human capital on EF across different income groups which is provided by this study. Controlling for the impact of globalization is necessary as the world is a global village and countries produce goods and services and engage in trade, according to their comparative advantage. As natural resources are finite therefore this study controlled for its impact along with human capital. The study examined the long-run relationship using FMOLS and DOLS while endogeneity problems are also covered by this study by applying SGMM. Furthermore, for a deeper understanding, the study examined the impact of globalization, financial development, natural resources, and human capital on EF in B& R, BRICS, G7, MENA, and OECD economies as well.

5.2 Theoretical Contribution and Policy Implications:

The findings of this study support the “pollution haven hypothesis” which postulates adverse effects of globalization (trade/FDI) on environmental quality in the presence of weak environmental regulations to attract foreign investment (Majeed and Mazhar, 2019b). Economic growth exerts heterogeneous effects on environmental pollution, validating the implications of the “environmental Kuznets curve (EKC)”. However, the expected outcome for low-income countries is inconsistent with the EKC framework. In the case of high-income countries, “ecological urbanization theory” is validated which postulates that urbanization supports sustaining the environment by increasing income and environmental awareness, encouraging people to adopt eco-friendly lifestyles (Majeed and Tauqir, 2020). In a global setting our results are also consistent with “ecological modernization theory” which implies that in the earlier stages of modernization, ecological quality disrupts and tends to improve at later stages when clean technologies are used.

The policy recommendations include the promotion of globalization to support the flow of green technologies and research and development that can promote environmental quality. As HC boosts EF, therefore, promoting awareness regarding the use of resources efficiently can contribute to a decline in EF. As countries and regions differ in their policies related to globalization and HC accumulation, therefore, conditions of the economies should be considered before designing policies as “one size does not fit all”.

5.3 Limitations of the Study

The study was not able to examine the impact of globalization, financial development, natural resources, human capital, and urbanization on individual components of ecological footprint including built-up land, carbon, cropland, fishing ground, forest products, and grazing land, which can be focused by the future studies. This will help in building deeper insights regarding the most affected component of environmental quality in the era of globalization and financial development respectively. The study did not focus on dependence among the countries which can be examined by future studies.

5.4 Future Study Directions

Future researchers can focus on regional and country-specific analysis that will provide deeper insights into how globalization and HC change environmental quality. Asymmetries in the relationship can also undermine true relationships among the variables, therefore, non-linear analysis can be conducted to overcome this issue. Furthermore, the impact of structural breaks can also be examined, that how an economic downturn can lead to change in the observed relationships respectively. Future research can focus on how biocapacity is affected by globalization and financial development.

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