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Combining Economic Growth and Financial Development in Environment-Health Nexus

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Abstract
This study examines the impact of monetary developments on environmental quality and economic growth. We utilize ARDL/PMG models to study twelve climatically vulnerable countries from 1996 to 2018. We find that a 1% increase in real GDP and domestic credit harms the environment by 0.827% and 0.220%, respectively. However, savings improve environmental excellence by 0.373%. A 1% environmental degradation decreases human health by 0.317%; consequently, economic growth declines by 1.102%. Good governance emerges as a key solution, with a 1% improvement in public institutions mitigating the adverse impact of real GDP on the environment by 0.777%. Redirecting 1% of loans to eco-friendly projects improves the environment by 1.311%. Dumitrescu-Hurlin and PVAR Granger tests support these findings.

Keywords: Environmental degradation index, human health index, PCA technique, panel ARDL method, good governance, high-risk countries

JEL Classification: O44, Q51, C33

1. Introduction

Environmental excellence is a key component of economic prosperity and good health, while a degraded environment is a byproduct of economic growth and financial development (Su *et al.*, 2023; Iorember *et al.*, 2020). Anthropogenic activities such as the utilization of natural, energy and

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financial resources (Ahakwa, 2023; Raihan *et al*., 2023; Kirikkaleli *et al*., 2022; Javed *et al*., 2023) for monetary growth (Kucheryavyy *et al*., 2023; Marfatia, 2023; Kirikkaleli and Adebayo, 2022) have significantly diminished environmental quality by polluting water, soil and air (Singh *et al*., 2022). Consequently, the severity of climate-related risks has escalated, posing a grave threat to human well-being (Akbar *et al*., 2021; Dong *et al*., 2021).

For the last three decades, CO_2 emissions contribute 60% to rising global temperature and the toxicity of contaminants in the air, which are associated with climatic instability (Dubo *et al*., 2023; Zhou *et al*., 2023). As a result, the world has witnessed many disastrous consequences such as Australia's bushfires from 2019 to 2020[1] (Jegasothy *et al*., 2023), the 2021 forest fires in Turkey[2] (Yilmaz *et al*., 2023), the 2021 flood in China[3], and the floods of 2010 (Shahbaz, Tiwari, Nasir, 2013) and 2022 in Pakistan[4].

Many studies have empirically confirmed a wide range of natural disasters and environmental degradation. However, the health consequences of environmental degradation, which were not supposed to be unnoticed, have unfortunately been ignored in the existing studies of environmental economics, although the detrimental influence of environmental degradation on health is as bigger as the other concerns (Carré *et al*., 2017). In 2019 alone, air pollution caused 21%, 17% and 15% of the lung, brain damage, and heart-associated demises, respectively. Furthermore, 13% of diabetes, 13% of breathing contagions and 7% of newborn deaths due to a deteriorated environment were reported[5]. A degraded environment damages reproductive health[6] (Gaskins *et al*., 2021), reduces life expectancy (Majeed *et al*., 2020), and increases mortality among the elders (Zeng *et al*., 2010) as well. The situation infers that the implication of improving living standards through economic growth today diminishes the foundation of future life, *i.e.*, health due to poor weather conditions (Bouchoucha, 2020). Moreover, an unhealthy population contributes less to national output (Misango, 2022). In light of the discussed facts, if environmental degradation is not alleviated, this spiral can continue by creating a cycle of environmental degradation, health consequences and economic decline. In this vein, the objectives of this study set as achievable are to:

(1) empirically analyse the influence of real GDP, gross domestic savings and domestic credit on environmental degradation;

1 https://www.worldwildlife.org/stories/3-billion-animals-harmed-by-australia-s-fires

2 https://reliefweb.int/report/turkey/turkey-forest-fires-situation-report-manavgat-03-august-2021

3 https://www.scmp.com/topics/flooding-china

4 https://www.worldbank.org/en/news/press-release/2022/10/28/pakistan-flood-damages-and-economic-losses-over-usd-30-billion-and-reconstruction-needs-over-usd-16-billion-new-assessme

5 https://www.unep.org/interactive/air-pollution-note/?gclid=Cj0KCQjwr82iBhCuARIsAO0EAZwnmrIUouHsd_qExjCDHDEe4J3O3GLiRv5qKg07xamiQrPMegGkVjwaAvbOEALw_wcB

6 https://www.hsph.harvard.edu/news/hsph-in-the-news/air-pollution-fertility/

(2) examine the impact of environmental degradation on human health;
(3) analyse the nexus between human health and economic growth; and
(4) examine the role of good governance as a cure for environmental degradation.

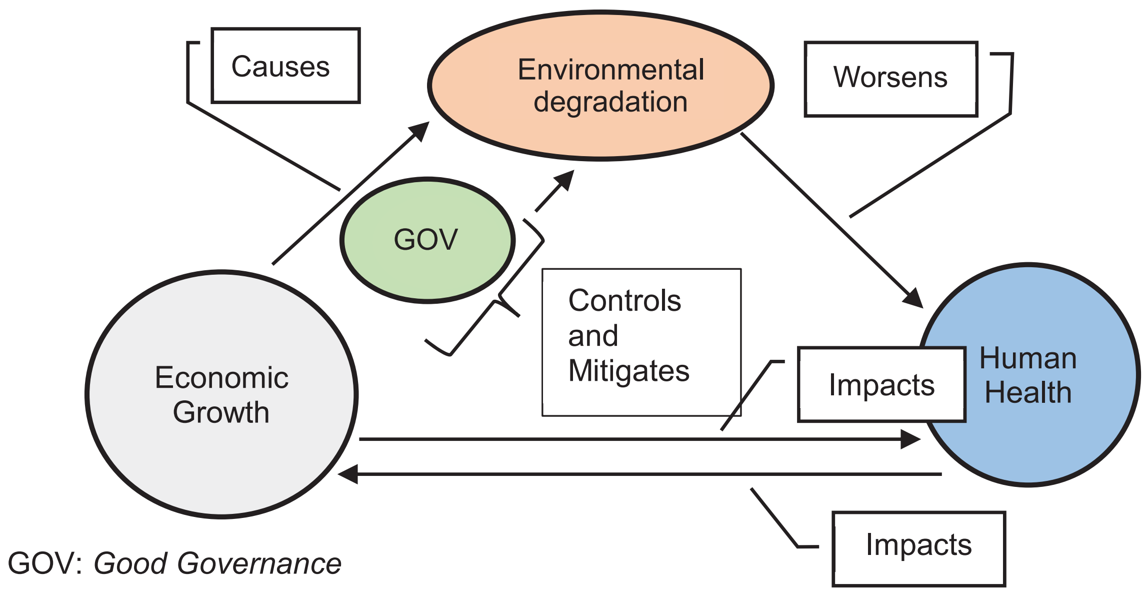
The empirical findings of this study contribute to the existing body of knowledge by providing evidence that supports the assertion of the Paris Agreement, that governments can address environmental issues. This study introduces a novel approach and transforms the measures of environment, governance and health into respective indices. The current study incorporates a range of variables on health and environment that in existing studies have been tested individually or ignored altogether.

2. Literature Review

To address global climatic risks and promote sustainable development, nations need effective policies (Adebayo, 2023). Considering this fact, Adebayo (2023) studied BRICS countries from 1990 to 2018 and found that sustainable energy and economic diversification benefit the environment. Conversely, reliance on monetary growth driven by fossil fuels harms the environment. Adebayo *et al*. (2023a) studied MINT countries from 1990–2018 and found that monetary growth, trade liberalization, political risk and urban population growth harm the environment. The study also showed that renewable energy improves the environment. The findings are robust as Adebayo *et al*. (2023a) used CS-ARDL, CCEMG and AMG methods. A study driven by Finland's strong commitment to carbon neutrality by 2035 through adopting a circular economic model, Alola *et al*. (2023) conducted a study for the period 1990–2020, and found that monetary progress hinders sustainable development, but innovative technologies can significantly improve environmental quality. A 184-country study for the period 1990–2017 found energy consumption harmful to the environment, while financial development had no significant impact (Khan *et al*., 2021). Finances could enhance economic activities by reducing credit limits, leading to environmental degradation (Adebayo *et al*., 2021; Zeqiraj *et al*., 2020). On the other hand, finances could improve environmental quality by redirecting investments into green economic activities (Hamdan *et al*., 2018). Examined results of a Southeast Asian study revealed that a sustainable environment is in favour of human health and economic growth (S. A. R. Khan *et al*., 2020b). This is because the mental and physical state of workers may affect the national output (Zhao *et al*., 2021). A South Asian study for the period 1991–2019 found a positive significant impact of health on economic output (Mehmood *et al*., 2020). Likewise, from 1985 to 2018 life expectancy showed a significant impact on GDP in Kenya (Misango, 2022). The relationships among the variables of concern are supported by some existing theories. In this context, the limits to growth (LTG) theory asserted that industry-driven economic growth leads nations towards extreme weather exposures (Meadows *et al*., 1972). While the environmental Kuznets curve (EKC) philosophy asserts that economic growth degrades the environment at the beginning, but after getting to a certain level, it eventually reverses the hazardous effects (Beyene *et al*., 2020). However, it is still uncertain whether the environment will indeed improve. Meanwhile, global environmental governance (GEG) theory suggests that all stakeholders should respond collectively to environmental issues by developing organizations, policies and financial frameworks[7]. However, the democratic principles of GEG are reluctant to address the issues of leadership and economic barriers (Gunderson, 2018). Therefore, by following contemporary theorists, we incorporate world governance indicators as an interactive term with variables causing environmental degradation (Yasmeen *et al*., 2018). By doing so at the national level, countries can formulate institutional excellence-based climate action strategies that will ultimately make valuable contributions at the global level.

By adopting a multidisciplinary approach, this study fills the research gap by scrutinizing those monetary dynamics which pose potential threats to environmental quality. Once the harmful dynamics are identified, this study deals with them through good governance. As a result, the parallel concerns of health in environmentally vulnerable nations are also moderated. In light of the discussed literature, a theoretical model of our study is shown in Figure 1 below.

Figure 1: Theoretical model of study



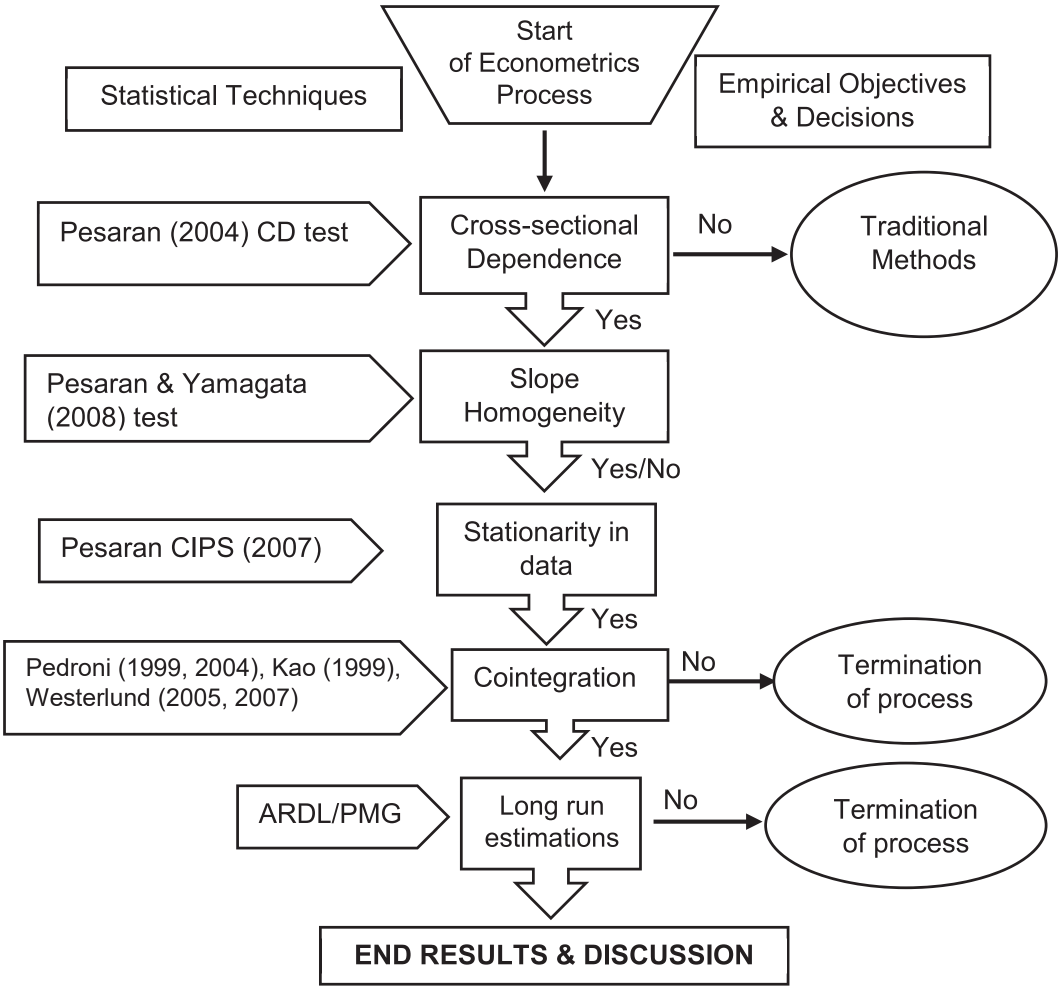
Source: Authors' own preparation

7 https://sustainabledevelopment.un.org/index.php?page=view&type=400&nr=195&menu=35

3. Information and Techniques

This study has a thorough methodology as illustrated in Figure 2.

Figure 2: Methodological flow



Source: Authors' own preparation

3.1 Datasets and variables

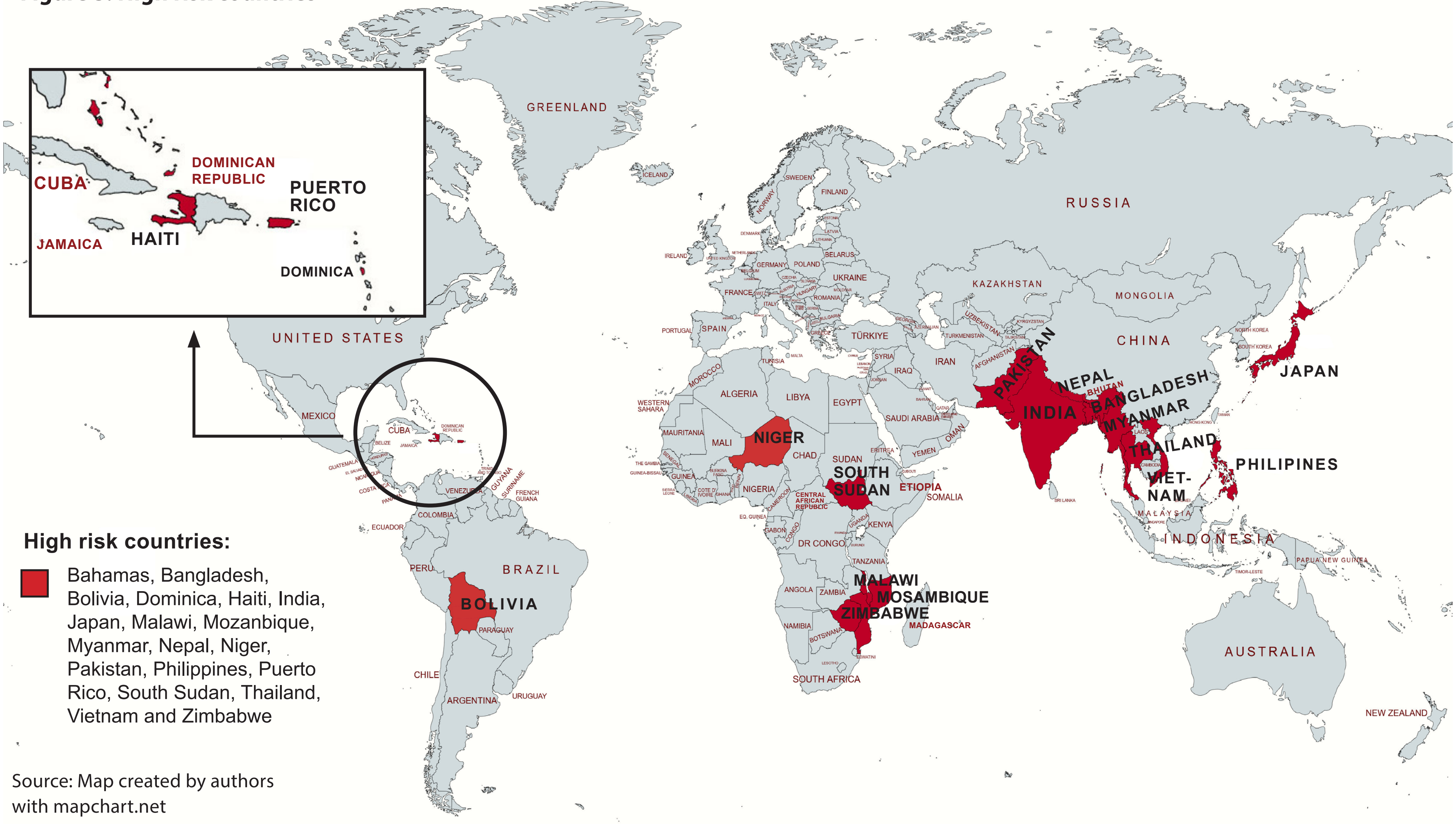
The top ten countries of the Global Climate Risk Index (GCRI), that were ranked as environmentally vulnerable countries during 1999–2018, 2000–2019 and in 2019, are selected for this study. For an impartial analysis of the health concerns, the sample countries which scored below 50 in the Global Health Security Index (GHSI) are included. The study period from 1996 to 2018 is guided by data availability. Thus, nineteen countries are selected (see list A of Table 1 and Figure 3), from which twelve countries (see list B of Table 1) are finalized and named as high-risk countries (HRCs). The missing values are treated with the interpolation technique (Bhuiyan *et al*., 2018). Table 2 explains a list of variables of concern, their expected influences and data sources. The data sources and measurement units of gathered data are different; thus, before estimating the composite indices, the min-max normalization technique is applied (Singh *et al*., 2020). Besides that, the natural log (ln) of RGDP, GDS and DCPS is also calculated. The nexuses of the accepted variables are illustrated in Figure 4.

Table 1: High-risk countries (HRCs)

A.	B.
Puerto Rico[a], Myanmar[a], Haiti, Philippines, Pakistan, Vietnam, Bangladesh, Thailand[b], Nepal, Dominica[a], Mozambique, Bahamas, Zimbabwe, Japan[b], Malawi[a], India, South Sudan[a], Niger, and Bolivia	Haiti, Philippines, Pakistan, Vietnam, Bangladesh, Nepal, Mozambique, Bahamas, Zimbabwe, India, Niger, and Bolivia.

[a] Not studied due to insufficient data., [b] Health scores more than 50.
Source: GCRI (2020, 2021)

Figure 3: High risk countries



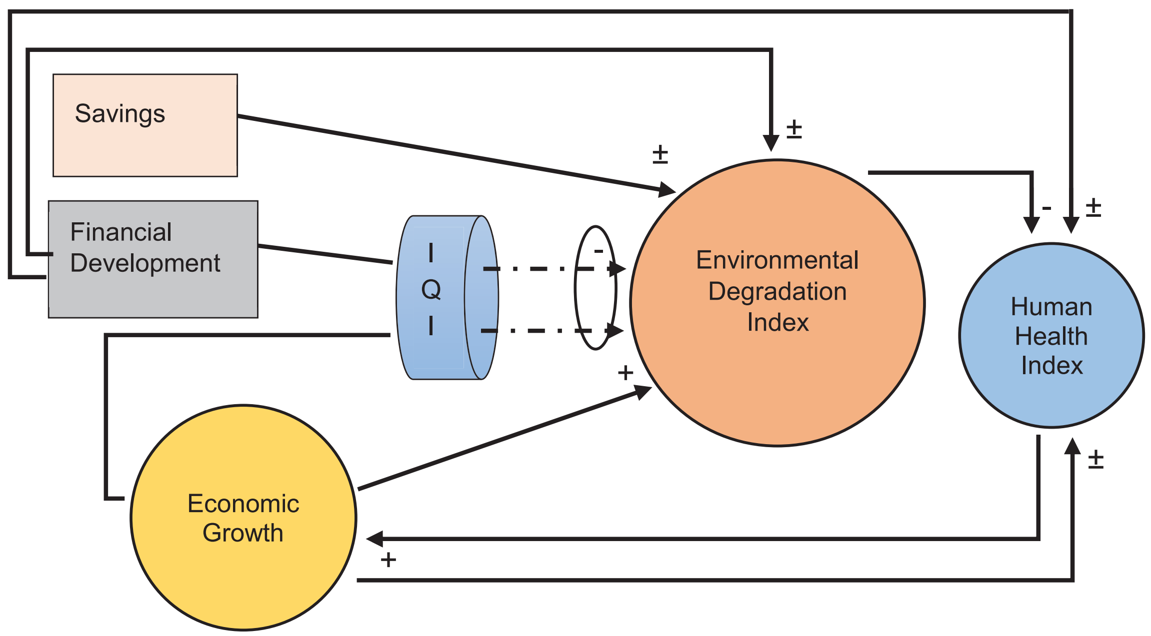
Source: Map created by authors with mapchart.net

Table 2: List of variables and their definitions, symbols, expected impacts and data sources

Variables	Measures		Symbol	Expected impact	Data sources
Response and explanatory variable (Human Health Index) consists of:		Index	*HHI*	(+)	Created by the authors
Life expectancy at birth	Total years		*LEX*		World Development Indicators (2021)
Fertility rate	Total births per woman		*FRT*		
Survival to age 65 female	Percentage of cohort		*SOF*		
Survival to age 65 male	Percentage of cohort		*SOM*		
Response and explanatory variable (Environmental Degradation Index) consists of:		Index	*EDIN*	(–)	Created by the authors
Total greenhouse gas emissions	kt of CO_2 equivalent		*TGHG*		World Development Indicators (2021)
Ecological Footprints	Global hectares per person		*ECFP*		Global footprint network
Temperature	Annual mean temperature in degrees Celsius		*TEMP*		Climate Change Knowledge Portal
Precipitation	Climatic Research Unit observed		*PRPN*		
Explanatory Variables					
Real GDP	GDP constant 2015 US$	----	*RGDP*	(+)	World Development Indicators (2021)
Gross domestics savings[1]	Ratio of GDP	----	*GDS*	(+/–)	
Domestic credit to the private sector by banks	Ratio of GDP	----	*DCPS*	(+/–)	
Institutional Quality Index includes the following world governance indicators:		Index	*IQI*	---------	Created by the authors
Government Effectiveness	Perception of excellence in civil services		*GEFF*		World Governance Indicators (2020)
Regulatory Quality	Frame and apply thorough rules		*RQTY*		
Control of Corruption	Degree to which civic authority is used for non-public advantages		*CCOR*		
Rule of Law	Community confidently relies on rules and abides by formulated laws generally		*ROL*		
Interaction Terms					
Real GDP × *IQI*	Real GDP multiplied by institutional quality index	----	*RGIN*	(–)	Calculated by authors
Domestic credit to private sector by banks × *IQI*	Internal loan to private enterprises by financial institutions multiplied by institutional quality index	----	*DCIN*	(–/+)	Calculated by authors

Source: Authors' own preparation

Figure 4: Illustration of relationships and impacts of variables



Source: Authors' own preparation

3.2 Statistical techniques

Firstly, the principal component analysis (PCA) technique is applied to the normalized datasets (A. Khan *et al*., 2020a) to estimate environmental degradation, human health and institutional quality indices. PCA enhances data interpretability by focusing on key variables in original datasets (Hotelling, 1933; Pearson, 1901). This technique usually generates various principal components (PC_1, PC_2 …, PC_n), where the first component enlightens a higher percentage of the variance than the others. The first component is obtained by multiplying the data matrix into variable loadings.

$$PC_1 = X \times V \tag{1}$$

where PC is the principal components, X is the data matrix and V is loadings.

Overlooking cross-sectional dependency can distort econometric analysis (Wang *et al*., 2019). Therefore, this study implements Pesaran's 2004 CD test, estimated as follows (Pesaran, 2021; Li *et al*., 2020):

$$CD_P = \sqrt{\frac{2T}{N(N-1)}}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\hat{\rho}_{ij}\right) \sim N(0,1) \tag{2}$$

where $\hat{\rho}_{ij}$ is the coefficient of pairwise correlation statistics between residuals, obtained through ADF regressions, $i = 1, 2, …, N$ is the cross-section and $t = 1, 2, …, T$ is the time element.

This study employs delta tests of slope homogeneity, which have standardized normal dispersions (Qin *et al*., 2021; Li *et al*., 2020; Pesaran *et al*., 2008). Delta statistics are valid for large and small samples and calculated as follows (Pesaran *et al*., 2008):

$$\tilde{\Delta} = \sqrt{N}\left(\frac{N^{-1}\tilde{S}-k}{\sqrt{2k}}\right) \tag{3}$$

$$\tilde{\Delta}_{ADJ} = \sqrt{N}\left(\frac{N^{-1}\tilde{S}-E_{(\tilde{z}_{iT})}}{\sqrt{Var\left(\tilde{z}_{iT}\right)}}\right) \tag{4}$$

H_0: Cross-sectional slopes are homogenous

H_1: The slopes are heterogeneous

where $\tilde{\Delta}$ and $\tilde{\Delta}_{ADJ}$ indicate delta tilde and biased adjusted delta tilde, respectively, N is for the cross-sections, $\tilde{S}$ is the measure of the Swamy 1970 test, and k is exogenous regressors.

Testing unit roots is a prerequisite for panel co-integration models (Le *et al*., 2020). We adopt a second-generation CIPS unit root test (A. Khan *et al*., 2020a). Pesaran's 2007 test improves the ADF regressions at levels and first differences and calculates the CIPS as follows (Pesaran, 2007; Wang *et al*., 2019):

$$CIPS\left(N,T\right) = \frac{1}{N}\sum_{i=1}^{N} t_i\left(N,T\right) \tag{5}$$

Null hypothesis for all (i = 1, 2, …, N and t = 1, 2, …, T) is H_0: $\beta_i \geq 0$.

Alternative hypothesis for all (i = 1, 2, …, N and t = 1, 2, …, T) is H_1: $\beta_i < 0$, where $t_i(N, T)$ is a statistic for i-th cross-section.

To ensure long-run associations, this study adopts Kao (1999), Westerlund (2005) and Pedroni (1999, 2004) tests of cointegration. Moreover, the study also applies Westerlund's 2007 cointegration test, which consists of between groups (G_t), among groups (G_a), between panels (P_t), and among panels (P_a) tests (Le *et al*., 2020). It suggests null: no co-integration for at least one cross-section and no co-integration for all cross-sections (Ahmad *et al*., 2020). The group means (G_t, G_a) and panel statistics (P_t, P_a) are specified below:

$$G_t = \sum_{i=1}^{N} \frac{\frac{\hat{a}_i}{SE\left(\hat{a}_i\right)}}{N} \tag{6}$$

$$G_a = \sum_{i=1}^{N} \frac{\frac{T\hat{a}_i}{SE(1)}}{N} \tag{7}$$

$$P_t = \frac{\hat{a}}{SE(\hat{a})} \text{ and } P_a = T\hat{a} \tag{8}$$

where the conventional standard error of $\hat{a}_i$ is $SE(\hat{a})$and the parameter of error is calculated as $P_a = T\hat{a}$, which shows the percentage-wise annual error rectification.

4. Econometric Modelling

This study utilizes the panel ARDL long-run PMG model because the model is also useful when data are stationary at I(0), I(I), or both (Ahmed *et al*., 2021; Pesaran, 1995). Thus, by following the footsteps of Baloch *et al*. (2021), Shahbaz, S. Khan, Tahir (2013) and Pesaran *et al*. (1999), this study estimates econometric models as follows:

ARDL-PMG $$EDIN_{1_{it}} = a_i \sum_{j=1}^{k} b_{2it} lnRGDP_{it-j} + \sum_{j=0}^{k} b_{3it} lnGDS_{it-j} + \sum_{j=0}^{k} b_{4it} lnDCPS_{it-j} + er_{1it} \tag{9}$$

ARDL-PMG Model 2(10) $$HHI_{1_{it}} = ɐ_i \sum_{j=1}^{k} \vartheta_{2it} lnRGDP_{it-j} + \sum_{j=0}^{k} \vartheta_{3it} lnDCPS_{it-j} + \sum_{j=0}^{k} \vartheta_{4it} EDIN_{it-j} + ŋ_{1it} \tag{10}$$

ARDL-PMG Model 3 $$lnRGDP_{1_{it}} = ɷ_{i} \; {}_i\sum_{j=1}^{k} Ѣ_{2it} HHI_{it-j} + ơ_{1it} \tag{11}$$

Lagged values are taken for all the dependent variables in the models (Egbetokun *et al*., 2020) and the theoretic explanations of the symbols are given below.

1. If the values of b_2, b_3, b_4 are negative or tend to be negative and <0, economic growth, savings and financial development are good for the environment, but positive values infer otherwise.
2. The impact of economic growth and financial development is considered favourable for human health if the values of ϑ_2 and ϑ_3 are positive or tend to be positive, but a negative value of ϑ_4 represents harmful impact.
3. Human health is considered good for economic growth when $Ѣ_2$ is a positive number, whereas a negative value determines inverse impact.

To investigate good governance as a solution to the issues, we incorporate *IQI* as an interaction term (see Table 2 above) by following Bouchoucha (2020) and Hayat (2019) and Model 4 is constructed as follows:

ARDL-PMG Model 4

$$EDIN_{2_{it}} = q_i \sum_{j=1}^{k} d_{2it} RGIN_{it-j} + \sum_{j=0}^{k} d_{3it} DCIN_{it-j} + E_{1it} \tag{12}$$

4. When d_2 and d_3 result negative or moving to 0, institutional quality plays an extensive role in making peace with nature.

In the models, *ln* is the natural logarithm, a_i; ɐ$_i$; Ꝏ$_i$ and q_i represent intercepts, er_{1it}; Ꝺ$_{1it}$, ᘐ$_{1it}$ and E_{1it} , are error terms, b_{2it}; b_{3it}; b_{4it}; ϑ_{2it}; ϑ_{3it}; ϑ_{4it}; Ъ$_{2it}$; d_{2it}, and d_{3it} are estimated parameters of relative proxies.

5. Empirical Results and Discussion

5.1 PCA results

Table 3 illustrates the results of the Human Health Index, in which the first principal component (PC_1) displays the highest eigenvalue of 3.622 (see Figure 5) and explains 90.542% of the variance. The eigenvalue is a factor by which a principal component is scaled. Since PC_1 shows reasonably the highest percentage of variance in the original dataset and possesses the highest eigenvalue, the first PC is accepted as the Human Health Index. After orthogonal rotation, PC_1 shows 98.8%, 98%, 96.9%, and −86.3% of correlation with survival up to the age of 65 years in females, survival up to the age of 65 years in males, life expectancy, and fertility, respectively. The Kaiser–Meyer–Olkin (KMO) result shows 0.776/1 of sampling competence and Bartlett's test of sphericity is valid at a *p*-value of 0.000 with X^2 = 2236.334. The results of the Environmental Degradation Index (see Table 4) illustrate that PC_1 holds an eigenvalue of 1.676 (see Figure 6) and explains 41.89% of the variance, which is comparatively higher than the other components. That is why we accept PC_1 as the Environmental Degradation Index. The rotated PC_1 demonstrates 89.2%, 89.8%, 17.8% and 10.4% influence on *TGHG*, *ECFP*, *TEMP* and *PRPN*, respectively. Moreover, KMO is 0.482, and the sphericity is valid at the 0.000 level of significance with a chi-square of 161.624. Findings of the Institutional Quality Index reveal that PC_1 holds an eigenvalue of 2.370 (see Table 5 and Figure 7) and explains 59.256% of the variance; thus, the first principal component is considered the Institutional Quality Index. Loadings show a linear combination of original variables to PC_1. KMO is 0.678 at a 0.000 significance level with a X^2 of 308.479.

Table 3: PCA estimations of health dynamics

<table>
<tr><th>Component</th><th>Eigenvalue</th><th>Difference</th><th>Variance (%)</th><th colspan="3">Cumulative variance (%)</th></tr>
<tr><td>C_1</td><td>3.622</td><td>3.300</td><td>90.542</td><td colspan="3">90.542</td></tr>
<tr><td>C_2</td><td>0.322</td><td>0.269</td><td>8.041</td><td colspan="3">98.583</td></tr>
<tr><td>C_3</td><td>0.052</td><td>0.048</td><td>1.304</td><td colspan="3">99.887</td></tr>
<tr><td>C_4</td><td>0.005</td><td colspan="1">–</td><td>0.113</td><td colspan="3">100.000</td></tr>
<tr><td>Indicator</td><td>PC_1</td><td colspan="2">Kaiser–Meyer–Olkin</td><td colspan="3">Bartlett's test</td></tr>
<tr><td>LEX</td><td>0.969</td><td colspan="2" rowspan="4">0.776</td><td rowspan="2">Chi-square</td><td rowspan="2">df.</td><td rowspan="2">Sig.</td></tr>
<tr><td>FRT</td><td>(0.863)</td></tr>
<tr><td>SOM</td><td>0.980</td><td rowspan="2">2236.338</td><td rowspan="2">6</td><td rowspan="2">0.000</td></tr>
<tr><td>SOF</td><td>0.988</td></tr>
</table>

Source: Authors' own calculation

Table 4: PCA estimations of environmental degradation characteristics

<table>
<tr><th>Component</th><th>Eigenvalue</th><th>Difference</th><th>Variance (%)</th><th colspan="3">Cumulative variance (%)</th></tr>
<tr><td>C_1</td><td>1.676</td><td>0.523</td><td>41.890</td><td colspan="3">41.890</td></tr>
<tr><td>C_2</td><td>1.152</td><td>0.328</td><td>28.811</td><td colspan="3">70.701</td></tr>
<tr><td>C_3</td><td>0.825</td><td>0.477</td><td>20.618</td><td colspan="3">91.319</td></tr>
<tr><td>C_4</td><td>0.347</td><td>–</td><td>8.681</td><td colspan="3">100.000</td></tr>
<tr><td>Indicator</td><td>PC_1</td><td colspan="2">Kaiser–Meyer–Olkin</td><td colspan="3">Bartlett's test</td></tr>
<tr><td>TGHG</td><td>0.892</td><td colspan="2" rowspan="4">0.482</td><td rowspan="2">Chi-square</td><td rowspan="2">df.</td><td rowspan="2">Sig.</td></tr>
<tr><td>ECFP</td><td>0.898</td></tr>
<tr><td>TEMP</td><td>0.178</td><td rowspan="2">161.624</td><td rowspan="2">6</td><td rowspan="2">0</td></tr>
<tr><td>PRPN</td><td>0.104</td></tr>
</table>

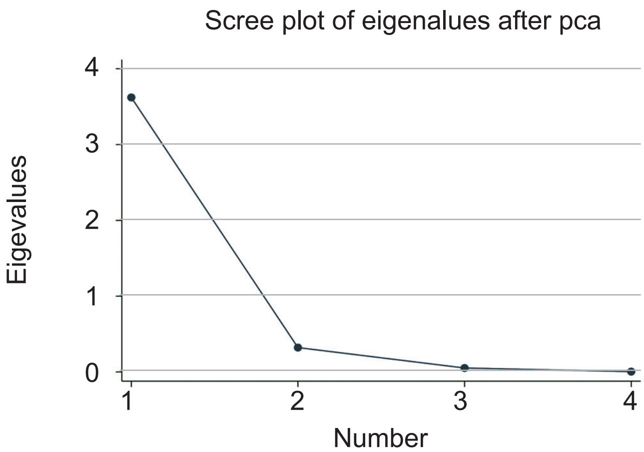
Source: Authors' own calculation

Table 5: PCA estimations of good governance features

<table>
<tr><th>Component</th><th>Eigenvalue</th><th>Difference</th><th>Variance (%)</th><th colspan="3">Cumulative variance (%)</th></tr>
<tr><td>C_1</td><td>2.370</td><td>1.676</td><td>59.256</td><td colspan="3">59.256</td></tr>
<tr><td>C_2</td><td>0.694</td><td>0.076</td><td>17.353</td><td colspan="3">76.609</td></tr>
<tr><td>C_3</td><td>0.618</td><td>0.301</td><td>15.457</td><td colspan="3">92.066</td></tr>
<tr><td>C_4</td><td>0.317</td><td>–</td><td>7.934</td><td colspan="3">100.000</td></tr>
<tr><th>Indicator</th><th>PC_1</th><th colspan="2">Kaiser–Meyer–Olkin</th><th colspan="3">Bartlett's test</th></tr>
<tr><td>GEFF</td><td>0.747</td><td colspan="2" rowspan="4">0.678</td><td rowspan="2">Chi-square</td><td rowspan="2">df.</td><td rowspan="2">Sig.</td></tr>
<tr><td>RQTY</td><td>0.840</td></tr>
<tr><td>CCOR</td><td>0.721</td><td rowspan="2">308.479</td><td rowspan="2">6</td><td rowspan="2">0.000</td></tr>
<tr><td>ROL</td><td>0.766</td></tr>
</table>

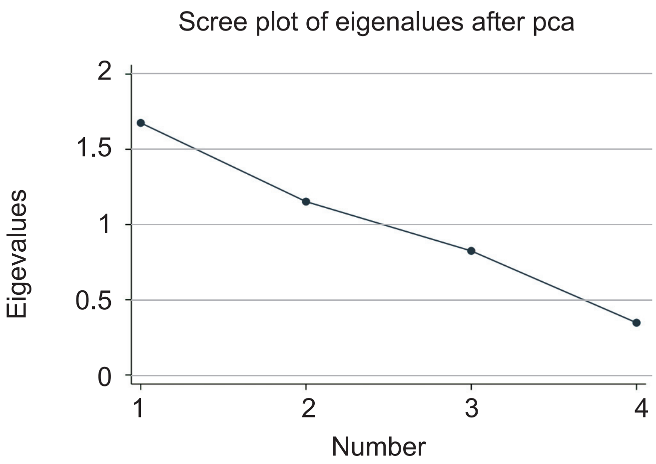
Source: Authors' own calculation

Figure 5: Scree plot of human health



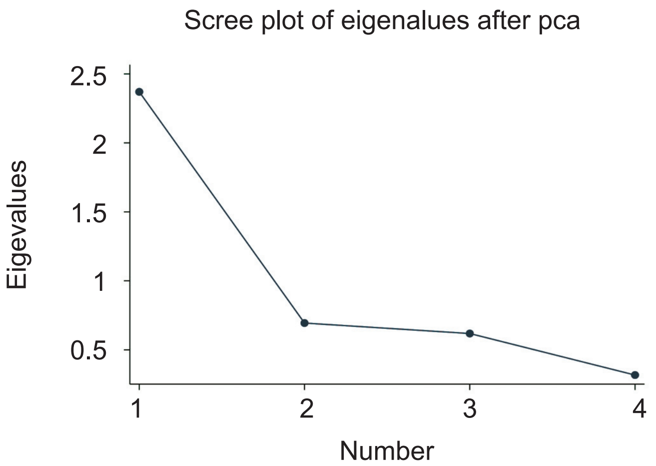
Source: Stata output based on authors' own calculation

Figure 6: Scree plot of environmental degradation



Source: Stata output based on authors' own calculation

Figure 7: Scree plot of institutional quality



Source: Stata output based on authors' own calculation

5.2 CD, SH, unit root, and co-integration tests results

Table 6 illustrates the results of the CD, SH and CIPS tests. The outcomes of Pesaran's CD test direct us to decline the null hypothesis "data are not cross-sectionally dependent for countries" at <1%. In contrast, ln*GDS* admits that H_0 is correct, whereas 86% of the variables accept H_1. Conclusively, the CD test results urge high-risk countries (HRCs) to consider the importance of other nations while making economic decisions. The outcomes of the delta ($\tilde{\Delta}$) and adjusted delta ($\tilde{\Delta}_{ADJ}$) tests display the existence of panel heterogeneity. Thus, the null hypothesis suggesting slope homogeneity is ruled out at <1% of significance. The presence of a unit root in all the cases regarding H_0: "the dataset is not stationary" is commonly assumed at level (Abbasi *et al*., 2020). For preventing bias and unreliable estimates, we adopted the 2^{nd} generation unit root test that shows the mixed order of integration at I(0) and I(1). Therefore, the null hypothesis suggesting that the panel is not stationary is rejected at integration orders I(0) and I(1) for all the variables. The decision of mixed order of integrations guides us to run Westerlund's 2007 co-integration technique (Li *et al*., 2020; Ahmad *et al*., 2020) and to apply the panel MG/ARDL models for long-run estimations (Ahmed *et al*., 2021). Pedroni (1999, 2004), Kao (1999) and Westerlund (2005) tests affirm the existence of long-term relationships among the measures (see Table 7) in high-risk countries (HRCs). The robustness of Pedroni's 1999 and 2004 tests is validated by the Engle–Granger 1987 two-step residual test of Kao (1999). The Pedroni test consists of 4 within-group and 3 between-group statistics. The Kao test comprises of Dickey–Fuller and Augmented Dickey–Fuller types of investigation. Moreover, Westerlund's 2007 test also affirms the long-run co-integration among all the variables of consideration.

Table 6: Results of CD, P&Y and CIPS

Variables	***HHI***	***EDIN***	**ln*RGDP***	**ln*GDS***	**ln*DCPS***	***RGIN***	***DCIN***
Pesaran (2004) CD test statistics							
***t*-stat**	36.048*	17.354*	31.042*	(0.693)	4.148*	4.284*	4.655*
Average absolute value of the off-diagonal	0.93	0.60	0.81	0.36	0.54	0.39	0.39
CIPS (2007) test statistics							
Stationarity at level	(1.018)	(2.270)**	(1.501)	(2.626)*	(0.591)	(1.223)	(1.205)
Stationarity at 1st difference	(2.620)*	–	(3.767)*	–	(3.805)*	(3.511)*	(3.517)*
Order decision	I(1)	I(0)	I(1)	I(0)	I(1)	I(1)	I(1)

P&Y (2008) delta $\tilde{\Delta}$ and adjusted delta $\tilde{\Delta}_{ADJ}$ statistics

Models	***EDIN* = f (ln*RGDP*, ln*GDS*, ln*DCPS*)**		***HHI* = f (ln*RGDP*, ln*DCPS*, *EDIN*)**		**ln*RGDP* = f (*HHI*)**		***EDIN* = f (*RGIN*, *DCIN*)**	
Statistics	$\tilde{\Delta}$	$\tilde{\Delta}_{ADJ}$	$\tilde{\Delta}$	$\tilde{\Delta}_{ADJ}$	$\tilde{\Delta}$	$\tilde{\Delta}_{ADJ}$	$\tilde{\Delta}$	$\tilde{\Delta}_{ADJ}$
	9.958*	11.256*	20.567*	23.248*	23.807*	25.530*	11.217*	12.342*

Note: * and ** indicate significance at 1% and 5%, respectively.
Source: Authors' own calculation

Table 7: Results of Pedroni, Kao, Westerlund (2005) and Westerlund (2007) co-integration tests

Pedroni (1999, 2004)					Kao (1999)	Westerlund (2005)
H_1: Common AR coefficients			H_1: Individual AR coefficients		H_0: No co-integration	
Model 1	P_w	1.389***	G_a	0.528	***t*-statistics**	**Variance ratio**
	P_x	(0.718)	G_b	(3.175)*		
	P_y	(3.409)*	G_c	(1.051)	(1.424)***	(1.351)**
	P_z	(1.723)**	–	–		
Model 2	P_w	9.691*	G_a	2.367	***t*-statistics**	**Variance ratio**
	P_x	0.767	G_b	(1.138)		
	P_y	(3.197)*	G_c	(2.192)**	(1.532)***	1.907**
	P_z	(3.679)*	–	–		
Model 3	P_w	15.345*	G_a	0.758	***t*-statistics**	**Variance ratio**
	P_x	0.066	G_b	(5.244)*		
	P_y	(2.658)*	G_c	(5.675)*	(2.235)**	(1.376)***
	P_z	(3.098)*	–	–		
Model 4	P_w	0.217	G_a	0.500	***t*-statistics**	**Variance ratio**
	P_x	0.108	G_b	(8.147)*		
	P_y	(2.819)*	G_c	(5.957)	2.126**	(1.346)***
	P_z	(4.130)*	–	–		

Westerlund (2007) co-integration test results [H_0: no co-integration]

Statistics	Model 1		Model 2		Model 3		Model 4	
	Value	*Z*-value	Value	*Z*-value	Value	*Z*-value	Value	*Z*-value
G_t	(2.118)	0.424	(2.402)*	(3.373)	(3.424)*	(4.507)	(3.209)*	(2.802)
G_a	(3.572)	3.642	(2.091)	2.365	(8.468)	1.805	(10.888)	1.297
P_t	(9.231)*	(2.439)	0.515	2.831	(9.528)*	(2.527)	(8.296)	(0.412)
P_a	(9.377)	(1.013)	0.209	1.914	(6.404)	1.429	(8.661)	0.936

Note: *, ** and *** show significance at 1%, 5% and 10%, respectively. P_w , P_x , P_y and P_z are panel v-statistic, panel rho-statistic, panel PP-statistic and panel ADF-statistic, respectively, while G_a , G_b and G_c are group rho -statistic, group PP-statistic and group ADF-statistic, respectively.

Source: Authors' own calculation

5.3 Long-run panel ARDL/PMG models and causality estimation results

Table 8 reveals the outcomes of all the econometric models. ***Model 1*** shows that in high-risk countries a 1-unit growth in the real GDP causes a 0.827-unit increase in the Environmental Degradation Index. The results articulate that an increase in lnRGDP upsurges the total greenhouse gas emissions, enhances the pressure on natural capital, increases the environmental temperature and causes abrupt precipitation patterns in sample countries. This finding is consistent with the outcome of Phrakhruopatnontakitti *et al*. (2020). Gross domestic savings, due to the negative value, result in favourable environmental quality in high-risk countries (HRCs). A 1% rise in savings improves climatic conditions by 0.373%. Moreover, the study exposes that a 1% rise in domestic credit to the private sector by banks (*DCPS*) causes a 0.220% deterioration in the climate. This outcome is consistent with the studies of Le *et al*. (2020), and Adebayo *et al*. (2023b). Moreover, Irfan *et al*. (2023) also proved that anthropogenic activities such as tourism boost economic growth but harm the environment. Thus, Model 1 concludes that economic growth and financial development worsen the environmental excellence in high-risk countries, while savings are advantageous. ***Model 2*** unveils that if total GHG emissions are not controlled, if overexploitation of natural capital is not stopped, if the global temperature keeps rising, and if the precipitation remains unpredictable, then the world could come across more dangerous health catastrophes in the future. At present, if the environment is degraded by one percent, it decreases life expectancy, human survival to age 65, and fertility by 0.317% in HRCs. Generally, the outcomes illuminate that an unclean environment curtails longevity and causes infertility. The results are alarming because a degraded environment is gradually ending the existence of the human race by killing the existing humans and hindering new births. On the other hand, economic growth and financial development are promising for healthiness, if the climate is not contaminated. A degraded atmosphere is detrimental to health; this result is consistent with those of Rahman *et al*. (2022), Bernard (2021) and Wang *et al*. (2020). ***Model 3*** uncovers that a 1% of poor health declines output by 1.1%. Conversely, a healthy population contributes 1.1 units extra to economic growth. The outcomes of Models 1, 2 and 3 show a shock wave-type impact running from economic growth to environmental degradation to human health to economic growth. Therefore, if the causes of environmental degradation are properly managed, then the health issues can be resolved and, as a result, persistent and healthy economic growth can be achieved. Thus, this study tests good governance as a remedy to the problems. The findings of ***Model 4*** suggest that institutional quality helps in curbing the unfavourable impacts of economic growth and financial development on the environment. The *RGIN* shows a 0.056% impact on environmental degradation which reveals that a 1% improvement in government effectiveness, regulatory quality, control of corruption and rule of law causes the growing GDP to improve environmental quality and mitigate the causes of the worsening environment by 0.777%. The impact of real GDP on environmental deterioration after incorporating good governance is 0.056 units, which is 0.777 units lower than the direct hazardous impact of economic growth on the environment, *i.e.*, 0.827%. Likewise, the *DCIN* is categorically favourable for environmental quality and shows a negative impact on environmental degradation, meaning that if government redirects 1% of domestic credit towards environment-friendly projects, it improves the degraded environment by 1.311%. Irrefutably, the experimental results of the *RGIN* and *DCIN* explain that if the civil services in high-risk countries are kept out of the political influence, and if the rule of law is upheld by applying thorough regulations impartially, the economic growth and financial development could maintain peace with nature. Based on long-run estimations, this study establishes that good governance is an immediate remedy for environmental degradation, health concerns and the realization of long-run sustainable and healthy economic growth in the twelve high-risk countries (Haiti, the Philippines, Pakistan, Vietnam, Bangladesh, Nepal, Mozambique, Bahamas, Zimbabwe, India, Niger, and Bolivia). Lastly, the results of the D-H and the PVAR Granger causality tests (see Tables 9 and 10) display a bidirectional and unidirectional causality among the variables of consideration in high-risk countries.

Table 8: Results of panel ARDL/PMG long-run models

Models	Model 1 (4, 1, 1, 1)		Model 2 (2, 3, 3, 3)		Model 3 (2, 3)		Model 4 (4, 2, 2)	
Variables	***EDIN*** **is the dependent variable**		***HHI*** **is the dependent variable**		**ln*RGDP*** **is the dependent variable**		***EDIN*** **is the dependent variable**	
	Coefficient	***t*-stat**	**Coefficient**	***t*-stat**	**Coefficient**	***t*-stat**	**Coefficient**	***t*-stat**
ln*RGDP*	0.827*	5.776	1.619*	6.755	–	–	–	–
ln*GDS*	(0.373)**	(2.126)	–	–	–	–	–	–
ln*DCPS*	0.220**	2.054	0.944*	6.649	–	–	–	–
EDIN	–	–	(0.317)*	(5.423)	–	–	–	–
HHI	–	–	–	–	1.102*	2.166	–	–
RGIN	–	–	–	–	–	–	0.056*	4.203
DCIN	–	–	–	–	–	–	(0.367)*	(4.356)*
N		228	–	240	–	240	–	228
Sum sq. residual		20.311	–	0.068	–	0.106	–	20.933
Log-likelihood		(6.498)	–	816.956	–	699.292	–	(3.047)

Note: *, ** and *** show significance at $p < 1\%$, $p < 5\%$ and $p < 10\%$ respectively. The maximum lag length is selected through Akaike-Information-Criterion (AIC).

Source: Authors' own calculation

Table 9: Pairwise Dumitrescu-Hurlin panel causality tests

Model 1 Stats		***EDIN***	**ln*RGDP***	**ln*GDS***	**ln*DCPS***
EDIN	*W*-stat	–	1.625	2.006***	2.230**
	Z-stat	–	1.016	1.778	2.225
ln*RGDP*	*W*-stat	5.626*	–	4.900*	3.347*
	Z-stat	9.019	–	7.562	4.460
ln*GDS*	*W*-stat	1.156	2.222**	–	7.449*
	Z-stat	0.078	2.210	–	12.667
ln*DCPS*	*W*-stat	2.673*	1.287	4.145*	–
	Z-stat	3.112	0.338	6.058	–

Model 2 Stats		***HHI***	**ln*RGDP***	**ln*DCPS***	***EDIN***
HHI	*W*-stat	–	5.238*	**EDIN**	*W*-stat
	Z-stat	–	3.875		*Z*-stat
ln*RGDP*	*W*-stat	11.664*	–	**ln*RGDP***	*W*-stat
	Z-stat	12.309	–		*Z*-stat
ln*DCPS*	*W*-stat	13.820*	3.590***	**ln*GDS***	*W*-stat
	Z-stat	15.139	1.712		*Z*-stat
EDIN	*W*-stat	5.204*	2.312	**ln*DCPS***	*W*-stat
	Z-stat	3.830	0.035		*Z*-stat

Model 3 Stats		**ln*RGDP***	***HHI***
ln*RGDP*	*W*-stat	–	11.664*
	Z-stat	–	12.309
HHI	*W*-stat	5.238*	–
	Z-stat	3.875	–

Model 4 Stats		***EDIN***	***RGIN***	***DCIN***	
EDIN	*W*-stat	–	8.979	**ln*RGDP***	*W*-stat
	Z-stat	–	0.848		*Z*-stat
RGIN	*W*-stat	7.718	–	**HHI**	*W*-stat
	Z-stat	0.308	–		*Z*-stat
DCIN	*W*-stat	7.186	11.858**		
	Z-stat	0.080	2.082		

Note: *, ** and *** indicate significance at 1%, 5% and 10%, respectively. H_0: No causality among the series.
Source: Authors' own calculation

Table 10: Panel VAR Granger causality results

Dependent variables	**Variables/Indices**	X^2
Human Health Index (*HHI*)	*EDIN*	15.977**
	ln*RGDP*	6.458
Environment Degradation Index (*EDIN*)	ln*RGDP*	11.221***
	HHI	20.969*
Economic growth (ln*RGDP*)	*HHI*	45.028*
	EDIN	16.936*

Note: * , ** and *** indicate significance at 1%, 5% and 10%, respectively.

Source: Authors' own caculation

6. Conclusion

The statistical associations among real output, domestic credit, gross savings, environment and health were tested in 12 nations (Haiti, the Philippines, Pakistan, Vietnam, Bangladesh, Nepal, Mozambique, Bahamas, Zimbabwe, India, Niger, and Bolivia) for the period 1996–2018. The countries were named as high-risk countries, due to their higher climatic vulnerabilities and lower health scores. This study established various statistical checkpoints to ensure that datasets move step by step towards robust outcomes. First, the data were rescaled by taking the natural logarithms and the min-max technique. Later on, composite indices of environment, health, and institutional quality were constructed by applying the PCA method. After that, the CD test (Pesaran, 2004) was applied, which rejected the null hypothesis at a significance level of 1%. The delta and adjusted delta tests were also conducted, and null suggested the slope homogeneity was rejected at 1%. We used the 2nd generation unit-root test to avoid unreliable estimates, which showed mixed order of integration in the datasets. The acquired results of the unit root test channelled us to Westerlund's 2007 co-integration test and the panel ARDL model (Pesaran *et al*., 1999) for long-run estimations. In addition, this study also used residual-based co-integration tests of Pedroni, Kao and Westerlund (2005).

The theoretical background of the study clarified that environmental degradation is a by-product of monetary developments. Moreover, a deteriorated climate harms citizens' well-being, leading to a decline in economic growth. Likewise, these interrelationships and impacts among the variables of consideration were also statistically acknowledged by our study through co-integration and long-run estimations. Thus, given the importance of the Paris Agreement's 1/CP.17 and Sustainable Development Goal 13, this study empirically tested the institutional quality of countries as a means of achieving environmental sustainability. The obtained results were satisfactory and the importance of good governance in controlling, curbing and mitigating environmental degradation in high-risk countries (HRCs) was upheld by the findings of this study. Our results are consistent with the Paris Agreement's claim that good governance can mitigate environmental degradation. Moreover, a few existing studies (Ehigiamusoe *et al*., 2019; Jian *et al*., 2019; Koc *et al*., 2020) have also affirmed the importance of quality institutions in this regard.

Overall, the current study provides valuable insights into the dynamics causing environmental degradation in high-risk countries. The outcomes of this study may help policymakers manage economic growth and domestic credit in a way that does not harm the environment. As a result, parallel consequences can also be mitigated. In the field of environmental research, our study emphasizes the importance of an interdisciplinary approach. Although the findings of this study are robust, some limitations need to be discussed. For instance, this study had a smaller sample size and tested only four out of the six features of the World Governance Indicators.

Moreover, a limited number of monetary variables were examined. In future studies, the scope and implications can be enhanced by incorporating a bigger sample size and testing more features of environment, governance and health.

7. Policy Recommendations

This study urges policymakers in high-risk countries to focus on institutional quality and promote development of green finance mechanisms such as green bonds, green loans and green investment funds, which can provide funding for environmentally sustainable projects and initiatives. In addition, policymakers could consider developing policies and incentives to encourage private sector investment in green finance, such as tax incentives or subsidies for green investments. By promoting green finance mechanisms and encouraging private sector investment in environmentally sustainable projects, policymakers can help promote sustainable economic growth while also addressing pressing environmental and public health challenges.

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