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Human Capital and Environmental Sustainability Nexus in Selected SADC Countries

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Abstract: This paper sought to examine the nexus between human capital and environmental sustainability in Southern African Development Community (SADC) countries. This contemporary topic has not received much attention in the region, hence the need to investigate the nexus between human capital and environmental sustainability. The paper used one of the most recent methodologies, namely, the pooled mean group (PMG) estimation technique, to assess this relationship from 1980 to 2021. The findings of the study are that human capital increases environmental sustainability in the long run in SADC countries. This implies that as human capital increases, countries will see an increase in technological innovations and research and development (R&D), enabling the mitigation of environmental degradation in the region. Therefore, it is imperative for the region to embark on human capital programs that improve environmental sustainability.

Keywords: human capital; environmental degradation; pooled mean group; SADC countries

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1. Introduction

The 21st century is riddled with challenges, such as environmental degradation, poverty, stagnant economic growth of governments, and health issues. Chief amongst these challenges is environmental degradation, which has been caused by factors such as increased worldwide population, intense production, increased consumption, and industrialisation, to mention but a few [1,2] (Bayar et al., 2022; Lim, 2022). These factors have led to environmental challenges such as carbon emissions, water pollution, and loss of natural rent. Environmental challenges are multidimensional, affecting the health-related, social, economic, and political environments. For instance, the exploitation of natural resources solely depends on population size, which in turn affects environmental sustainability. Thus, the overuse of resources as a result of a high demand for energy and other natural resources creates erosion, diseases, and climate change [3]. It is against this background that developing and developed governments have joined hands to fight this challenge in line with the twelfth and thirteenth United Nations Sustainable Development Goals (SDGs). The twelfth SDG emphasises sustainable consumption and production patterns, while the thirteenth SDG goal emphasises urgent steps to combat climate change and its effects [4].

The Southern African Development Community (SADC) has taken steps to combat environmental degradation and ensure environmental sustainability [5]. Among the policies enacted are the Soil and Water Conservation and Land Utilization (SWCLU) of 1981, the Environment and Land Management Sector (ELMS) of 1991, the SADC protocol of Energy, and the SADC Environment and Sustainable Development Programme [6]. These policies aim to ensure environmental sustainability since most of the region's electricity is generated using coal [7]. It is further reported that coal supplies about 63 percent of power generation in the region, which is the major source of environmental degradation [6,8]. In addition, about 68 percent of rural areas in the region have no electricity access, and they use other sources that are not environmentally friendly [8]. This points to the fact that the region has fallen behind Africa and the world in ensuring environmental sustainability.

The lack of environmental sustainability in the region has captured the attention of researchers and academics. Scholars have speculated that factors such as human capital, political stability, globalization, and advanced technology should not be overlooked when dealing with environmental sustainability [9–11]. The proponents posit that human capital is more likely to improve environmental quality and ensure awareness of environmentally friendly behaviour [12]. The notion is that information and knowledge concerning environmentally friendly behaviour go a long way, leading to pro-environment steps that reduce environmental degradation. Ismail and Hilal [13] (2022) argue that leadership must take the lead in implementing green human capital and encourage green behaviour in their organisations. Given these benefits, the current study seeks to contribute to the pertinent debate on the relationship between human capital and the environment.

This study intends to make two contributions. Firstly, the literature reviewed shows that the majority of the studies on environmental sustainability and human capital concern high-income countries, such as China and European Union countries, where carbon emissions are high [14–16]. However, little is known about environmental sustainability and human capital in low-income countries in Africa. This is particularly relevant in relation to the Southern African Development Community, since the region relies solely on coal for power generation. Thus, this study will contribute to the body of literature by assessing the nexus between environmental sustainability and human development in the SADC region. This will create more research avenues for emerging researchers in the field of environmental economics. Secondly, the current study considers human capital based on years of schooling and returns to education, specifically regarding education outcomes and health. These two aspects of human development emphasise productivity above all else, whereas other measures, such as tertiary enrolment, human development index, and secondary school attainment, lack this element [17,18]. Thus, the human development aspect tends to focus on productivity, not just educational attainment. The notion behind the selection of this proxy is that it tends to enhance better environmental performance through highly skilled workers that may move to cleaner energy use. The objective of this paper is to examine the impact of human capital on environmental degradation in the selected SADC countries for the period 1980 to 2021. The hypothesis of the study is as follows:

H0: Human capital did not have a significant impact on environmental sustainability in the selected countries in the SADC region for the period 1980–2021.

H1: Human capital had a significant impact on environmental sustainability in the selected countries in the SADC region for the period 1980–2021.

Having presented the introductory part, the remainder of the article is organised in the following manner. Section 2 presents the literature that links the two main variables, human capital and environmental sustainability; Section 3 outlines the materials and methods employed in this study, and Section 4 presents the study's empirical results. Section 5 provides the recommendations, conclusions, and limitations of the study.

2. Literature Review

The relationship between human capital and environmental sustainability can be explained using the Environmental Kuznets Curve theory (EKC) [19]. The EKC theory was developed by [20] in the early 1990s. The theorists put emphasis on the nexus between economic growth and the environment. The EKC theory assumes that environmental degradation is key to the early stages of economic growth. According to [21], in the early stages of development the environment suffers, but as the economy grows, environmental sustainability is ensured. This might be attributed to several factors, such as investment in human capital and technological advancements. For instance, human capital development in terms of education enables people to value the environment by finding better and sustainable ways of development without compromising the environment. The proponents of EKC opine that it is human capital that is responsible for a decline in carbon emissions [19]. The decline of environmental degradation is a result of better innovation and education. This creates awareness of dangers to the environment while simultaneously appreciating the importance of economic activities. Thus, this theory is imperative in explaining the relationship between environmental degradation and human capital.

The previous literature [11,15,16,22,23] has linked human capital to environmental sustainability in different countries, using different methods in different time periods. Empirically, the literature on environmental sustainability indicates that, among other factors, the development of human capital plays a crucial role in changes in environmental degradation. This is because human capital complements research and development (R&D), improving production efficiency and green technologies and reducing energy consumption and carbon emissions [24]. It is argued that new abatement technologies that ensure better environmental performance are likely to be adopted by firms with more human capital, which in turn promotes environmental sustainability. Again, other studies are of the view that the use of non-renewable energy resources is highly likely to promote environmental sustainability. Other studies [25–27] argue that human capital development worsens environmental degradation since it escalates technological innovations and R&D, leading to an upsurge in the demand for energy and natural resources, which ultimately result in an increase in carbon emissions, thereby worsening environmental degradation.

These mixed assertions necessitate the need to evaluate the nexus between human capital and environmental sustainability for the selected SADC member states. Indeed, studies in different regions and countries have examined the link between human capital and environmental degradation in different regions, yet they found different results on the relationship. For example, a study by [14] examined human capital's effects on the environmental performance of Chinese industrial firms. The study considered both the external and internal effects of human capital using a cross-sectional dataset. The findings reveal that human capital ameliorates environmental compliance across firms, thereby reducing environmental degradation.

Bano, Zhao, Ahmad, Wang, and Liu [28] investigated the impact of human capital on Pakistan's carbon environment from 1971 to 2014. The study examined the relationship by employing the ARDL model and the VECM approach. The findings of this study suggest that environmental degradation can be mitigated by education, thus improving human capital.

For the BRICS countries, a study was contacted by [15] which investigated the relationship between energy, investment, human capital, environment, and economic growth for the period 1981 to 2015. The study employed different panel estimation techniques, including the F.M.O.L.S and R.L.S methods and the Dumitrescu–Hurlin Panel causality test. The study's key findings are that human capital development contributes significantly positively towards economic growth, while environmental pollution diminishes economic growth. The findings from the panel causality test show that a one-way causality runs from environmental pollution to human capital.

In the case of the G7 countries, Ahmed, Zafar, and Ali [11] examined the link between human capital and the ecological footprint, employing panel data spanning the period between 1971 to 2014 and advanced panel data estimators. The techniques used in this study include the CUP-FM and the CUP-BC estimators. The study's results show that human capital significantly reduced the ecological footprint of the selected countries. The long-term results were validated by employing CO_2 emissions as an alternative measure of environmental degradation. The panel causality tests also show that a unidirectional causality exists for the selected countries, which runs from human capital to ecological footprint.

Ahmed et al. [10] contributed to the debate in the case of China. The study examined the relationship that exists between natural resource abundance, human capital, urbanisation, and the environment in China whilst controlling economic growth. The study used the Bayer–Hanck cointegration and bootstrap causality techniques to examine the relationship. The study found out that human capital significantly mitigates environmental degradation in China. The study's findings further show that if human capital interacts with urbanisation, it can result in the in the reduction of the ecological footprint, demonstrating a moderating effect of human capital in the mitigation of environmental degradation.

A study was conducted in Pakistan for the period 1985 to 2018 by [29], which investigated the link between human capital, natural resources, economic growth, and environmental degradation using the dynamic autoregressive distribution lag (DARDL) model. The study's findings indicate that human capital has a statistically significant negative long-term effect on carbon emissions. The results also show that human capital has a statistically significant positive effect on carbon emission in the short term.

Abdouli and Omri (2021) [16] explored FDI, environmental quality, human capital, and economic growth nexus. The study was conducted on the Mediterranean region for the period 1990–2013. The techniques used in the study include the dynamic OLS and F.M.L.S models. A bidirectional causality was found to exist between human capital and the environment.

For the EU countries, Cakar, Gedikli, ErdoGan, and Yıldırım [17] explored the link between human capital and the environment for the period 1994 to 2018. The study employed the panel smooth transition regression model (PSTR) model. The study found that human capital's effect on the environment differs with the growth regime of the country studied. For instance, the study shows that a negative relationship exists for low-growth regimes, while on the other hand a positive relationship exists in high-growth regimes. This is consistent with the findings of [30], who found a negative and significant effect of human capital on greenhouse gas emissions in the case of BIMSTEC economies.

The reviewed literature shows that most research has been undertaken in high-income countries such as China, EU countries, and some countries under BRICS. The same cannot be said of low-income countries, including the Sub-Saharan African Countries and the Southern Africa Development Committee.

3. Methodology, Data, and Model

This paper assesses the environmental sustainability effects of human capital in 16 SADC countries from 1980 to 2021. The model of the study was adapted from [17], who examined the effect of human capital on environmental degradation in EU countries. Their model was expressed as:

$$CO_{2it} = \beta_0 + \beta_1 HDI_{it} + \beta_2 X_{it} + \varepsilon_{it} \quad (1)$$

where:

CO_{2it} is the dependent variable that measures the carbon emission per capita in Mt CO_2/year, X represents the regressors which include the main independent variable, HDI_{it} is the human capital index, and control variables which include foreign direct investment (FDI) and GDP per capita $(GDPC)$. $Urban$ accounts for urban dwellers. $Energy$ refers to the use of primary energy consumption and patents.

The current study employs the heterogenous dynamic panel model, also known as the panel autoregressive distributive lag (ARDL) model, which consists of dynamic fixed effect (DFE), mean group (MG) and pooled mean group (PMG) estimation techniques. Thus, the generalised ARDL $(p, q, q \ldots .q)$ model is specified in Equation (2) as:

$$y_{it} = \sum_{j=1}^{p} \delta_i y_{it-j} + \sum_{j=0}^{q} \beta'_{ij} X_{it-j} + \varphi_i + e_{it} \quad (2)$$

where y_{it} is the dependent variable, δ_i is the coefficient of the lagged dependent variable, X_{it} is the k*1 vector that is allowed to be purely cointegrated or 1(0) or 1(1), β'_{ij} is the k*1 coefficient vector, p and q are optimal lag orders, φ_i is the unit-specific fixed effect and e_{it} is the disturbance term. The current paper aims to assess both the short- and long- term impact of human capital on environmental sustainability in SADC countries. Thus, the study utilises the re-parameterised ARDL (p, q, q . . . . . . q) error correction model, which comes with a difference operator for the dependent variable. Differencing the ARDL model leads to loss of lag; therefore, the lag length will be $p - 1$ and $q - 1$. The re-parameterised ARDL (p, q . . . . q) error correction model is expressed as:

$$y_{it} = \theta_i[y_{i,t-1} - \gamma_i X_{it}] + \sum_{j=1}^{p-1} \zeta_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \beta_{ij} \Delta X_{i,t-1} + \omega_i + \varepsilon_{it} \quad (3)$$

where:

θ_i is the adjustment coefficient, $[y_{i,t-1} - \gamma_i X_{it}]$ is the error correction term which represents the long-term information in the model, $p - 1$ and $q - 1$ represent the number of lags for the dependent and independent variables, respectively, and ζ_{ij} and β_{ij} are short-term parameters. Taking this into account, the environmental sustainability–human capital model for the current paper is specified as:

$$CO_{2it} = \theta_i[CO_{2i,t-1} - \gamma_i X_{it}] + \sum_{j=1}^{p-1} \zeta_{ij} \Delta CO_{2i,t-j} + \sum_{j=0}^{q-1} \beta_{ij} \Delta X_{i,t-1} + \omega_i + \varepsilon_{it} \quad (4)$$

where:

CO_{2it} denotes the carbon emissions in country i at time t, which is the proxy for environmental sustainability, and X_{it} denotes the regressors which may only be purely 1(0) or 1(1). The explanatory variable includes the main regressor, the human capital index, which is measured based on the years of schooling and returns to education, and the control variables, which consist of the FDI, GPC, $ACTE$, $APEC$, $URBAN$, $and\ PLS$. The FDI is foreign direct investment. $GDPC$ is the gross domestic product (GDP) per capita. $ACTE$ is access to electricity. $APEC$ refers to the annual primary energy consumption. $URBAN$ denotes the percentage of the population living in urban areas. PLS indicates institutional quality measured by the political stability index, which captures the absence of such issues as violent takeovers, terrorism and conflicts. θ_i is the adjustment coefficient. $[CO_{2i,t-1} - \gamma'_i X_{it}]$ denotes the error correction term that represents the long-term information of the model. γ_i is the vector of a long-term association. The dependent variable has a different operator in the error correction model. As a result, when the ARDL is differenced, the lag length will be reduced. Hence, the number of lags to be used is $p - 1$ for the dependent variable and $q - 1$ explanatory variables (p and q are optimal lag orders). ω_i and ε_{it} denote the unit-specific fixed effects and the disturbance term, respectively.

The relationship between human capital development and environmental sustainability is debatable. According to other studies [31] (O'Neill et al., 2020), increased levels of education may cause a slight increase in emissions due to economic growth. However, the majority of studies [10,15,17,19] (Ahmed et al., 2020; Azam, 2019; Çakar et al., 2021; Jain & Nagpal, 2019) contend that educational attainment is beneficial because it helps people become more resilient to the negative effects of climate change. Additionally, Jain and Nagpal (2019) [19] found that improved innovation and education are associated with a decline in environmental degradation. Given the previous explanation, the current paper anticipates a favourable relationship between environmental sustainability and human capital development.

Following [32,33] Egesa et al. (2022) and Wang and Huang (2022), who claimed that foreign direct investment causes an increase in carbon emissions in China, India, Iran, Indonesia, South Africa, the OCED, and East Asia, the study anticipates a positive impact of FDI on carbon emissions. Akbar et al. (2021) and Ahmed et al. (2020) [10,34] assert once more that an increase in urban population is linked to an increase in environmental degradation. As a result, the paper expects a negative association between urbanisation and environmental sustainability (ES) in SADC countries.

Begum et al. (2015) [35] argued that there is a long-term positive relationship between per capita energy consumption and carbon emissions; thus, the paper also anticipates a negative impact of energy consumption on environmental sustainability. The EKC hypothesis postulates that there is a positive relationship between GDP and environmental degradation at the first stages of development and a negative relationship at a later stage of development. Hence, the paper anticipates both negative and positive effects of economic growth on ES. The study anticipates that political stability and ES, as well as access to electricity and ES, will be positively related.

The paper employs the panel ARDL estimation technique, preferably the pooled mean group (PMG) estimation technique, which is more efficient compared to its counterparts, dynamic fixed effect (DFE) and mean group (MG) estimation techniques. The MG and DFE estimators do not recognise the fact that certain parameters may be the same across groups. However, the PMG involves pooling and averaging of the sample and allows the intercepts, short-term coefficients and error variances to differ across groups, but the long-term coefficients are homogenous. Unlike the DFE and MG, the PMG developed by [36,37] is a more informative and intermediary method between new and traditional estimators. The PMG estimation method, which is resistant to non-stationarity, controls for unobserved common factors [37,38]. It addresses the issue of endogeneity by expanding the parameters with lags of the explanatory variables [39,40]. This minimises the bias of the estimators and enables the regressors to be treated as exogenous by making sure that the regression residuals are uncorrelated and distributed independently of the regressors [41,42].

Even if the MG provides consistent estimates of the mean of the long-term coefficients, these will be inefficient if the slope homogeneity holds. However, the PMG estimators are consistent and efficient under the assumption of long-term slope homogeneity. Thus, the PMG is the preferred estimator in the current study. However, the Hausman test [43] will be used to determine the appropriate estimator for the model. Thus, the null hypothesis states that the MG and the PMG are not significantly different. That is, the PMG is more efficient under the null hypothesis. The alternative hypothesis is that the null hypothesis is not true:

H0: *MG and the PMG are not significantly different;*

H1: *the null hypothesis is not true*

The decision criteria will be that the PMG will be preferred if the p-value is greater than 0.05 and the MG will be preferred if the p-value is less than 0.05. The following section presents descriptive statistics, a correlation coefficient matrix, and unit root tests, which summarize the preliminary findings.

Table 1 below shows the descriptive statistics for the variables used in the environmental sustainability model. Most significantly, the table displays the standard deviations, which demonstrate the variability of the sample. The descriptive statistics reveal that between 1994 and 2020, the average carbon emission in the SADC countries was 400, and the average human capital was 1.9. Table 1 also shows that all other variables' standard deviations are sufficiently large to allow for an investigation of the variation in the data. The next section presents the correlation coefficient between the major factors affecting environmental sustainability.

Table 1. Descriptive statistics.

Variable	Definition	Source	Obs	Mean	Std. Dev.	Min	Max
C02pc	Carbon emissions	Global Economy	400	1.539525	2.178536	0.02	9.09
hci	Human capital index	World Penn tables 10.0	364	1.911251	0.4543397	1.114	2.94
gpc	GDP per capita	Global Economy	432	2967.464	3278.011	219.2	15,913.
fdi	Foreign direct investment	World Bank	416	0.5763702	1.564642	−7.4	10.03
acte	Access to electricity	Global Economy	383	41.09436	30.48317	1.27	100
apec	Energy consumption	World energy data	417	4.517494	12.90212	−33.92	142.66
urban	Urbanisation	Global Economy	432	37.44509	13.96879	12.91	70.88
pls	Political stability index	Global Economy	352	−0.1093182	0.8334821	−2.84	1.28

Source: Author's compilation.

Table 2 below presents the correlation coefficients for the variables under study. Thus, GDP per capita and access to electricity are positively and highly correlated with environmental sustainability. However, the correlation test indicates that GDP per capita increases as access to electricity increases in SADC countries. The correlation coefficients for other regressors are not greater than 0.8, indicating that they are not linearly related. This suggests that there is no precise or linear relationship between the relevant variables. Hence, they can be applied to the same regression model. The correlation test only shows the direction and strength of the relationship between variables, yet they do not indicate the impact of the explanatory variables on the dependent variable. Therefore, to check the impact of human capital on environmental sustainability, we performed regression analysis using the panel ARDL estimation technique. The correlation test only shows the direction and strength of a relationship between variables; it does not reveal how the explanatory variables affect the dependent variable. As a result, the study uses panel ARDL estimation techniques to conduct a regression analysis to estimate the impact of human capital on environmental sustainability. The results of the unit root test are shown in the following section.

Table 2. Correlation coefficient.

	lC02pc	Lhci	lgpc	lfdi	lacte	lapec	lurbn	lpls
lC02pc	1.0000							
Lhci	0.2159	1.0000						
Lgpc	0.8705	0.0634	1.0000					
Lfdi	0.1581	0.2823	0.0002	1.0000				
Lacte	0.7792	0.0857	0.8853	0.1154	1.0000			
lapec	−0.0871	−0.1215	−0.0524	0.0801	−0.1198	1.0000		
lurban	0.6215	0.2367	0.6563	0.2252	0.6487	−0.0322	1.0000	
Lpls	0.3959	0.1463	0.4939	−0.0930	0.3424	0.0942	0.1510	1.0000

Source: Author's compilation from pairwise correlation regressions.

Stationarity Test

The paper utilised the [44,45] and Augmented Dickey–Fuller (ADF) tests to check unit root. Since most of the data series were not strongly balanced, we took into consideration the effective and useful individual stationarity tests [44,45] (the Fisher type and Im Pesaran and Shin [45], which can be used when some panel series have gaps [46]. Nonetheless, some variables responded to the common unit root test (LLC) even if the panel is not balanced. Table 3 presents the results for the LLC, Im Pesaran, and ADF tests in Table 3.

Table 3. Stationarity tests.

Method	LLC		IM Pesaran		ADF	
Order of integration	1(0)	1(1)	1(0)	1(1)	1(0)	1(1)
Variable	t-stat	t-stat	t-stat	t-stat	t-stat	t-stat
lC02pc	−0.1250	−7.094 ***	1.6371	−9.663 ***	0.9229	−15.138 ***
lhci	−0.4687	−1.8645 **	4.2966	−2.3029 **	−80,404 ***	−3.1218 ***
lgpc	−4.747 ***	−15.19 ***	−8.717 ***	−14.64 ***	−12.52 ***	−26.683 ***
Lfdi			−6.3623 **	−17.445 **	−3.1806 **	−19.3000 **
Lacte	-	-	−1.0605	−12.11 ***	−1.2985 *	−23.320 ***
Lapec	-	-	−11.08 ***	−13.66 ***	−17.57 ***	−26.308 ***
Lurban	0.8213	−1.6231 **	5.9367	−1.5265 *	−4.500 ***	−1.4318 **
lpls	−1.745 **	−5.681 ***	−3.549 ***	−9.454 ***	−5.143 ***	−17.565 ***

$p < 0.01$ **, $p < 0.05$ ***, $p < 0.01$ *, Source: author's compilation.

Table 3 indicates that all the variables used in the study become stationary after the first difference. This is robust to all three stationarity tests. The model for the current paper is estimated in ARDL (1) form. Thus, the optimal lag length for all the variables in this study is 1 (see Table A1). The ARDL dynamic panel model specification was chosen using Akaike's Information Criterion (AIC). To obtain the PMG coefficients, a common ARDL (1, 1, 1, 1, 1, 1, 1, 1, 1, 1) for all the countries under consideration is estimated. The section that follows shows the empirical findings of the association between human capital and environmental sustainability based on the PMG estimation technique.

4. Empirical Results

The Hausman test p-values in Table 4 are above 5%. Thus, the null hypothesis of homogeneity cannot be rejected. Therefore, the PMG estimator is the appropriate estimator. Hence, the current paper's regression results are based on the pooled mean group estimator, with the MG and DFE supplied for comparison. The PMG estimator indicates that there is long-term cointegration among the variables in the relationship as determined by the negative error correction term (ECT) (−0.42), which implies that any deviation from long-term equilibrium is corrected at 42% adjustment speed. The regression results are presented in Table 4. Again, all estimated coefficients are interpreted as long-term elasticities since the variables are in natural logarithms.

The empirical results in Table 4 are based on the last two columns under the PMG estimator. The empirical results for short-run (SR) coefficients in Table 4 indicate that human capital, foreign direct investment, urbanization, and access to electricity are insignificant in explaining changes in CO_2 emissions in the short run. However, political stability, energy consumption, and GDP per capita are positively related to carbon emissions. Thus, a 1% increase in the political stability index increases carbon emissions by 0.04% in the short term. However, this is insignificant to explain changes in per capita carbon emission in the long term. Again, a 1% increase in energy consumption and GDP per capita is associated with a 0.01% and 0.4% increase in carbon emissions, respectively, in SADC countries.

As for the long-term coefficients, the PMG estimator indicates that a percentage increase in *hic* is associated with a 0.3% decrease in carbon emissions per capita, holding other variables constant. This implies that human capital promotes environmental sustainability. This result aligns with [17,28], who argued that improving human capital reduces carbon emissions in EU countries. The result also accords with [28], who postulate that improving human capital through education will aid in the long-term decrease of carbon emissions in Pakistan. This suggests that, as the population of the SADC becomes more educated, they become conscious of the need to protect the environment and learn more about environmental preservation, which leads to reduced land degradation. This shows that the SADC governments should expand their investments in education when addressing environmental degradation reduction policies.

Table 4. Empirical results.

	(DFE)	(DFE)	(MG)	(MG)	(PMG)	(PMG)
Variables		**SR**		**SR**		**SR**
ECT		−0.349 ***		−1.329 ***		−0.415 ***
		(0.0579)		(0.510)		(0.138)
D.lhci		0.518		128.4		−7.929
		(0.586)		(90.60)		(6.958)
D.lfdi		0.00923		−0.136		0.0344
		(0.00608)		(0.285)		(0.0268)
D.lurban		−3.138 **		−45.09		−5.104
		(1.262)		(83.50)		(7.426)
D.lpls		−0.00142		−0.698		0.0349 *
		(0.0219)		(0.652)		(0.0213)
D.lapec		0.00252		−0.0172		0.00461 **
		(0.00176)		(0.0181)		(0.00181)
D.lgpc		0.384 ***		1.780		0.431 **
		(0.103)		(1.202)		(0.174)
D.lacte		−0.0433		12.67		−0.535
		(0.0275)		(11.69)		(0.466)
	LR		LR		LR	
L.lhci	−0.0762		328.3		−0.282 **	
	(0.257)		(311.4)		(0.131)	
L.lfdi	0.0225		1.518		0.0204 ***	
	(0.0200)		(1.152)		(0.00366)	
L.lurban	0.339		230.3		0.707 ***	
	(0.253)		(327.8)		(0.168)	
L.lpls	−0.0655		−2.335		0.0202	
	(0.0492)		(2.114)		(0.0198)	
L.lapec	0.0156 **		−0.157		0.0134 ***	
	(0.00764)		(0.133)		(0.00197)	
L.lgpc	0.434 ***		−8.242		0.716 ***	
	(0.127)		(5.521)		(0.0182)	
L.lacte	−0.0728		1.660		−0.146 ***	
	(0.0627)		(1.460)		(0.0426)	
Constant		−1.268 ***		−231.6		−2.949 ***
		(0.398)		(278.3)		(1.030)
Hausman *p*-value		1.000		1.000		0.9626
Observations	.	.	224	224	224	224

Note: SR are the short-run coefficients; LR represents the long-run coefficients. Standard errors in parentheses, *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Again, the empirical findings show that a percentage increase in FDI is associated with a 0.02% increase in carbon emissions per capita in the long term in SADC countries. This implies that foreign direct investments exacerbate environmental degradation in the SADC countries in the LR. This is consistent with [32,33,47], who argued that foreign direct investment increases carbon emissions in China, India, Iran, Indonesia, South Africa, OCED, and East Asia. This shows that the SADC governments should formulate policies around FDIs that can protect the environment. Some FDIs normally come with conditions; often, developing countries are at the mercy of developed countries, thereby making poor developing countries pollution havens. Therefore, the SADC governments should promote clean production technology and environmentally friendly management practices among international investors while also paying attention to changes in the trade structure. This could be accomplished by providing businesses with incentives to adhere to stringent emissions regulations in their domestic and international operations, lowering the export share of sectors with high carbon emissions, and encouraging the modernization of export sectors.

Table 4 shows that the SADC countries' per capita carbon emissions rose by 0.71 percent for every 1% increase in urbanisation. This implies that environmental degradation in the SADC countries is accelerated by the growing urban population. The result is consistent with [10,17,48], who document evidence of a positive relationship between urbanisation and environmental degradation. This could be explained by the fact that greater urbanisation is linked to greater economic activity, which increases wealth. Wealthier residents also tend to seek more energy-intensive goods, such as air conditioning, cars, and other electrical equipment, increasing carbon emissions. As a result, SADC countries should embrace renewable energy sources for domestic and industrial development.

The results of the current paper also show that in the short- and long term, energy consumption in SADC nations increases with per capita carbon emissions. Accordingly, in the long term for SADC nations, a percentage increase in energy consumption is linked to a 0.01% rise in carbon emissions per person, ceteris paribus. This result aligns with Muhammad's [49] argument that energy consumption increases in all countries, but economic growth increases in both developed and emerging countries. Again, the result is consistent with [35], who argued that there is a long-term positive relationship between per capita energy consumption and carbon emissions.

Moreover, the results indicate that a percentage increase in GDP per capita is associated with a 0.72% increase in carbon emissions per capita, ceteris paribus, in the long term in SADC countries. The study's results did not support the EKC hypothesis, which postulates that there is a positive relationship between GDP and environmental degradation at the first stages of development and a negative relationship at a later stage of development. The result corroborates with [50], who found that the EKC is supported by the data from high-income countries and not so much for less-developed countries.

The empirical results indicate that using clean energy such as electricity reduces carbon emissions, promoting environmental sustainability. Thus, a percentage increase in access to electricity leads to a 0.2% reduction in carbon emission, holding other variables constant in the long run. This could be attributed to the SADC countries applying innovative electric grid technologies such as wind, solar, and hydropower, potentially reducing per capita carbon emissions.

According to the Durbin–Watson diagnostic test (see Table A1), serial correlation affected 2 out of 16 groups. The White test indicates that heteroscedasticity was not present across all groups. The cumulative sum of squares (CUSUMQ) was performed based on the Brown, Durbin and Evan [51] model stability tests to ascertain consistency of the coefficients in the models. The CUSUMQ graphic shows that the null hypothesis of parameter stability was not rejected at 5% (see Figure A1). This implies that the CUSUMQ of the recursive residuals are sufficient.

5. Conclusions, Policy Implications, and Recommendations

This study examined the environmental sustainability effects of human capital in SADC countries from 1994 to 2020 using the PMG estimation method. The paper used foreign direct investment, GDP per capita, urbanisation, political stability, energy consumption, and access to electricity as control variables in the environmental sustainability–human capital model. The diagnostics indicate that only 2 out of 16 groups showed a serial correlation. Nonetheless, the employment of the PMG estimator resulted in serially uncorrelated regression residuals. The White test indicates that there was no indication of heteroscedasticity across all groups. Again, the CUSUMQ plots indicate that the recursive residuals are satisfactory.

The current study's empirical findings suggest that human capital is insignificant to explain changes in environmental sustainability in the short term. Human capital, on the other hand, plays a long-term role in reducing environmental sustainability in SADC countries. This necessitates greater investment in human capital by the SADC governments to develop and expand their understanding of environmental compliance across the region. The literature has recently focused on green human capital and its impact on environmental outcomes. The SADC member countries should prioritise green human capital, as it has been shown to improve the environment. It should be incumbent upon the leaders of the organisations to prioritise green human capital and green behaviour programmes in order to minimise the impact on the environment. The empirical findings also indicate that access to electricity in SADC countries also reduces carbon emissions, resulting in environmental sustainability. On the other hand, the current study's findings show that GDP per capita, FDI, urbanisation, the political stability index, and energy do not promote environmental sustainability in SADC countries. As a result, SADC governments and citizens should be more conscious of the energy sources they use, both in the production process and in household use. Moreover, the SADC government should increase investments in renewable energy technologies, such as hydropower, wind, and solar, to reduce environmental degradation in the region.

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Appendix A

Table A1. Optimal Lag Length Selection.

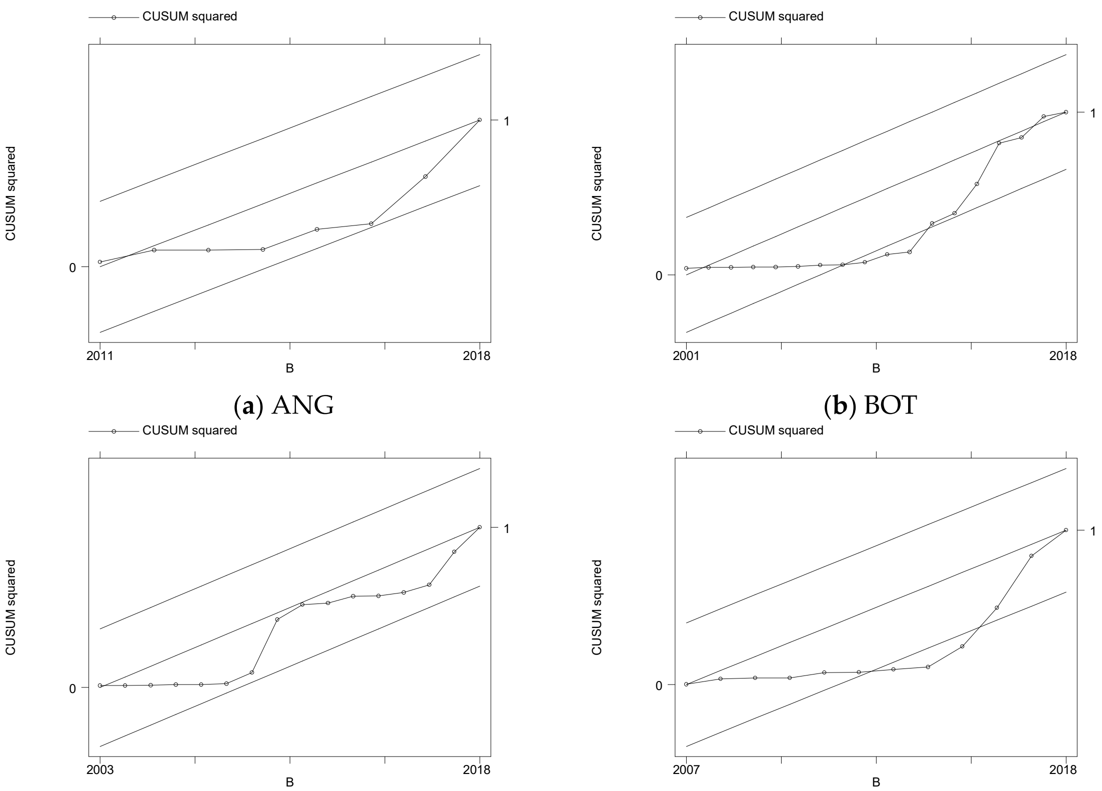
Country	C02pc	Hci	fdi	lgpc	lacte	lapec	urban	pls
Angola	1	1	0	0	1	1	1	1
Botswana	1	1	1	1	1	0	1	1
Comoros	1	1	1	1	1	1	1	1
DRC	1	0	1	1	0	1	1	0
Eswatini	1	1	1	1	1	1	1	1
Lesotho	1	1	1	0	0	0	1	0
Madagascar	1	1	0	0	1	1	1	0
Malawi	1	1	1	0	1	1	1	1
Mauritius	1	0	1	1	1	1	1	1
Mozambique	1	1	1	1	1	1	1	1
Namibia	1	1	0	1	0	1	1	1
Seychelles	1	1	1	1	1	1	1	1
South Africa	1	1	1	1	0	1	1	0
Tanzania	1	0	1	1	0	1	1	1
Zambia	1	1	1	1	1	1	1	1
Zimbabwe	1	1	0	0	1	1	1	0
Common_lag	1	1	1	1	1	1	1	1

Source: Author's compilation.

Table A2. Diagnostic Tests.

Group/Country	Durbin-Watson	White	CUSUMQ
Angola	2.5840	17.00	stable
Botswana	2.1110	20.00	stable
Comoros	2.3284	20.00	stable
DRC	2.2010	18.00	stable
Eswatini	2.3604	17.00	stable
Lesotho	2.40007	18.00	stable
Madagascar	2.1260	20.00	stable
Malawi	1.0669	20.00	stable
Mauritius	2.0001	20.00	stable
Mozambique	2.0226	19.00	stable
Namibia	2.130	20.00	stable
Seychelles	1.990	20.00	stable
South Africa	2.000	20.00	stable
Tanzania	2.2072	20.00	stable
Zambia	2.100	20.00	stable
Zimbabwe	2.3654	20.00	stable

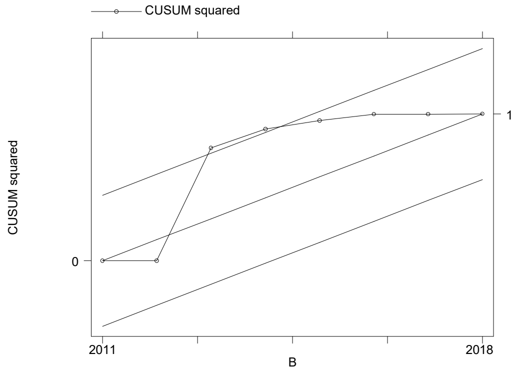
Source: Author's compilation.



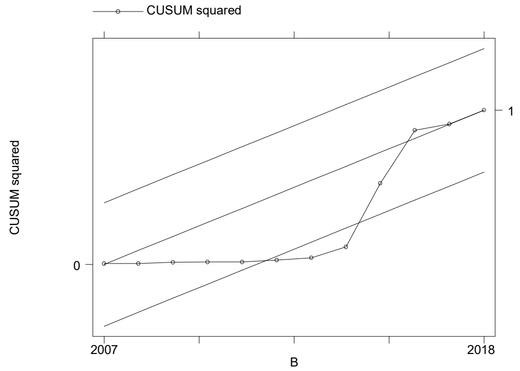
(**a**) ANG (**b**) BOT

(**c**) COM (**d**) DRC

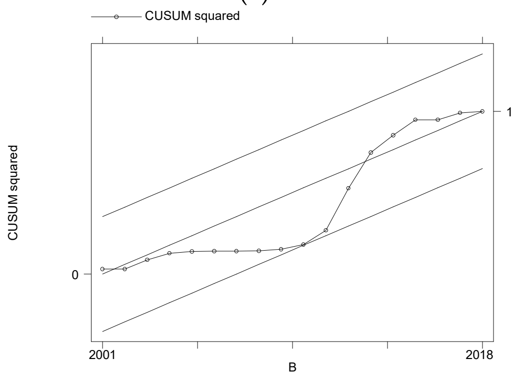
Figure A1. *Cont*.



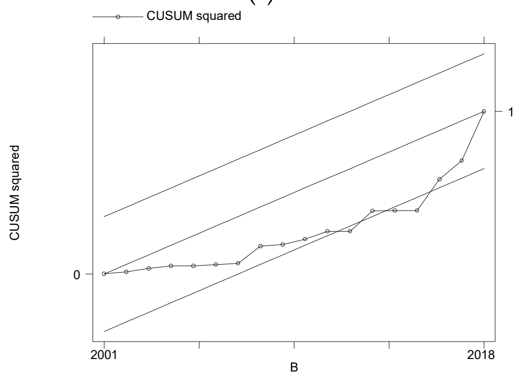
(**e**) ESW



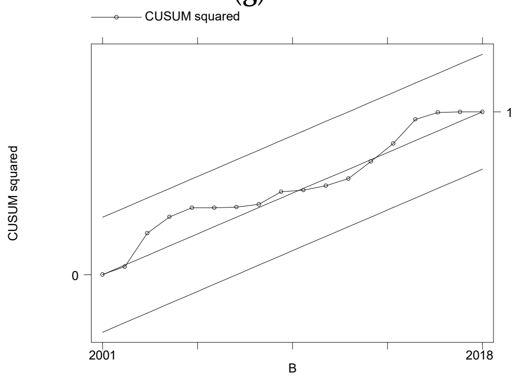
(**f**) LES



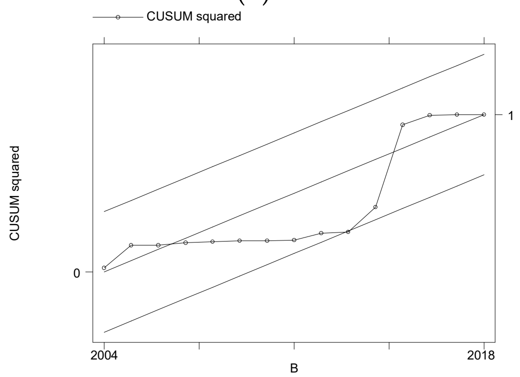
(**g**) MAD



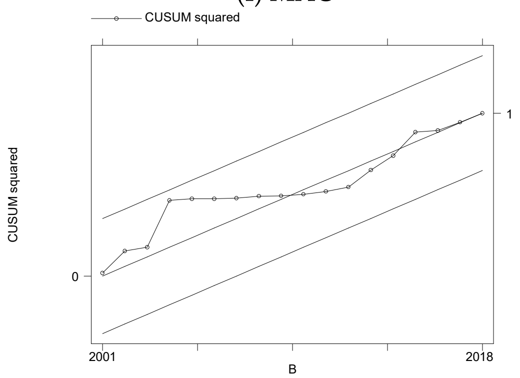
(**h**) MAL



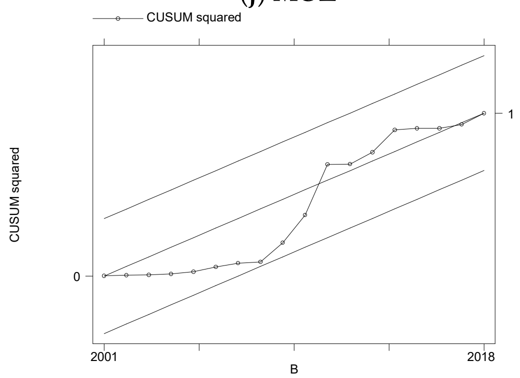
(**i**) MAU



(**j**) MOZ

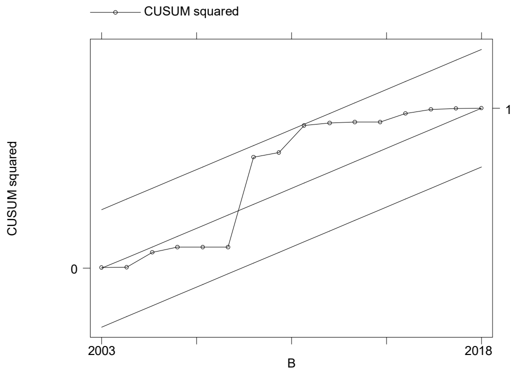


(**k**) NAM

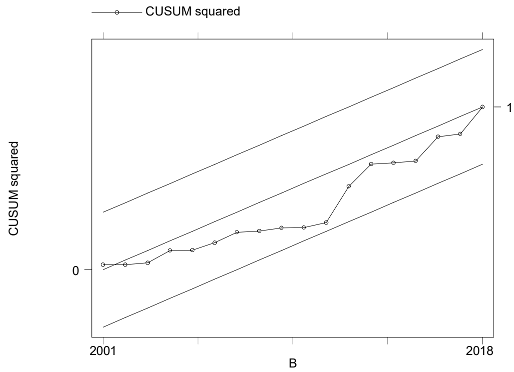


(**l**) SEY

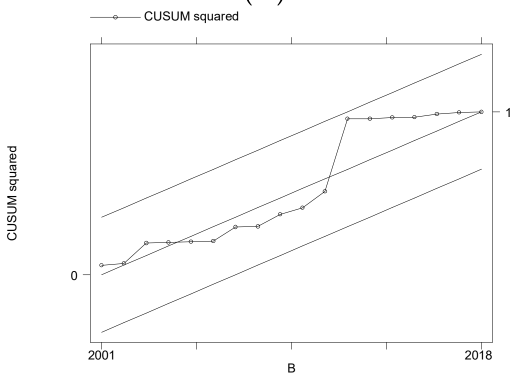
Figure A1. *Cont*.



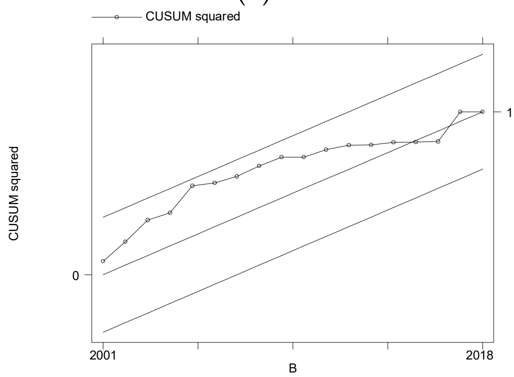
(**m**) SA



(**n**) TAN



(**o**) ZAM



(**p**) ZIM

Figure A1. Plot of the Cumulative Sum of Squares of Recursive Residuals (CUSUM Plots of Squares) Source: Extract from STATA results.

References

1. Bayar, Y.; Smirnov, V.; Danilina, M.; Kabanova, N. Impact of Institutions and Human Capital on CO_2 Emissions in EU Transition Economies. *Sustainability* **2022**, *14*, 353. [CrossRef]
2. Lim, W.M. The sustainability pyramid: A hierarchical approach to greater sustainability and the United Nations Sustainable Development Goals with implications for marketing theory, practice, and public policy. *Australas. Mark. J.* **2022**, *30*, 142–150. [CrossRef]
3. Garidzirai, R. Time Series Analysis of Carbon Dioxide Emission, Population, Carbon Tax and Energy Use in South Africa Provided. *Int. J. Energy Econ. Policy* **2020**, *10*, 353–360. [CrossRef]
4. United Nations. The 17 Goals: Sustainable Development Goals. 2022. Available online: https://sdgs.un.org/goals (accessed on 10 November 2022).
5. Iiyama, M.; Neufeldt, H.; Dobie, P.; Njenga, M.; Ndegwa, G.; Jamnadass, R. The potential of agroforestry in the provision of sustainable woodfuel in sub-Saharan Africa. *Curr. Opin. Environ. Sustain.* **2014**, *6*, 138–147. [CrossRef]
6. SADC Secretariat. *Southern African Development Community (SADC) Regional Indicative Strategic Development Plan (RISDP) 2020–2030*; SADC Secretariat: Gaborone, Botswana, 2020.
7. SADC. Environment and Climate. 2022. Available online: https://www.sadc.int/pillars/environment-climate-change (accessed on 2 October 2022).
8. Bowa, K.C.; Mwanza, M.; Sumbwanyambe, M.; Ulgen, K.; Pretorius, J.-H. Assessment of Electricity Industries in SADC Region Energy Diversification and Sustainability. *Adv. Sci. Technol. Eng. Syst. J.* **2021**, *6*, 894–906. [CrossRef]
9. Ahmed, Z.; Wang, Z. Investigating the Impact of Human Capital on the Ecological Footprint in India: An Empirical Analysis. *Environ. Sci. Pollut. Res.* **2019**, *26*, 26782–26796. [CrossRef]
10. Zahoor, A.; Asghar, M.M.; Nasir, M.N.; Kishwar, N. Moving towards a sustainable environment: The dynamic linkage between natural resources, human capital, urbanization, economic growth, and ecological footprint in China. *Resour. Policy* **2020**, *67*, 101677.
11. Ahmed, Z.; Zafar, M.W.; Ali, S.; Danish. Linking Urbanization, Human Capital, and the Ecological Footprint in G7 Countries: An Empirical Analysis. *Sustain. Cities Soc.* **2020**, *55*, 102064. [CrossRef]
12. Chankrajang, T.; Muttarak, R. Green Returns to Education: Does Schooling Contribute to Pro-Environmental Behaviours? Evidence from Thailand. *Ecol. Econ.* **2017**, *131*, 434–448. [CrossRef]

13. Ismail, S.S.M.; Hilal, O.A. Behaving green. Who takes the lead? The role of responsible leadership, psychological ownership, and green moral identity in motivating employees green behaviors. In *Global Business and Organizational Excellence*; Wiley Online Library: Hoboken, NJ, USA, 2002.
14. Lan, J.; Munro, A. Environmental Compliance and Human Capital: Evidence from Chinese Industrial Firms. *Resour. Energy Econ.* **2013**, *35*, 534–557. [CrossRef]
15. Azam, M. Relationship between Energy, Investment, Human Capital, Environment, and Economic Growth in Four BRICS Countries. *Environ. Sci. Pollut. Res.* **2019**, *26*, 34388–34400. [CrossRef]
16. Abdouli, M.; Omri, A. Exploring the Nexus among FDI Inflows, Environmental Quality, Human Capital, and Economic Growth in the Mediterranean Region. *J. Knowl. Econ.* **2021**, *12*, 788–810. [CrossRef]
17. Çakar, N.D.; Gedikli, A.; Erdoğan, S.; Yıldırım, D. Exploring the Nexus between Human Capital and Environmental Degradation: The Case of EU Countries. *J. Environ. Manag.* **2021**, *295*, 113057. [CrossRef]
18. World Bank. Human Capital Project. 2022. Available online: https://www.worldbank.org/en/publication/human-capital (accessed on 12 October 2022).
19. Jain, M.; Nagpal, A. Relationship between Environmental Sustainability and Human Development Index: A Case of Selected South Asian Nations. *Vision* **2019**, *23*, 125–133. [CrossRef]
20. Grossman, G.M.; Krueger, A.B. Environmental Impacts of a North American Free Trade Agreement, NBER Working Papers 3914, National Bureau of Economic Research, Inc. 1991. Available online: https://www.nber.org/system/files/working_papers/w3914/w3914.pdf (accessed on 12 October 2022).
21. Vijayan, S.; Arjunan, T.; Kumar, A. Exergo-Environmental Analysis of an Indirect Forced Convection Solar Dryer for Drying Bitter Gourd Slices. *Renew. Energy* **2020**, *146*, 2210–2223. [CrossRef]
22. Platform for Advancing Green Human Capital. Advancing Green Human Capital: A Framework for Policy Analysis and Guidance. 2017. Available online: http://hdl.voced.edu.au/10707/445465 (accessed on 12 October 2022).
23. Munawar, S.; Yousaf, H.Q.; Ahmed, M.; Rehman, S. Effects of green human resource management on green innovation through green human capital, environmental knowledge, and managerial environmental concern. *J. Hosp. Tour. Manag.* **2022**, *52*, 141–150. [CrossRef]
24. Asongu, S.A.; Tchamyou, V.S. Human Capital, Knowledge Creation, Knowledge Diffusion, Institutions and Economic Incentives: South Korea versus Africa. *Contemp. Soc. Sci.* **2020**, *15*, 26–47. [CrossRef]
25. Xu, R.; Lin, B. Why Are There Large Regional Differences in CO_2 Emissions? Evidence from China's Manufacturing Industry. *J. Clean. Prod.* **2017**, *140*, 1330–1343. [CrossRef]
26. Yang, L.; Li, Z. Technology Advance and the Carbon Dioxide Emission in China–Empirical Research Based on the Rebound Effect. *Energy Policy* **2017**, *101*, 150–161. [CrossRef]
27. Jiao, J.; Yang, Y.; Bai, Y. The Impact of Inter-Industry R&D Technology Spillover on Carbon Emission in China. *Nat. Hazards* **2018**, *91*, 913–929. [CrossRef]
28. Bano, S.; Zhao, Y.; Ahmad, A.; Wang, S.; Liu, Y. Identifying the Impacts of Human Capital on Carbon Emissions in Pakistan. *J. Clean. Prod.* **2018**, *183*, 1082–1092. [CrossRef]
29. Zhang, L.; Godil, D.I.; Bibi, M.; Khan, M.K.; Sarwat, S.; Anser, M.K. Caring for the Environment: How Human Capital, Natural Resources, and Economic Growth Interact with Environmental Degradation in Pakistan? A Dynamic ARDL Approach. *Sci. Total Environ.* **2021**, *774*, 145553. [CrossRef] [PubMed]
30. Sharma, G.D.; Shah, M.I.; Shahzad, U.; Jain, M.; Chopra, R. Exploring the Nexus between Agriculture and Greenhouse Gas Emissions in BIMSTEC Region: The Role of Renewable Energy and Human Capital as Moderators. *J. Environ. Manag.* **2021**, *297*, 113316. [CrossRef] [PubMed]
31. O'Neill, B.C.; Carter, T.R.; Ebi, K.; Harrison, P.A.; Kemp-Benedict, E.; Kok, K.; Pichs-Madruga, R. Achievements and needs for the climate change scenario framework. *Nat. Clim. Chang.* **2020**, *10*, 1074–1084. [CrossRef]
32. Egesa, K.; Legoff, G.; Borga, M.; Pegoue, A.; Rodelgo, A.S.; Entaltsev, D. Measuring Carbon Emissions of Foreign Direct Investment in Host Economies. *IMF Work. Pap.* **2022**, *2022*, 1. [CrossRef]
33. Wang, Y.; Huang, Y. Impact of Foreign Direct Investment on the Carbon Dioxide Emissions of East Asian Countries Based on a Panel ARDL Method. *Front. Environ. Sci.* **2022**, *10*, 878. [CrossRef]
34. Akbar, U.; Li, Q.-L.; Akmal, M.A.; Shakib, M.; Iqbal, W. Nexus between Agro-Ecological Efficiency and Carbon Emission Transfer: Evidence from China. *Environ. Sci. Pollut. Res.* **2021**, *28*, 18995–19007. [CrossRef]
35. Begum, R.A.; Sohag, K.; Abdullah, S.M.S.; Jaafar, M. CO_2 Emissions, Energy Consumption, Economic and Population Growth in Malaysia. *Renew. Sustain. Energy Rev.* **2015**, *41*, 594–601. [CrossRef]
36. Pesaran, M.H.; Shin, Y.; Smith, R.P. *Pooled Estimation of Long-Run Relationships in Dynamic Heterogeneous Panels*; University of Cambridge, Department of Applied Economics: Cambridge, UK, 1997.
37. Pesaran, M.H.; Shin, Y.; Smith, R.P. Pooled Mean Group Estimation of Dynamic Heterogeneous Panels. *J. Am. Stat. Assoc.* **1999**, *94*, 621–634. [CrossRef]
38. Zahonogo, P. Trade and economic growth in developing countries: Evidence from sub-Saharan Africa. *J. Afr. Trade.* **2017**, *3*, 41. [CrossRef]
39. Guei, K.M.; le Roux, P. Trade Openness and Economic Growth: Evidence from the Economic Community of Western African States Region. *J. Econ. Financ. Sci.* **2018**, *12*, 1–9. [CrossRef]

40. Anjum, N.; Pervaiz, Z. Effect of Trade Openness on Unemployment in Case of Labour and Capital Abundant Countries. *Bull. Bus. Econ.* **2016**, *5*, 44–58.
41. Asteriou, D.; Stephen, G.H. *Applied Econometrics*, 3rd ed.; Palgrave Macmillan: New York, NY, USA; London, UK, 2016.
42. Shin, S.; Pesaran, M.H.; Smith, R.P. *Pooled Mean Group Estimation of Dynamic Heterogeneous Panels: Discussion Paper Series Number 16*; University of Edinburgh: Edinburgh, UK, 1998. Available online: http://www.econ.ed.ac.uk/papers/id16_esedps.pdf (accessed on 12 October 2022).
43. Hausman, J. Specification Tests in Econometrics. *Econometrica* **1978**, *46*, 1251–1271. [CrossRef]
44. Levin, A.; Lin, C.-F.; Chu, C.-S.J. Unit Root Tests in Panel Data: Asymptotic and Finite-Sample Properties. *J. Econom.* **2002**, *108*, 1–24. [CrossRef]
45. Im, K.S.; Pesaran, M.H.; Shin, Y. *Testing for Unit Roots in Heterogeneous Panels*; Department of Applied Economics, University of Cambridge: Cambridge, UK, 1997.
46. StataCorp. Xtunitroot Panel-Data Unit-Root Tests. Stata Longitud. *Data/Panel-Data Ref. Man.* **2013**, *13*, 440–469.
47. Sarkodie, S.A.; Strezov, V. Effect of Foreign Direct Investments, Economic Development and Energy Consumption on Greenhouse Gas Emissions in Developing Countries. *Sci. Total Environ.* **2019**, *646*, 862–871. [CrossRef]
48. Yazdi, S.K.; Dariani, A.G. CO_2 emissions, urbanisation and economic growth: Evidence from Asian countries. *Econ. Res.-Ekon. Istraživanja* **2019**, *32*, 510–553. [CrossRef]
49. Muhammad, B. Energy Consumption, CO_2 Emissions and Economic Growth in Developed, Emerging and Middle East and North Africa Countries. *Energy* **2019**, *179*, 232–245. [CrossRef]
50. Narayan, P.K.; Saboori, B.; Soleymani, A. Economic Growth and Carbon Emissions. *Econ. Model.* **2016**, *53*, 388–397. [CrossRef]
51. Brown, R.L.; Durbin, J.; Evans, J. Techniques for Testing the Constancy of Regression Relationships over Time. *J. R. Stat. Soc. Ser. B* **1975**, *37*, 149–192. [CrossRef]