Relationships among renewable energy, environmental degradation and economic growth in selected South Asian countries: Progress towards poverty alleviation and green economy

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Introduction

Globally, Greenhouse Gases (GHG) and caused climate change and global warming are well debated among researchers, scientists, government, head of states, policy makers and head of states. Carbon dioxide (co_2) emissions as the significant anthropogenic GHGs (Owusu & Asumadu-Sarkodie, 2016), which are accountable for more than 60 percent of the greenhouse effect (Ozturk & Acaravci, 2010), importantly contribute to the upsurge in temperatures of the world and especially climatic changec. Under these circumstances, policy makers try to bring cleaner environments without diminishing economic growth and proportions are being put forward with a determination to decrease reliance on non-renewable resources of energy, ensuring poverty reduction and energy security (Chaudhry, 2010; Pao & Tsai, 2010; Siddiqui, 2004).

The main objective of this study is to examine the short-run and long-run causality association among renewable energy, natural resource depletion, carbon-dioxide emission, poverty and Gross Domestic Product (GDP) in the South Asia region. This Study attempts to analyze the nexus between economic growth and environmental factors in the case of South Asian economies. This study used data from five countries: Pakistan, India, Sri Lanka, Nepal and Bangladesh, which have been categorized as developing and in transition to industrialized economies (see Table 1). Therefore, it is significant in order to understand the pattern of co_2 emission with an empirical analysis of these countries in their transitional phase of development.

Methodology

This study investigates the scenario of the study area using short and long run analyses. It was utilized the data on energy from electricity production, renewable sources (excluding hydroelectric (kwh)), carbon dioxide (co_2) emission, natural resources depletion, poverty head count ratio and gross domestic product (GDP) in select south Asian economies (Pakistan, Sri Lanka, India, Bangladesh and Nepal) over a time periods of 1970 to 2013.

Table 1 Trends in energy consumption, GDP (per capita) and Co_2 emission in South Asian countries (1980-2012)

Year	Pakistan	India	Bangladesh	Nepal	Sri Lanka
			Co_2emission per capita (metric tons)		
1980	0.4	0.498	0.092	0.037	0.225
1990	0.617	0.794	0.144	0.037	0.221
2000	0.74	1.138	0.21	0.139	0.531
2010	0.95	1.39	0.39	0.139	0.615
2011	0.93	1.48	0.41	0.2	0.75
2012	0.91	1.59	0.43	0.21	0.79
2013	0.94	1.59	0.44	0.23	0.78
			Energy consumption per capita (in Kg of oil equivalent)		
1980	309.55	293.51	101.84	317.12	307.5
1990	385.78	364.53	118.59	319.64	324.19
2000	445.42	438.65	140.43	349.7	435.9
2010	486.92	600.3	203.51	380.62	476.66
2011	481.61	613.71	204.72	382.63	499.33
2012	479.44	645	212.29	384.95	516.52
2013	488.42	606.87	215.29	401.37	487.37
			GDP per capita (in US $)		
1980	296.17	271.24	219.85	135.27	272.91
1990	360.15	375.89	283.97	200.29	472.08
2000	514.15	457.28	355.97	236.98	854.92
2010	1024.5	1419.1	664.06	596.37	2400
2011	1213.9	1533.6	731.89	704.18	2835.9
2012	1256.6	1489.2	752.15	690.2	2923.2

Note: statistical data is taken from WDI (2016) statistics.

Followed the study of Kanjilal and Ghosh (2013) and Zeb et al. (2014), this study based on panel data analysis for selected South Asian countries used the variables in log-linear form to express the interrelationship between several factors as specified in Eq.(1).

$$\text{LnERP}_{it} = \gamma_0 + \gamma_1 \ln\text{CRB}_{it} + \gamma_2 r_t + \gamma_3 \ln\text{DNR}_{it} + \gamma_4 \ln\text{GDP}_{it} + \gamma_5 \ln\text{PVE}_{it} + e_t \quad \ldots\ldots (1)$$

Where; ERP is measured as electricity production from renewable sources excluding hydroelectric in KWH, CRB is related to Carbon dioxide emission from electricity and heat production, Natural resource depletion (% of GNI) is denoted as DNR, GDP stands for Gross Domestic Product and PVE is measured by Poverty Head Count ratio and e_t is the error term.

The next step is based on Johansen's co-integration technique and Multivariate Granger-causality tests on error-correction model.

Table 2 Description of data

Variables	Measurement	Expected Sign
Electricity production from renewable sources, excluding hydroelectric (ERP)	Kilo Watt (hour kwh)	-
CO_2 emissions (CRB)	million (metric tons)	NEG
Depletion of natural resources (DNR)	GNI (%)	POS
Economic growth (GDP)	Current US $	POS
Poverty(PVE)	Head count ratio	NEG

Source: World Bank (2016)

Results and discussion

In the beginning of estimation process, it is essential to check the potential non-stationary problem through the tests of Augmented Dickey Fuller (ADF). The results for the ADF test indicate that all the given variables are integrated of first order $I(1)$.

Table 3 Results of Augmented Dickey Fuller (ADF) test

Name of the country	Variables	Constant	with trend	Differences
Pakistan				
	ERP	-1.18665	2.363889	5.337277*
	CBR	0.709058	-2.609058	-6.07238*
	DNR	0.519043	-	-5.07238**
	GDP	5.34999	2.404476	-3.8686***
	PVE	-3.41251*	-3.7654	-7.07238*
Sri Lanka				
	ERP	-1.652866	-2.548819	-6.301651*
	CBR	-0.3336	-2.77011	-8.404942*
	DNR	-3.318946	-3.56789**	-6.98670*
	GDP	2.84693	2.770111	-3.4768***
	PVE	2.004049	3.390244	-3.90350*
Bangladesh				
	ERP	-0.730699	-2.837307	-7.905479*
	CBR	-5.94567	2.509475	-8.406328*
	DNR	-2.091018	-2.45677	-5.709683*
	GDP	3.105025	2.800513	-3.12786**
	PVE	-6.71803*	-6.340358	-11.40655*
INDIA				
	ERP	-0.085734	1.123654	-4.805354*
	CBR	5.565676	-0.214521	-5.43854**
	DNR	-3.03345*	-2.908762	-9.750834*
	GDP	2.738986	2.56042	-3.345678*
	PVE	-1.58623	-1.107559	-13.90139*
NEPAL				
	ERP	3.879755	-0.575110	-5.354382*
	CBR	-1.897576	8.30370*	-4.192437*
	DNR	-2.96639	-3.45678	-7.152066*
	GDP	6.356332	6.100045	-3.86860**
	PVE	-1.724265	-1.404712	-10.54345*

*Note: The lag length (optimum) was designated using Akaike criterion (AIC) *, ** and *** shows 1%, 5 %and 10% significance levels.*

Therefore, multivariate co-integration test was applied by using Johansen and Juselius test (in 1990) with the maximum likelihood estimation method. Table 3 shows the results of ADF test. The results of Johansen and Juselius integration which was done to check the results of multivariate co integration test show one cointegration relationship among India, Bangladesh and Nepal. This scenario predicts that there is a long run relationship among electricity production (from renewable sources), natural resource depletion, GDP, carbon dioxide emission and poverty. Results are supported by Zeb et al. (2014) and Paramati et al. (2017), where they found significant long-run relationship between use of energy, GDP growth and carbon dioxide emission.The strong relationship found between economic growth, use of energy and environmental issues are found in the literature of Ang (2007, 2008), Halicioglu, (2009), Jalil and Mahmud (2009), Zhang and Cheng(2009). However, a long run relationship was not found among dependent and independent variables in the case of Pakistan and Sri Lanka. These results are consistent with the results of Zeb et al. (2014) in the case of south Asian countries from the period of 1975 to 2010.

Table 4 Results of Johnson cointegration test

Null Hyp	Alt Hyp	test stats	At 5%(critical values)	p-value
Pakistan				
λ_{trace}	λ_{trace}			
hy=0*	hy>0	88.37389	77.97277	0.0065
hy = ≤ 1	hy>1	53.75752	54.07904	0.0434
hy = ≤ 2	hy>2	32.69432	36.19275	0.0719
λ_{max}	λ_{max}			
hy=0*	hy>0	31.61637	34.80587	0.0892
hy = ≤ 1	hy>1	22.0632	28.58808	0.3351
hy = ≤ 2	hy>2	19.07252	22.29962	0.1757
Sri Lanka				
λ_{trace}	λ_{trace}			
hy=0*	hy>0	48.26514	69.81889	0.8732
hy = ≤ 1	hy>1	25.37265	48.85613	0.9343
hy = ≤ 2	hy>2	10.26915	30.23457	0.9544
λ_{max}	λ_{max}			
hy=0*	hy>0	0 24.89248	33.87687	0.3923
hy = ≤ 1	hy>1	13.1035	13.1035	0.8792
hy = ≤ 2	hy>2	2 7.556833	21.13162	0.928
Bangladesh				
λ_{trace}	λ_{trace}			
hy=0*	hy>0	91.905	68.818	0
hy = ≤ 1	hy>1	61.623	49.7568	0.03
hy = ≤ 2	hy>2	24.875	29.978	0.302
λ_{max}	λ_{max}			
hy=0*	hy>0	42.305	34.768	0.001
hy = ≤ 1	hy>1	25.713	28.584	0.063
hy = ≤ 2	hy>2	12.672	21.231	0.48

Note: Hyp = Hypotheses testing, Alt= Alternative hypotheses.

Table 4 continued.

Null Hyp	Alt Hyp	test stats	At 5%(critical values)	p-value
India				
λ_{trace}	λ_{trace}			
hy=0*	hy>0	81.76955	68.99881	0.0035
hy = ≤ 1	hy>1	43.46148	46.7658	0.221
hy = ≤ 2	hy>2	22.5643	29.8765	0.3296
λ_{max}	λ_{max}			
hy=0*	hy>0	37.2288	33.98787	0.27961
hy = ≤ 1	hy>1	37.34568	34.87651	0.091
hy = ≤ 2	hy>2	10.39564	21.5678	0.7172
Nepal				
λ_{trace}	λ_{trace}			
hy=0*	hy>0	40.1347	48.8561	0
hy = ≤ 1	hy>1	40.1342	47.6785	0.1237
hy = ≤ 2	hy>2	18.5268	29.8698	0.5334
λ_{max}	λ_{max}			
hy=0*	hy>0	63.7654	33.87687	0
hy = ≤ 1	hy>1	21.70502	27.8765	0.2359
hy = ≤ 2	hy>2	14.7843	21.1316	0.3425

Note: Hyp = Hypotheses testing, Alt= Alternative hypotheses.

Table 4 shows that there is one long run co-integration in Nepal and Bangladesh among the production of electricity from carbon dioxide emission, natural resource depletion, renewable sources, poverty and GDP. The results of trace statistics show that there is no co-integrating or long run relationship between the variables and null hypotheses cannot be rejected in the case of both of these countries.

The results of the multivariate Granger-causality technique on Error-correction (EC) model the required negative (-) sign shows speed of adjustment and statistical significance of the error correction in all equations indicates a long-run impact of variables. The equations of renewal energy production, natural resource depletion and poverty signify a long run impact of variables in case of Bangladesh. The unidirectional long-run relationship found towards ERP, GDP to PVE, between CRB, ERP to GDP and towards DNR to GDP in the case of India. The long-run relationship is found by Attiaou et al. (2017) and Rashid and Rehaman (2017) among these variables.

The results of statistical significance of the EC with the negative sign reflects speed of adjustment of after a shock from previous year in PVE, GDP and DNR equations. Other findings represent that there is bidirectional granger causality between poverty and energy production and carbon-dioxide emission and natural resource exhaustion in Pakistan.

Table 5 Results of multivariate granger-causality tests

Regression	DERP	DCRB	DDNR	DGDP	DPVE	Error term (e_t)
Pakistan						
DERP	-	4.0762	2.3639	0.8701	9.3377*	-4.6022
DCBR	0.2140	-	0.6091	0.4032	1.5064	-0.054*
DDNR	0.2342	0.5190	-	1.8007	0.7088	-0.0030
DGDP	4.2401	0.3500	1.4045	-	1.4060	-2.5570
DPVE	8.9576*	0.4125	3.9817	2.8120	-	-0.0840
Sri Lanka						
DERP	-	0.2529	0.5488	2.3017	-0.4064	-3.6704
DCBR	0.9938	-	0.7824	1.4049	1.0889	-0.2080
DDNR	2.4630	1.3189	-	0.5047	0.4501	-0.2070
DGDP	2.1874	0.8469	2.7701	-	0.0752	-2.6690
DPVE	12.3442*	2.0040	3.3902	3.9035	-	-0.432*
Bangladesh						
DERP	-	1.7307	0.8373	2.9055	-5.300271*	-8.840*
DCBR	0.7084	-	2.5095	3.4063	1.2005	0.0400
DDNR	0.8065	8.0918*	-	2.7097	0.6954	-2.80*
DGDP	1.2037	9.1050*	0.8005	-	2.6016	-3.8700
DPVE	0.4615	0.7180	2.3404	0.6035	-	-0.605*
India						
DERP	-	0.8857	2.1237	5.8053**	5.834871*	-0.0001
DCBR	10.0658*	-	1.1452	5.4385**	1.0304	-144563
DDNR	0.1023	1.0833	-	6.75083*	1.2844	-4.1100
DGDP	1.8355	2.7390	2.5604	-	2.8467	-5.210*
DPVE	5.0871	4.5862	1.1076	4.0014	-	-4.789*
Nepal						
DERP	-	0.8798	0.5751	0.3544	1.3004	-3.0000
DCBR	3.8626	-	8.3037*	2.1924	2.1206	-0.7850
DDNR	1.0681	8.1966*	-	3.6521	3.9549	-0.4300
DGDP	1.7468	0.3563	5.1000	-	1.5342	-1.6900
DPVE	2.5163	0.1243	0.2047	1.4543	-	-0.0219

*Note: ** and * shows the 5% and 10% statistical significant levels respectively. '(-)' denotes not appropriate and in the parenthesis are degrees of freedom.*

Results are supported by Zeb et al. (2014), Jebli and Youssef (2015) and Paramati et al. (2017), where they found significant long-run relationship between use of energy, GDP growth and carbon dioxide emission, results are consistent with Attiaou et al. (2017). The strong relationship found between economic growth, use of energy and environmental issues are found in the literature of Ang (2007, 2008), Halicioglu, (2009), Jalil and Mahmud (2009) and Zhang and Cheng (2009). However, there is no long run relationship found among dependent and independent variables in the case of Pakistan and Sri Lanka, results are consistent with the results of Zeb et al. (2014) in the case of South Asian countries from the

period of 1975 to 2010. The positive unidirectional causality running towards PVE to ERP and error correction (EC) term is significant and has negative sign in case of Sri-Lanka, results are consistent with the findings of (Dafauce & Martin, 2015) that Sri Lanka as low income country have high consumption of renewable energy (biomass) consumption. Nepal found positive bidirectional causality between CRB and DNR, results are consistent with Akhmat et al. (2014), where they found carbon dioxide, air pollution and its adverse effects on environment in developing countries also.

The results show that the distortion of natural resources leads to spiraling carbon emissions, as distortion of natural resources leads to spiraling carbon emissions whereas an increase in energy production increases in carbon emissions in these countries. Because growing demand of for fossils fuels to intensive use of energy lead to depletion of natural resources, higher carbon dioxide emission and finally environmental degradation (Rashid & Rehaman, 2017). Consequently, a significant rise in production of energy leads to growth in GDP which further upsurge carbon dioxide emission in the region, results found consistent Chien and Hu (2007), Chien and Hu (2008), Shahbaz et al. (2011).

Table 6 shows the overall results of cointegration of Pedroni Panel cointegration test for study area. It indicates that there is long-run association between these variables, a panel cointegration technique to examine the long-run equilibrium relationship among the variables. The panel cointegration method is very useful, if a time series component of all cross section is short (Alam & Paramati 2015). Due to benefit, many researchers started applying the panel cointegration approach to observe the long-run equilibrium correlation among the variables. This analysis applies Fisher-type Johansen cointegration methodology which is developed by Maddala and Wu (1999).

Table 6 Pedroni Panel co-integration test results

Alternative hypothesis: "with common AR coefficients" (within - dimension)				
Panel v (stat)	Statistics values	p-value	Weighted statistics	p-value
Panel v-(stat)	1.656867	0.0488**	0.822052	0.1855
Panel rho-(stat)	-1.480148	0.0694***	-1.363888	0.0763***
Panel PP- (stat)	-3.641114	0.0001*	-4.138672	0.0010*
Panel ADF-(stat)	-3.819671	0.0001*	-4.138672	0.0000*
Alternative hypothesis: individual common AR coefficients. (Within - dimension)				
Tests	-0.70855			0.2456
Group rho-stat				
Group PP-stat	-3.470020 0.0000		0	
Group ADF-stat	-3.860477 0.0000		0	

Table 6 Continued.

(II) Johansen test of fisher Panel Co- integration

Unrestricted Co-integration Rank statistics Test (from Trace and Maximum Eigenvalue)

Tests	Fisher Stat. (applying trace test)	P-value	Fisher (statistics). (Maxeigentest)	p-value
None	164.7	0.0000*	93.92	0.0000*
At most 1	1 89.53	0.0000*	52.69	0.0000*
At most 3	57.86	0.0000*	27.76	0.0001*
At most 4	37.71	0.0001*	25.8	0.0034*
At most 2	23.71	0.0130**	23.71	0.0130**
(III) Test of Kao Residual Co-integration				
None			t-Statistic	p-value
ADF test			-5.00078	0

Where, stats= statistics and Probabilities are calculated applying asymptotic Chi-square distribution.

Table 7 Results of panel groups FMOLS statistics

Variables	Coefficients	t-values
ERP equation		
CBR	1.251	2.602*
DNR	-4.821	-0.927
GDP	0.047	2.963*
PVE	4.775	2.316*
CBR equation		
ERP	9.08	6.743*
DNR	1.11	1.970***
GDP	1.3	0.77
PVE	0.036	1.566
DNR equation		
ERP	3.812	0.037
CBR	0.017	1.605
GDP	-1.981	-0.735
PVE	0.013	1.001
GDP equation		
ERP	3.2	7.230*
CBR	1.244	9.980*
DNR	-2.31	-0.965
PVE	-3.403	-2.357*
PVE equation		
ERP	6.76	2.218*
CBR	0.017	0.053
NRD	2.425	0.901
GDP	-1.99	-0.448

The test of cointegration explains the long-run correlation among the underlying vectors. Therefore, in this analysis, it was used fully modified OLS (FMOLS) estimation technique (Table 7) designed by Pedroni (2001) which provided

consistent and unbiased long run coefficients in the model. The results of panel FMOLS analysis show that carbon dioxide emission, GDP and poverty are significantly associated with ERP. Further, it was found an inverse relationship in between GDP and poverty, results are consistent with the finding of Zaman and Moemen (2017) based on SAARC countries and poverty and positive relationship in between ERP and CRB which is very consistent with the results of Zeb et al. (2014). These results indicate that when electricity is produced from renewable sources of energy, there is a tendency to increase CRB and raise GDP. Accordingly, it can be noticed that ERP has a significant positive correlation with CRB also supported by Long et al. (2015). Furthermore, study reveals that GDP has a positive association with ERP and CRB. Overall, the statistical results provide evidences for the presence of a positive causal relationship and have a long-run presence of energy production, environmental degradation and income in the region.

Conclusion

The findings of the study explain that long run cointegration relationship exist among these variable for all selected countries. The term error correction is significant with the required negative (-) sign for all selected countries revealing speed of adjustment of after a shock from previous year. Pedroni Panel Cointegration test and Panel Group FMOLS is used. It indicates that there is long-run association between these variables, a panel co-integration technique to examine the long-run equilibrium relationship among the variables. The results of Pedroni Panel cointegration test reveal that there is a long run relationship among Renewable energy, GDP, carbon dioxide emission, depletion of natural resources and poverty, as evident from the statistically significant Panel rho, Panel PP and group ADF statistics. The results of Panel FMOLS analysis show that carbon dioxide emission, GDP and poverty are significantly associated with ERP. Further, it was found an inverse relationship in between GDP and poverty, results are consistent with the finding of Zaman and Moemen (2017) based on SAARC countries and poverty and positive relationship in between ERP and CRB which is very consistent with the results of Zeb et al. (2014). These results indicate that when electricity is produced from renewable sources of energy, there is a tendency to increase CRB and raise GDP. Accordingly, it can be noticed that ERP has a significant positive correlation with CRB.

For policy recommendation there is basic requirement for corporation on the international level to overcome the problem of global environmental.

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