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The impact of population on environmental degradation in South Asia: application of seemingly unrelated regression equation model

Abstract

The objective of this study is to undertake an empirical study for interaction between population and environmental degradation of 1985-2009 for three SAARC countries i.e., India, Pakistan and Sri Lanka. The Im-Pesaran-Shin (IPS) test of unit root is applied to find out the order of integration. The long-run relationship is investigated through the Pedroni test of panel cointegration. Finally, the seemingly unrelated regression equation (SURE) model is used for estimation of the impact of demographics indicators on environmental factors in these three countries. The result reveals that excessive population growth rate has a deleterious impact on environment. Increase in population put pressure on demand to produce more, this may cause increase in arable land and growing population that exerts pressure on agriculture land, forcing the cultivation on land poorer and poorer quality deterioration.

Keywords: population dynamics, environmental degradation, panel cointegration, population and environment.
JEL Classification: C23, O13, Q56.

Introduction

Developing countries have been experiencing a serious problem of rapidly growing population which results in accelerating environmental degradation. High population growth rate with low per-capita income has worsened environmental condition during the past four decades that seem to erode the economic and social progress of SAARC (South Asian Association for Regional Cooperation) countries specifically. A complex and dynamic relationship is observed between population and environment. They are closely intertwined with each other. The relationship between population and environment is mediated by a number of socio-economic, cultural, political, and developmental variables which relative significance varies considerably from one context to another. Over the past three to four decades, economists, biologists, and environmentalists have been debating the role of population in environmental degradation (Hummel et al., 2009).

Research proves that population is considered an important source of development, yet it is also a major source of environmental degradation when it exceeds the threshold limits of the support system. Population growth has an impact on the environment primarily through the consumption of natural resources and production of wastes. It is also associated with environmental stresses like loss of biodiversity, air and water pollution and increased pressure on arable land (UNRISD, 1994). Main factors causing degradation to air quality are: (a) rapidly growing energy demand; and (b) swiftly growing transport sector. In cities, extensive usage of low quality fuel, combined with the dramatic expansion in the number of vehicles on roads, has led to significant air pollution problems. In Pakistan's most populated cities like Lahore and Karachi, air pollution levels are high and are climbing up at accelerating rate causing serious health issues. Although Pakistan's energy consumption is still low according to world standards, but lead and carbon emissions are the major air pollutants in urban areas (Government of Pakistan, 2009-2010).

India. The recent global developments are challenging India's strong growth performance of the recent years. India's economy has enjoyed a high GDP growth rate of above 9 percent in recent years and now it's likely to experience a low GDP growth around 7.4 percent in 2008. Increase in oil and world commodity prices and partial pass-through of price increases have triggered steep domestic inflation in double digit (11.5 percent) in 2008 from a low level of 4.7 percent in 2007 (ADB, 2008). The level and pattern of economic development also affect the nature of environmental problems. India's development objectives have consistently emphasized the promotion of policies and programs for economic growth and social welfare. Between 1994-1995 and 1997-1998, the Indian economy has grown a little over 7 percent per annum: the growth of industrial production was recorded, averaging higher than 8.4 percent and manufacturing was 8.9 percent during these years. The manufacturing technology adopted by most of the industries has placed a heavy load on environment especially through intensive resource and energy use, as is evident in natural resource depletion (fossil fuel, minerals, and timber), water, air and land contamination, health hazards and degradation of natural ecosystems. Fossil fuels have high proportion of consumption as the main source of industrial energy and major air polluting industries such as iron and steel, fertilizers and cement. Growing industrial sources have contributed to a relatively high share in air pollution. According to UNEP (1999), large quantities of industrial and hazardous wastes, brought about by expansion of chemical based industry have compounded the wastes management problem with serious environmental health implications.

Pakistan. Pakistan is the world's sixth most populous country, with an estimated population of 169.9 million as at the end of June 2009. As Pakistan's annual growth rate (revised) is 2.05 percent, it is expected that Pakistan will become the fourth largest nation on earth in population terms by 2050. According to Government of Pakistan (2009-2010), since 1950, it is estimated that Pakistan's urban population has expanded over sevenfold. The proportion of population residing in urban centers has risen to 36%. In 2008, the unprecedented increase in global oil and food prices and domestic policy uncertainties have stressed the economy which revealed as a slowdown in growth rate, buildup in inflation, wide fiscal and current account deficits, weaker currency, and large drop off in foreign reserves. Increased risk perception has been seen in downgrading of credit ratings, rise in sovereign bond spreads, slide in capital inflows, and declining access to international capital. The GDP growth rate in 2008 was expected close to 4.5 percent significantly down from 6.8 percent which was achieved in 2007. Since then the inflationary pressures are high on both food and non-food items. Inflation was expected to increase to 12 percent in 2008 from 7.8 percent in 2007 (World Economic Outlook, 2008). Growth in the agriculture sector (the backbone of Pakistan's economy) is strongly reliant on the state of the environment, particularly on the country's land and water resources. The industrial sector is also dominated by agro-industries which is also dependent on the environment. However, finding show that there is general agreement on the prevailing deterioration of the environmental situation in the country. Current environmental problems in Pakistan include land degradation due to erosion, use of agrochemicals, water logging and salinity, depletion of forest and water resources, and pollution associated with industrial and domestic activities (Hussain and Giordano, 2004).

Sri Lanka. The country's economy, grew by 6.8 percent in 2007, and was estimated to grow around 6 percent in 2008, mainly due to the global slowdown affecting Sri Lanka's key export markets. In 2008, the Government increased fuel prices several times to allow a pass-through of international oil price increases. Electricity tariffs were also revised in 2008, reflecting cost pressures on thermal power generation. Adjustment in price has pushed up inflation, which is expected to reach 24.0 percent in 2008, compared to the 15.2 percent in 2007 (SHRDC, 2008). The major environmental challenges that Sri Lanka faces today include land degradation, deforestation, water pollution, coastal erosion, and growing urban and industrial pollution. Many factors contribute to the country's environmental challenges, but especially institutional and policy failures as well as inadequate funding are the most significant (Government of Sri Lanka, 2007).

The above discussion confirms a strong linkage between population and environmental degradation in the specific context of India, Pakistan and Sri Lanka. Agriculture sector is strongly dependent on environment, particularly on land and water resources. Current environmental problems associated with agriculture interalias include land degradation due to erosion, use of agrochemicals, water logging and salinity, depletion of forest and water resources.

In this paper an analysis has been carried out to find a panel relationship between population and environment in India, Pakistan and Sri Lanka by using secondary data from 1985 to 2009. This paper does not include all dimensions and factors of the population-environment problem but is limited to the following variables:

- **Population.** According to Marcoux (1999) there is a sharp variance between two main ideas: (1) stabilizing population to protect the environment; and (2) slowing population growth to foster more rapid economic growth. The problem is that economic growth, even coupled with slower population growth or even population stabilization, brings about greater environmental damage, other things being equal. In this study population growth and population density are taken into account which is represented by PG and PD.
- **Environment.** According to the United Nations International Strategy for Disaster Reduction (UN/ISDR, 2004) environmental degradation is defined as the reduction of the capacity of the environment to meet social and ecological objectives, and needs. Potential effects are varied and may contribute to an increase in vulnerability and the frequency and intensity of natural hazards. Some examples are: land degradation, deforestation, desertification, wild land fires, loss of biodiversity, land, water and air pollution, climate change, sea level rise and ozone depletion. In this study arable land and carbon dioxide emission were taken into account which is represented by AL and CO_2.

The objectives of this paper are to empirically investigate:

1. Whether there has been long-run relationship between population and environmental degradation in the context of Pakistan, India and Sri Lanka.
2. Whether population affects put stress on the environment and resources.

The paper is organized as follows. After introduction literature review is carried out in Section 1. Methodological framework is explained in Section 2. The estimation and interpretation of results are mentioned in Section 3. Finally, the last Section concludes the paper.

1. Literature review

The "population-environment nexus" has become a major issue in the recent literature on sustainable development. A large number of studies have been carried out to show how population affect environment. Some suggested that rapidly growing population not only increases pressure on marginal lands, over-exploitation of soils, overgrazing, over cutting of wood, soil erosion, silting, flooding but also increases excess use of pesticides, fertilizers, causing land degradation and water pollution (Khan et al., 2009).

Numerous researchers have suggested that population growth is the root cause of poverty and human sufferings (Malthus, 1798; Allen and Barness, 1995; Repetto and Holmes, 1983; Rudel, 1989; and Ehlich and Holdren, 1971). Boserup (1965) explained how technological advancement and increased innovation in the field of agriculture became the result of increased density of population. Trainer (1990) stated that most of the developing countries suffer because of the rapid increase in population, that in turns cause to deplete natural resources, raising air and water pollution, deforestation, soil erosion, over grazing and damage to marine and coastal ecosystem. Because of rapidly growing population there is a tremendous pressure on the environmental resources to produce more food. Cropper and Griffiths (1994) argued that population growth, by increasing the demand for arable land, encourages the conversion of forests to agriculture. Since the people living in rural areas who are dependent on agriculture as a livelihood, one would expect deforestation to increase with rapid population density as well as rising demand for wood used for both timber and fuel. Cleaver and Schreiber (1994) found a declining trend among food productivity; population growth and natural resources, which deplete soil productivity resulting in vicious circle of population, poverty and environmental degradation. Meadow et al. (1974) concluded that if present trends in the world population, industrialization, pollution, food production and resource depletion continued with the same pace, the most probable result will be an uncontrollable decline in both population and industrial capacity. According to Ehrlic and Holden (1971), rising human population is the predominant factor in accelerating pollution and other resources problems, in both developed and developing nations of the world. Thomes (1989) stated that population growth contributes to high rates of deforestation both directly and indirectly.

The similar devastation is observed by the researchers around the globe in developed countries as well. A study of Dasgupta and Lubchenco (2000) empirically found relationship between population growth and natural resources in the United States. They stated that the composition and scale of activities in the United States are changing chemistry of the nation's land, water and atmosphere so dramatically that some of these changes are adversely affecting its natural capital and thus, the ecosystem services are required to support its population.

There are alternative views on population-environment linkages. Most theories of population and environment are expounded primarily in relation to agricultural resource usage, but they can be applied 'mutandis mutatis' to all types of natural resources. For the natural science perspective humankind is one of the many species competing for the resources of the biosphere. As the resources of any ecosystem are finite, so is the latter's carrying capacity; hence, beyond a point, each additional inhabitant has a negative impact on the productivity of resources; this in turn depresses labor productivity and incomes. Policy-wise, this perspective leads to advocate population stabilization. At first sight, it thus seems redundant with policy prescriptions that emphasize the need to slow down population growth for the sake of enabling more productive investment and a higher rate of economic growth (Mishra, 1995; Marcoux, 1994, 1999; Bojo and Reddy, 2001; UN 2001). Kafka et al. (2009) examines how human activities are affecting our lives on planet Earth that receives less attention, i.e., the interaction among natural hazards, environmental degradation, and urbanization. Human actions that cause environmental degradation, as well as the ever-increasing population and built environment in hazard-prone regions, are worsening the devastation wrought by nature. Kafka et al. (2009) again pointed out this nexus of natural hazards, environmental degradation, and urbanization and argued that it is a complex problem that does not tend to yield simple, straightforward scientific answers as to where and when it will actually result in harmful effects.

Population and environmental degradation have been increasing in developing countries, more specifically, India, Pakistan and Sri Lanka. There is a pressing need to evaluate and analyze the population-environmental degradation nexus and to find out the inter relationship. In the subsequent sections an effort has been made to empirically find out the long-run relationship between population and environmental degradation in the context of India, Pakistan and Sri Lanka.

2. Data source and methodological framework

In this study, we consider a balanced panel of three countries, i.e., Pakistan, India and Sri Lanka over the period of 25 years from 1985-2009. Four variables i.e., arable land (AL); carbondiaoxide emissions (CO_2); population growth (PG) and population density (PD) are used for empirical investigation. All of the data were taken from *World Development Indicators* published by the World Bank (2009). In order to remove the biasness from the estimates due to differences in sizes of the economies we use natural logarithm for arable land, carbondiaoxide emission, population growth and population density, therefore, the regression coefficients can be directly interpreted as elasticities. The E-views 6.0 is used for empirical work.

To examine the impact of population indicators on the environment in Pakistan, India and Sri Lanka, as a beginning empirical framework, we used two environmental indicators (CO_2 and AL) as independent variables separately[1] covering the period of 1985-2009. We have estimated two simple nonlinear population-environment models which have been specified as follow:

$$\log(AL)_{it} = \alpha + \beta_{1t}\log(PG)_{it} + \beta_{2t}\log(PD)_{it} + \varepsilon_{it}, \quad (1)$$

$$\log(CO_2)_{it} = \omega + \gamma_{1t}\log(PG)_{it} + \gamma_{2t}\log(PD)_{it} + e_{it}, \quad (2)$$

where log is the natural logarithm; *AL* is the arable land (hectares); CO_2 are carbondiaoxide emissions (Kt); *PG* is the population growth (annual %); *PD* is the population density (people per square km), α and ω are intercepts for equation (1) and (2) respectively. β_1 and β_2 are coefficients of population growth and population density with respect to equation (1); γ_1 and γ_2 are coefficients of population growth and population density with respect to equation (2); t = 1, 2…25 periods; i = 1...3 countries; ε_t and e_t are the error terms with respect to equation (1) and (2), respectively.

In order to find out the long-run relation, we first check the order of integration by applying the unit root tests given by Im-Pesaran-Shin (IPS). Then, after getting the order of the integration the Pedroni's test of cointegration is applied. Finally, a seemingly unrelated regression (SUR) test is applied to find out whether population indicators have an impact upon environmental factors in case of Pakistan, India and China.

[1] *AL* used for agriculture sector and CO_2 for industrial sector.

2.1. Panel unit root test. The first step in determining a potentially cointegrated relationship is to test whether the variables involved are stationary or non-stationary. If all the variables are stationary traditional estimation methods can be used to estimate the (causal) relationship among variables. If, however at least one of the series is non-stationary more care is required. There are many tests available for testing unit root in panel data which are:

- Fisher's (p.) test (1932).
- Maddala and Wu (1999).
- The Levin-Lin, Chu (LL) tests (2002).
- The Im-Pesaran-Shin (IPS) test (2003).

Although the Fisher test can be applied but the disadvantage is that the p-values have to be derived through Monte Carlo simulation. So, we apply Im-Pesaran-Shin (IPS) test for unit root because it doesn't have only comparative advantage over all other tests but it is appropriate for our data as well. The IPS test provides separate estimation for each *i* section, allowing different specifications of the parametric values, the residual variance and the lag lengths. Their model is given by:

$$\Delta Y_{i,t} = \alpha_i + \rho_i Y_{i,t-1} + \sum_{k=1}^{n} \phi_k \Delta Y_{i,t-k} + \delta_i t + u_{it}. \quad (3)$$

While now the null hypothesis and the alternative hypothesis are formulated as:

$$H_0 : \rho_i = 0,$$

$$H_A : \rho_i < 0$$

for at least one *i*.

Thus, the null hypothesis of this test is that all series are non-stationary process under the alternative that fraction of the series in the panel are assumed to be stationary. IPS also suggested a group mean Lagrange multiplier test for testing panel unit roots.

Moreover, IPS test is the most powerful test as compared to the other tests. Another reason for using IPS test is that we have a balanced panel instead of different time series for different samples. In addition, the IPS test is the most cited unit root test in the literature. Another advantage of using the IPS test is that it is based on heterogeneity of the autoregressive parameters (there is a possibility of heterogeneity in the error variances and the serial correlation structure of the errors).

1.2. Panel cointegration test. With confirmation on the integrated order of variables of interest, the question is that they might or might not have a common stochastic trend, or, they might or might not be cointegrated. We resolve this question by looking for a long-run relationship among the variables using the panel cointegration technique. The available methods for panel data cointegration are given as follows: Johansen (1988); Larsson, Lyhagen and Lothgren (2001); Pedroni (1999).

This paper employs Pedroni's (1999) panel-co-integration method in order to examine the long-run relationship between population indicators and environmental proxies in the case of Pakistan, India and Sri Lanka. If the independent and dependent variables are co-integrated or have a long-run relationship, the residual e_{it} will be integrated of order zero, denoted $I(0)$. Pedroni uses two types of panel cointegration tests. The first is the "panel statistic" that is equivalent to a unit root statistic against the homogenous alternative; the second is the "group mean statistic" that is analogous to the panel unit root test against the heterogeneous alternative. Pedroni (2004) argues that the "panel statistic" can be constructed by taking the ratio of the sum of the numerators and the sum of the denominators of the analogous conventional time series statistics. The "group mean statistic" can be constructed by first computing the ratio corresponding to the conventional time series statistics, and then computing the standardized sum of the entire ratio over the N dimension of the panel. The two versions of the ADF statistics could be defined as:

panel: $$Z_t = (\tilde{s}^2_{NT} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{e}^2_{i,t-1})^{-1/2} \sum_{i=1}^{N} \sum_{t=1}^{T} \hat{e}_{i,t-1} \Delta\hat{e}_{I,T}, \quad (4)$$

group mean:

$$N^{-1/2} Z_T = N^{-1/2} \sum_{i=1}^{N} (\sum_{t=1}^{T} \hat{s}_i \hat{e}^2_{i,t-1})^{-1/2} \sum_{t=1}^{T} \hat{e}_{i,t-1} \Delta\hat{e}_{i,t}, \quad (5)$$

where $\hat{e}_{i,t}$ represents the residuals from the ADF estimation, $\tilde{s}_{NT}$ is the contemporaneous panel variance estimator, and $\hat{s}_i$ is the standard contemporaneous variance of the residuals from the ADF regression. The asymptotic distribution of panel and group mean statistics can be expressed in:

$$\frac{K_{N,T} - \mu\sqrt{N}}{\sqrt{v}} \Rightarrow N(0,1),$$

where $K_{N,T}$ is the appropriately standardized form for each of statistics, μ is the ADF regression is the mean term and v is the variance adjustment term. Pedroni provides Monte Carlo estimates of μ and v (Pedroni, 1999).

This technique is a significant improvement over the conventional cointegration tests applied on a single series. As explained in Pedroni (1999), conventional cointegration tests usually suffer from unacceptable low power when applied on data series of restricted length. The panel cointegration technique addresses this issue by allowing one to pool information regarding common long-run relationships between a set of variables from individual members of a panel. Further, with no requirement for exogenity of the regressors, it allows the short-run dynamics, the fixed effects, and the cointegrating vectors of the long-run relationship to vary across the members of the panel. Furthermore, it provides appropriate critical values even for more complex multivariate regressions. Pedroni (1999) refers to seven different statistics for testing unit roots in the residuals of the postulated long-run relationship. Of these seven statistics, the first four are referred to as panel cointegration statistics; the last three are known as group mean panel cointegration statistics. In the presence of a cointegrating relation, the residuals are expected to be stationary. A positive value for the first statistic and large negative values for the remaining six statistics allows rejection of the null hypothesis.

2.3. Seemingly unrelated regressions equation (SURE). The seemingly unrelated regression equation (SURE), also known as the multivariate regression, or Zellner's method, estimates the parameters of the system, accounting for heteroskedasticity and contemporaneous correlation in the errors across equations. The model can be estimated equation-by-equation using standard ordinary least squares (OLS). Such estimates are consistent, however generally not as efficient as the SUR method, which amounts to feasible generalized least squares with a specific form of the variance-covariance matrix. Two important cases when SUR is in fact equivalent to OLS, are: either when the error terms are in fact uncorrelated between the equations (so that they are truly unrelated), or when each equation contains exactly the same set of regressors on the right-hand-side.

The SUR model can be viewed as either the simplification of the general linear model where certain coefficients in matrix B are restricted to be equal to zero, or as the generalization of the general linear model where the regressors on the right-hand-side are allowed to be different in each equation. The SUR model can be further generalized into the simultaneous equations model, where the right-hand side regressors are allowed to be the endogenous variables as well.

3. Empirical findings

3.1. Panel unit root estimation. We begin by testing whether population indicators and environmental factors contain a panel unit root, using the panel unit root tests proposed by Im-Pesaran-Shin test (2003). The results of the panel unit root tests are presented in Table 1.

Table 1. Panel unit root test

	Levels		First differences	
	Individual effects	Individual effects and linear trends	Individual effects	Individual effects and linear trends
Im-Pesaran-Shin test (2003) variables (in logs)				
ln (*AL*)	0.421	-2.271*	-8.955*	-8.062*
ln (CO_2)	-2.772*	-2.350*	-9.605*	-6.041*
ln (*PG*)	-1.342***	-0.005	-7.694*	-6.876*
ln (*PD*)	-4.217*	3.681	0.550	-8.507*

Note: The lag length is selected based on SIC criteria, this ranges from lag zero to lag one. *, ** and *** indicate the rejection of the null hypothesis of non-stationary at 1%, 5% and 10% significant level, respectively.

The results of panel unit root test with or without linear trends, suggest that *AL*, CO_2, *PG* and *PD* do not contain a panel unit root. There is strong evidence of a stationary process for both environmental proxies and population indicators at levels. This means that the all variables could be considered as integrated of order zero, i.e., *I* (0).

3.2. Panel cointegration estimation. In the second step, after knowing the order of integration we applied the test of cointegration given by Pedroni (1999). Results are given in Table 2.

Table 2. Pedroni residual cointegration test

Cointegration test	Statistic
Panel v-statistic	0.38
Panel rho-statistic	-1.39
Panel PP-statistic	-2.72
Panel ADF-statistic	-2.76

Source: Calculated by the authors.

The result shows that first panel statistics are positive, i.e., Panel v-statistic = 0.38, while the rest of three panel statistics are negative, i.e., rho = -1.39; PP = -2.72 and ADF = -2.76. On the basis of Pedroni test we can conclude that the series are cointegrated and have a long-run relationship.

2.3. Estimation of seemingly unrelated regression (SUR). Finally, we used pooled estimation of seemingly unrelated regression equation (SURE) approach. In this model we used one lag for estimating the equations. The optimum lag length is found through Schwarz information criteria (SIC). Our result suggests that, if there is one percent increase in population density, arable land increases by almost 0.062 percent in case of Pakistan, 0.041 percent incase of India and 0.101 percent incase of Sri Lanka. In addition, population growth doesn't have any impact upon the increase in arable land in Pakistan, India and China. Results are reported in Table 3.

Table 3. Seemingly unrelated regression dependent variable: $\log(AL)_t$

		Coefficient	Std. error	t-statistic	Prob.
Pakistan	Intercept	16.572	0.143	115.529	0.000
	$\log(PG)_t$	-0.037	0.021	-1.705	0.102
	$\log(PG)_{t-1}$	-0.031	0.031	-0.992	0.334
	$\log(PD)_t$	0.062	0.024	2.532	0.018
	$\log(PD)_{t-1}$	0.345	0.828	0.416	0.682
India	Intercept	19.152	0.077	248.150	0.000
	$\log(PG)_t$	0.007	0.005	1.295	0.212
	$\log(PG)_{t-1}$	0.003	0.005	0.733	0.473
	$\log(PD)_t$	0.406	0.508	0.799	0.435
	$\log(PD)_{t-1}$	0.041	0.018	1.971	0.047
Sri Lanka	Intercept	-2.991	0.766	-3.903	0.001
	$\log(PG)_t$	0.100	0.049	2.045	0.054
	$\log(PG)_{t-1}$	-0.076	0.047	-1.620	0.121
	$\log(PD)_t$	-0.304	4.454	-0.517	0.610
	$\log(PD)_{t-1}$	0.101	0.677	3.703	0.010

Source: Calculated by the authors.

Statistics tests are given in Table 4 which appears to be very good in terms of the usual diagnostic statistics. The value of adjusted R^2 for Pakistan, India and Sri Lanka indicates that 61.4%, 90.5% and 93.2% variations in dependent variable have been explained by variations in independent variables. F-value is higher than its critical value suggesting a good overall significance of the estimated model for all three countries. Therefore, fitness of the model is accepted empirically.

Table 4. Diagnostic/statistical test for Pakistan, India and Sri Lanka in case of arable land

	Pakistan	India	Sri Lanka
R-squared	0.702177	0.927176	0.954582
Adjusted R-squared	0.614582	0.905757	0.932859
Durbin-Watson statistics	1.988641	2.012485	2.185291
F-statistic	8.016179*	43.28793*	51.822351*

The further results which is shown in Table 5 reveal that both population growth and population density cause to increase CO_2 emission in case of Pakistan. Our results are similar to those of Ahmad et al. (2005) in the specific context of Pakistan. In particular case of India and Sri Lanka only population growth cause to increase CO_2 emission in respective countries. The results support that population have a deleterious impact on environment.

Table 5. Seemingly unrelated regression dependent variable: $\log(CO_2)_t$

		Coefficient	Std. error	t-statistic	Prob.
Pakistan	Intercept	0.909	0.809	1.123	0.277
	$\log(PG)_t$	0.167	0.076	2.174	0.041
	$\log(PG)_{t-1}$	-0.104	0.075	-1.388	0.183
	$\log(PD)_t$	-1.843	1.414	-1.303	0.209
	$\log(PD)_{t-1}$	3.913	1.386	2.822	0.011
India	Intercept	-3.654	2.161	-1.691	0.109
	$\log(PG)_t$	0.006	0.063	1.914	0.049
	$\log(PG)_{t-1}$	-0.011	0.039	-0.288	0.776
	$\log(PD)_t$	1.528	2.108	0.724	0.478
	$\log(PD)_{t-1}$	1.501	2.073	0.724	0.478
Sri Lanka	Intercept	-1.991	0.656	-3.823	0.001
	$\log(PG)_t$	0.024	0.048	2.002	0.061
	$\log(PG)_{t-1}$	-0.089	0.027	-1.420	0.174
	$\log(PD)_t$	-0.402	4.352	-0.727	0.820
	$\log(PD)_{t-1}$	0.021	0.015	1.012	0.214

In addition, Table 6 shows diagnostic statistics for Pakistan, India and Sri Lanka. The value of adjusted R^2 for Pakistan, India and Sri Lanka indicates that 94.3%, 99.2% and 99.4% variations in dependent variable have been explained by variations in independent variables. F-value is higher than its critical value suggesting a good overall significance of the estimated model for all three countries. Therefore, fitness of the model is accepted empirically.

Table 6. Diagnostic/statistical test for Pakistan, India and Sri Lanka in case of CO_2

	Pakistan	India	Sri Lanka
R-squared	0.954	0.994	0.997
Adjusted R-squared	0.943	0.992	0.994
Durbin-Watson statistics	1.784893	1.412	1.274
F-statistic	74.285*	94.854*	102.274*

Summary and conclusion

The objective of this study is to empirically investigate population affects on the environment and resources. The results reveal that population density cause to increase arable land in all three SAARC countries, i.e., India, Pakistan and Sri Lanka. The population growth and population density cause to increase carbondiaoxide emission in Pakistan. While it is observed that only population growth is the most significant and positive factor which causes carbondiaoxide emission in India and Sri Lanka. The results suggest that increase in population put pressure on demand to produce more, this may cause increase in arable land and the quality of agriculture land deteriorate resulting in poorer yield. The reason is that SAARC region's geographic coverage is mere 3.95% of the global land mass. High population pressure on land, percentage of arable land to total area is much higher than the global average, e.g., the share of the region in global arable land is 14% (SAARC, 2009).

The results have important implications for further investigations, like designing appropriate economic policies. These policies are to be based on sound macro- and microeconomic management, coupled with good governance aimed at ameliorating poverty and promoting sustained economic growth which has perceptible and permanent effect in lowering population growth.

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