The Pakistan Development Review
44 : 4 Part II (Winter 2005) pp. 1135–1150

Interaction between Population and Environmental Degradation

MOHSIN HASNAIN AHMAD, USMAN AZHAR,
SYED ASHRAF WASTI, and ZESHAN INAM

I. INTRODUCTION

Economic development and population growth in the poor areas of the earth is a subject of an essential concern for the environmental economists. Developing countries are facing and suffering by the serious problem of high population growth which is causing environmental degradation. A rapidly growing population exerts pressure on agricultural land and raises demand for food and shelter which encourages the conversion of forest land for agricultural and residential uses, now we know that growing population is a major cause of air, water, and solid waste pollution.

The world population was 2.52 billion in the year 1950, which increased to 6.06 billion in 2000 and is likely to reach 8.3 billion by the year 2030. While the population size will remain almost stationary in the economically developed part of the world, around 1.2 billion, during the same period population is likely to grow in the less developed regions. This is likely to pose challenges for the economic growth and pressure on environmental resources in the developing countries. Furthermore, most of the population growth in the developing countries is likely to be concentrated in the urban areas. This has implication for increased demand for energy and water resources in the urban areas. This will also pose challenges for the management of increased solid waste, air and water pollution.

One of the striking experiences of the developing world in the last half century has been the rapid increase in population. This has been a concern for a number of reasons, and one of these is the notion that rapid population growth, considered to be responsible for continued environmental degradation.

Malthus (1798) and latter by Boserup (1965) elucidated the relationship between population growth and development. Malthus argued that population growth

Mohsin Hasnain Ahmed is Project Economist, Applied Economics Research Centre (AERC), University of Karachi, Karachi. Usman Azhar is Lecturer in the Faculty of Management Sciences, Balochistan University of Information Technology, Quetta. Syed Ashraf Wasti is Research Economist, Applied Economics Research Centre (AERC), University of Karachi, Karachi. Zeshan Inam is a PhD candidate at the University of Karachi, Karachi.

is the root cause of poverty and human sufferings, Boserup explained how technological advancement and increased innovation in the agriculture was the result of increased density of population. However, both views provided an alternative way of explaining the relationship between population growth and development. Recently environmental economists found emerging importance in the relationship between population growth and development. Allen and Barness (1995), Repetto and Holmes (1983), Rudel (1989), and Ehlich and Holdren (1971) empirically indicated the pressure of a causal relationship between rapid population growth and environmental degradation. 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, overgrasing and damage to marine and coastal ecosystem. There is a tremendous pressure on the environmental resources to produce more food for growing population.

The history of agricultural development in Pakistan clearly shows that agricultural production in the past has been achieved with heavy doses of chemical fertilisers and depleting the ground water resources. Wherever, surface water was available through canal irrigation, the water was used in excess leading to expansion of wastelands as a consequence of the growth of salinity and alkalinity in the soil. Although the growth of industrial production in the country has been more than 10 percent per annum during the last several years, but the quality of urban environment has also been deteriorated rapidly during this period. It is evident from increasing air pollution, declining quality of water and the poor sanitation conditions in the urban areas.

Pakistan's demographic and environmental indicators are not very impressive in the world. Pakistan is included among those countries that are highly populated. Currently its population is around 148.7 million, almost 2.3 percent of the world population, making it the 7th most populous country in the world. Pakistan's fertility rate is amongst the highest in the world. On the other hand, environmental indicators like CO_2 emissions, land cover by forest and ecological footprint are showing the worst conditions.[1] High population growth with low per capita income with worse environmental condition during the past four decades seems to eroding the economic and social progress of the country.

The present study examines the impact of demographic variables on environment by using the time series data over the period 1972–2001. However, there is compelling evidence that many macroeconomics time series are non-stationary and as a consequence, OLS estimates using such data may produce spurious results. There exists well-developed a technique for handling non-stationary time series data; however, no attempt has yet been made in Pakistan to study the relationship among demographic and environmental variables by using these techniques.

[1]Their world ranking is 27,136, and 157, respectively (UN common Database).

The plan of the paper is as follows: Section II discusses literature review, Section III provides trends of demographic and environmental indicators of Pakistan, data sources and econometric methodology is discussed in Section IV, the empirical findings are presented and analysed in Section V, while the Section VI presents a concluding summary.

II. REVIEW OF LITERATURE

The interaction between population and environment has a long history. Earlier, Malthus stated that a growing population exerts pressure on agricultural land, forcing the cultivation of poorer and poorer quality land. Later studies suggest that growing population exerts pressure on the of demand natural resources which can no longer be met without damaging the ability of the resources to support human life. Further, 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 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, industrialisation, 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.

Neo-classical theory of population growth stated that increased human activities would lead towards increasing stress on functioning of the environment and that will ultimately lead to environmental degradation. This could result from either emitting too much waste into the environment or exploiting the natural environment to the point of approaching or transcending ecological thresholds such as deforestation and overgrazing. 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.

Recent research suggests 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, fertilisers, causing land degradation and water pollution. They further, stated that this rapidly growing population influence in three ways, first contribution relate to industrial production and energy consumption resulting in carbon dioxide emission (CO_2) from the use of fossil fuel, second land-use changes such as deforestation affect the exchange of CO_2 between earth and the atmosphere, and third agricultural process such as paddy rice cultivation and live-stock are responsible for the greenhouse gasses in the atmosphere. According to their estimate, population growth accounts for 35 percent of greenhouse gasses in the atmosphere.

Population growth adds to the amount of greenhouse gases emitting into the atmosphere in many ways. With increasing deforestation, agricultural and industrial production, each of the activities require the burning of fossil fuels and/or increase the emissions of gases like carbon dioxide, methane, and hydrofluoric carbons (HFCs). Houghhton (1987) and Detweiler and Hall (1988) estimated 0.4-2.6 GtC of carbon dioxide were released into the atmosphere due to change in the pattern of land use, and 95 percent of this amount was due to deforestation in the tropical rain forests areas. More than one-third of the increase in the atmospheric carbon dioxide is due to depleting of land forests.

A study of Dasgupta and Lubchenco (2000) empirically found relationship between population growth and natural resources in the United States. He 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. Yojana (1984), major environmental problems include pollution and congestion associated with the geographical concentration of industry; the destruction of the forests, which lead to soil erosion, floods, and the desiccation of large tracts of land; and the exhaustion of agricultural soils aggravated by population growth, inadequate land reform policies, and low education level in rural areas.

III. DEMOGRAPHIC AND ENVIRONMENTAL INDICATORS

Table 1 presents demographic trend of selected countries. Pakistan's demographic indicators are showing the most deteriorated condition as compared to other countries.

Table 1

Demographic Indicators

		Bangladesh	China	India	Indonesia	Pakistan	Japan
Population Growth	1970s	2.53	1.68	2.29	2.31	3.13	1.20
	1980s	2.49	1.48	2.12	1.83	2.67	0.60
	1990s	1.76	1.01	1.77	1.43	2.48	0.00
Mortality Rate	1970s	382	162	270	338	287	100
(Per 1000 Adult)	1980s	365	153	239	247	231	82
	1990s	157	136	221	206	160	71
Population Density	1970s	2.53	1.75	2.30	2.44	3.11	1.90
Growth	1980s	2.48	1.40	2.12	1.76	2.73	0.57
(Tous. Hectares)	1990s	1.76	1.01	1.78	1.41	2.43	0.26
Fertility Rate	1970s	6.5	3	5.5	4.9	7	2.00
(Per Woman)	1980s	5.6	2.1	4.7	3.7	6.5	2.00
	1990s	4.7	2	3.5	2.8	5.5	1.20

Source: World Development Indicators (2003).

Having grown at an average rate of 3.1 percent in the 1970s, the population growth rate in Pakistan has been declining steadily, thereafter, averaging 2.7 percent in 1980s and at 2.1 percent in 1990s. Despite the declining trend in population growth, it is still comparatively high and according to UN projections, Pakistan will become the fourth most populous country by the year 2050. Similarly, there are indications of a downward trend; fertility rates in Pakistan remain high. In the 1970s and 1980s the total fertility rate (TFR—total number of children that would be born per woman if current fertility rates persisted) was more than 7 per woman and 6.5 per woman respectively. TFR continuously is declining and reached to 5.5 children during the 1990s, and 4.8 more recently. Further, population density growth is also worsening and evident higher as compared to other countries. Pakistan's population density was grew at an accelerating rate of 3.11 percent in 1970s, showing a steady decline thereafter i.e. 2.73 percent in 1980s and reduced to 2.43 percent in 1990s, compared to other developing countries. Table (2) depicted highest mortality rate in Bangladesh, whereas, Pakistan stands third in mortality rate. The mortality was 387 per thousand adult in 70s, that declined to 231 per thousand adults in 80s and 160 per thousand adults in 90s.

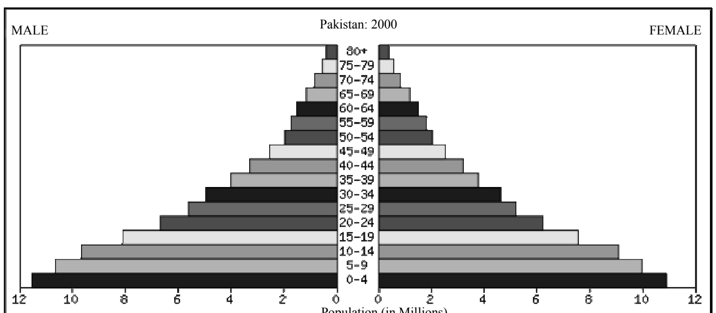
Table 2

CO_2 Emission in World Share

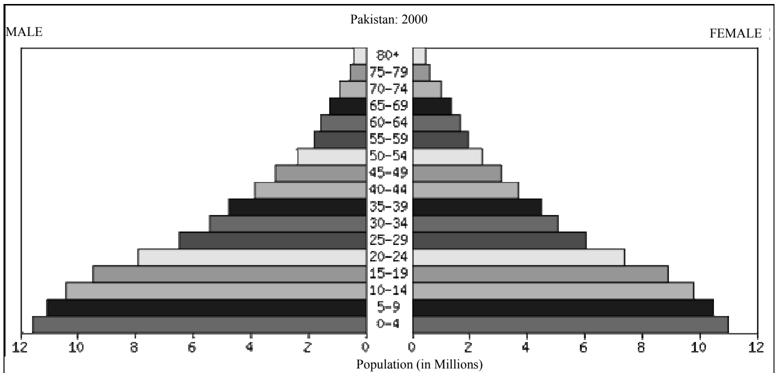
Countries	CO_2 Emission (Per Capita) 1980	2000	World Share 2000s	Rank 2000s
Bangladesh	0.1	0.3	0.1	62
China	1.5	2.7	12.1	2
India	0.5	1.2	4.7	5
Indonesia	0.6	1.2	1.2	20
Pakistan	0.4	0.7	0.5	27
Japan	7.9	9.4	5.4	4

Source: Human Development Report (2005).

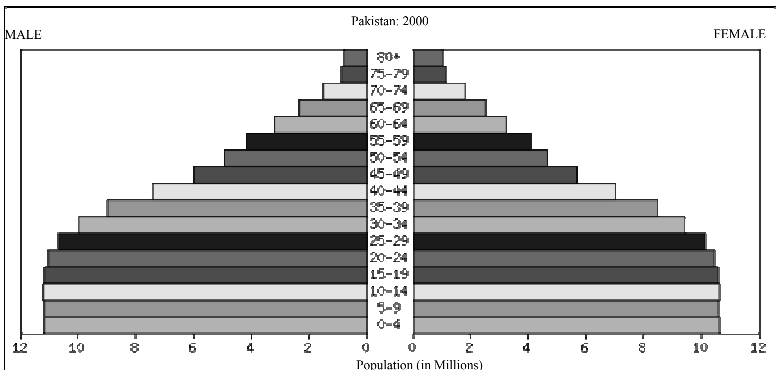
To have a clear picture of the demographic conditions in Pakistan, population pyramids of the years 2000, 2005 and projected pyramid, on current trends of population, for the year 2025 are depicted below.



Source: U.S. Census Bureau, International Data Base.



Source: U.S. Census Bureau, International Data Base.



Source: U.S. Census Bureau, International Data Base.

Table 2 gives CO_2 emission that is showing rising trend in all countries. In China CO_2 emission rises from 1.5 per capita metric tons to 2.7 per capita metric tons during the two decades and contributes 12.7 percent of total world CO_2 emission. China categorised the second polluted country in the world in CO_2 emission. Similarly, India and Japan's share in CO_2 emission are 4.7 percent and 5.4 percent respectively. Both these countries included in top ten polluted countries in the world. Pakistan ranked in Co_2 emission 27 out of the 177 countries of the world and reflecting 0.5 percent share. Pakistan CO_2 emission level rises from 0.4 per capita metric ton in 80s to 0.7 per capita metric ton in the year 2000.

IV. DATA SOURCE AND METHODOLOGY

To analyse the impact of population growth on environment, evidence suggests that most studies uses cross sectional data/time series data with many explanatory variables. In this paper, a simple model is specified because the objective of this paper is not to estimate determinants of environmental degradation but to analyse the long run effects of population on environment.

To examine the impact of population indicators on the environment in Pakistan, as a beginning empirical framework, we used two environmental indicators (CO_2 and AL) as independent variables separately[2] covering the period 1972-2001. We have estimated two simple linear population-environment which have been specified as follows:

$$CO_2 = \alpha 1 + \alpha 2\ PG + \alpha 3\ PD + \mu \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (1)$$

$$LA = B1 + B2\ PG + B3\ PD + \mu \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (2)$$

These two models consist four variables, arable land (hectares) thousand (AL), carbon dioxide emissions (kt) (thou) CO_2, population growth (*PG*) and population density (*PD*).[3] The data were obtained from World Development Series, Economic Survey of Pakistan.

IV.1. Econometric Procedure

In this paper, the impact of the demographic variables on environment is examined in the following ways:

(1) By examining whether a time series have a unit root, this paper has used Augmented Dickey-Fuller (ADF) unit root test.

(2) By findings the long run relationship among the variable, this study has applied the Johanson's multiple cointegration test.

(3) Once the variables are found cointegrated, that is long-run equilibrium relation between them; of course, in the short-run there may be disequilibrium. Therefore, we estimated an error-correction model (ECM) to determine the short-run dynamics of system.

The cointegration and error-correction modelling techniques are now well-known and widely used in applied econometrics.

The cointegration technique pioneered by Granger (1886), and Engle and Granger (1987) allows long-run components of variables to obey long-run equilibrium relationships with the short-run components having a flexible dynamic specification. In light of Shintani's (1994) finding that the Johanson method is more powerful than the Engle-Granger method. The multivariate cointegration framework that we propose to use here has now come to be established as a standard one for VAR systems. The procedure may be summarised as follows [see for example, Johanson (1988); Johansen and Juselius (1990)]. Unlike the Engle and Granger cointegation method the Johanson procedure can find multiple cointegration vectors. For this approach one has to estimate an unrestricted Vector Autoregression (VAR) of the form:

[2]AL used for agriculture sector and CO_2 for industrial sector.

[3]AL and CO_2 data is used for environmental consideration because consistent time series data is available.

Let Xt be an $I(1)$ vector representing the n-series of interest. A VAR of length p for Xt, would then be of the form.

$$Xt = \sum_{j=1}^{\rho} \Pi_j X_{t-j} + \mu + \varepsilon \qquad t=1, 2, 3,\ldots.T$$

Where the $\prod_j$ are matrices of constant coefficients, μ is an intercept, ε is a Gaussian error term and T the total number of observations.

The ECM corresponding to Equation (2) is

$$\Delta X = \sum_{j=1}^{p} \Gamma_j \Delta X_{t-1} + \Pi X_{t-p} + \mu + \varepsilon$$

Where Δ is the first-difference operator and the expression for Γ_j and ∏ are as given in Johanson and Juselius (1990).

If Rank $(\Pi)=r(r<n)$ then cointegration is indicated (with r cointegrating vectors present) and further, in this case Π may be factored as $\Pi=\alpha\beta$, with the matrix β comprising the r cointegrating vectors and α can be interpreted as the matrix of corresponding ECM weights. The matrix Π contains the information on long run relationship between variables. If the rank of $\Pi=0$, the variables are not cointegrated. On the other hand if rank (usually denote by 'r') is equal to one there exist one cointegrating vector and finally if $1<r<n$ there are multiple cointegrating vectors. Johanson and Juselius (1990) have derived two tests for cointegration, namely trace test and the maximum eigen value test. The first task in Johanson procedure is to choose an autoregressive order (p). There are tests for the choice of this appropriate lag length.[4] The ECM weights αi determine the short-run term error correction responses of the variables to deviations from long-run equilibrium values.

V. EMPIRICAL RESULTS AND ANALYSIS

The Johansen co-integration method and error-correction model technique has been used to examine the long run and the short run dynamic of system respectively.[5]

Prior to testing the long run co-integration relation, it is necessary to establish the order of integration presented. To this end, an Augmented Dickey Fuller (ADF) was carried out on the time series levels and difference forms. The results are given in Table (3) and as results show; all the variables have a unit root in their levels and are stationary in their first difference. Thus all four variables (AL, CO_2, PG and PD) are integrated of order one I(1).

[4]Akaike Information Criteria and Schwarz Criterion etc.

[5]The johansen-Juselius (1990) can find multiple cointegrating vectors; Engle-Granger approach has several limitations in the case of more than one cointegration vector.

Table 3

Test of the Unit Root Hypothesis

	Level		First Difference	
Variables	*t*-statistics	*K*	*t*-statistics	*k*
AL	–3.01	4	–4.83*	1
CO_2	–2.85	1	–3.36**	1
PG	–1.67	1	–3.80*	1
PD	–1.36	3	–4.81*	2

Note: The *t*-statistic reported in is the t-ratio on γ_1 in the following regression.
The optimal lags (k) for conducting the ADF test were determined by AIC (Akaike information criteria).
** and * Indicate significance at the 5 percent and 1 percent levels, respectively.

$$\Delta X = \gamma_O + \gamma_1 X_{t-1} + \sum_{i=1}^{p} \beta \Delta X_{t-i} + \gamma_3 T + u_t$$

In the next step, the data series are further check for presence of cointegration using Johansen maximum likelihood co-integration test of variables E (1) and E (2) respectively. First, present study examines long run relationship among CO_2, PG and PD has been estimated and reported in Table 4.

Table 4

Johansen's Test for Multiple Cointegration Vectors
Cointegration Test among CO_2 PG PD

H0:	H1:	Tests Statistics	95% Critical Values	99% Critical Values
Λtrace		λtrace		
$r = 0$	$r > 0$	55.22	42.44	48.45
$r \leq 1$	$r > 1$	23.66	25.32	30.45
$r \leq 2$	$r > 2$	9.01	12.25	16.26
Λmax Values		λmax Values		
$r = 0$	$r = 1$	31.56	25.54	30.34
$r = 1$	$r = 2$	14.65	18.96	23.65
$r = 2$	$r = 3$	9.01	12.25	16.26
Cointegrating Vector		CO_2	PG	PD
		–1	0.11	0.34

Starting with null hypothesis of no cointegration(r=0) among the variables, the trace statistic is 55.22 exceeds the 99 percent critical value of the λtrace statistic (critical value is 48.45), it is possible to reject the null hypothesis (r=0) of no cointegration vector, in favour of the general alternative $r \geq 1$. As evident in Table 4, the null hypothesis of $r \leq 1$ $r \leq 2$, cannot be rejected at 5 percent level of significance. Consequently, we conclude that there is one cointegration relationship involving variables CO_2, PG and PD.

On the other hand, λmax statistic reject the null hypothesis of no cointegration vector(r=0) against the alternative (r=1) as the calculated value λmax(0,1)=31.56 exceeds the 99 percent critical value (30.34). Thus, on the basis of λmax statistic there is also only one co-integration vector. The presence of cointegration vector shows that there exists a long run relationship among the variables. The cointegrating equation is reported in last row showing that long run elasticities of both demographic variables (PG and PD) are .11 percent and .34 percent respectively.

Similarly, long run relationship among AL, PG and PD are also examined by using Johansen maximum likelihood co-integration test.

Table (5) show that trace and maximum eigen value test reject the null hypothesis of no cointegration at 5 percent level of significance. Both tests show one cointegration vector. Consequently, we conclude that there exists also one cointegration relationship involving given variables of AL, PG and PD. The presence of cointegration vector shows the pressure of a long run relationship among the variables. The cointegrating equation is reported in last row showing that both demographic variables (PG and PD) increase the arable land and their long run elasticties are .18 percent and .29 percent respectively.

We estimated separately the error-correction model (ECM) for response variable CO_2 and AL each to determine the short run dynamic of system. To estimate the short run error correction model, we used general to specific approach [Hendry (1979)].

Table 5

Johansen's Test for Multiple Cointegration Vectors
Cointegration Test among AL PG, PD

H0:	H1:	Tests Statistics	95% Critical Values	99% Critical Values
λtrace		Λtrace		
$r = 0$	$r > 0$	50.20	42.44	48.45
$r \leq 1$	$r > 1$	20.83	25.32	30.45
$r \leq 2$	$r > 2$	6.76	12.25	16.26
Λmax Values		λmax Values		
$r = 0$	$r = 1$	29.38	25.54	30.34
$r = 1$	$r = 2$	14.07	18.96	23.65
$r = 2$	$r = 3$	6.76	12.25	16.26
Cointegrating Vector		LA	PG	PD
		–1	0.18	0.29

Table 6

Estimated Error Correction Model-I

Dependent Variable=ΔAL Regressors	Estimated Coefficients
Constant	0.004*
ΔAL (–1)	–0.4**
ΔPG(–2)	0.26***
ΔPD(–1)	0.15**
RES(–1)	–0.04*
Diagnostic Tests	
Serial Correlation	0.85
Heteroscedasticity	1.12
Functional Form	0.51
Normality	0.31

Table 7

Estimated Error Correction Model-II

Dependent Variable=ΔCO_2 Regressors	Estimated Coefficients
Constant	0.15*
ΔCO_2 (–1)	0.54
ΔPG(–1)	0.11
ΔPD(–1)	0.45
RES(–1)	–0.02*
Diagnostic Tests	
Serial Correlation	0.75
Heteroscedasticity	1.32
Functional Form	0.75
Normality	0.45

Following Hendry's general to specific modeling approach, we first include 2 lags of the explanatory variables and 1 lag of error-correction term, and then gradually eliminate the insignificant variables. Once a cointegrating relationship is established, then an ECM can be estimated.

The coefficient of error-correction terms of two models have correct sign (negative) and statistically significant at 1 percent.[6] It suggest the validity of long-run equilibrium relationship among the variables in Table (4) and Table (5). Meaning not only that the ECM is valid but also that there is significant conservative force

[6]The error-correction term was calculated from the Maximum Likelihood Estimates of cointegrating vector.

tendency to bring the model back into equilibrium whenever it strays too far. The results of diagnostic test indicate that both equations passes the test of serial correlation, functional form, normality and heteroscedasticity, the small sizes of coefficient of error-correction terms indicate that speed of adjustment is rather slow for equation to return to their equilibrium level once it has been shocked.

Since all variables are measured in logarithms, the regression coefficients can be directly interpreted as elasticities. Our econometric estimates function for suggests that both demographic variables (population growth and population density) have expected sign.

The result indicates that long run coefficients of population growth and population density have significant positive impact on environment. Table (4) indicate the long run elasticity coefficient of PG and PD suggests that one percent increase of (PG and PD) yield .11 percent and .34 percent increase in CO_2 respectively. Similarly, Table (5) also show that long run elasticities of (PG and PD) are .18 percent and .29 percent and increase in AL. Table (6) indicates that short run coefficient of demographic variables has significant impact on arable land (AL) equation while Table (7) reveals insignificant impact of demographic variables on CO_2 emission. The results suggest that increase population in short run put pressure on demand to produce more, this may cause increase in arable land and growing population that exerts pressure on agricultural land, forcing the cultivating of land poorer and poorer quality.

VI. CONCLUSION

Developing countries has been experiment a serious problem of rapidly growing population, that accelerating environmental degradation. High population growth with low real per capita income couples worsened environmental condition during the past four decades that seem to eroding the economic and social progress of Pakistan.

In this paper, we have applied Johansen-Juselius cointegration technique for valid long run relationship among the variables and error correction models to determine the short run dynamics of system to time series data for Pakistan economy, over the period 1972–2001. The paper finds the existence of a cointegrating vector, indicating a valid long relationship among the demographic and environmental indicators. The paper finding suggests that in long run both population growth and population density cause to increase in CO_2 emission and arable land in Pakistan. Moreover, demographic variables have significant effect in short run on AL, but have an insignificant impact on CO_2 emission. The results support that population have a deleterious impact on environment.

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

Population growth momentum in Pakistan is really huge hence the pressure of demand on resources are obviously large, it is only one of many other causes because over-consumption based, unsustainable development that may have an even larger impact. Our choice of how to use those resources (i.e. our economic policies) and for what purposes (i.e. our political directions and policies) are critical issues as well on the resulting impact on the environment to meet those uses and purposes.

REFERENCES

Allen, J. C., and D. F. Barness (1995) The Causes of Deforestation in Developed Countries. *Annals of the Association of American Geograpere* 75:2, 163–84.

Boserup, E. (1965) *The Conditions of Agricultural Growth*. Chicago: Aldine.

Cleaver, and Schreiber (1994) *Reversing the Spiral; the Population, Agricultural, and Environmental Nexus in Sub-Saharan Africa.* Washington, D. C.: World Bank.

Cropper, M., and C. Griffiths (1994) The Interaction between Population Growth and Environmental Quality. *American Economics Review* 84, 250–254.

Dasgupta, P., S. Levin, and J. Lubchenco (2000) Economic Pathways to Ecological Sustainability. *Bioscience* 50:4, 339–45.

Dickey, D. A., and W. A. Fuller (1981) Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root. *Econometrica* 49, 1057–1072.

Ehrlich, P. R., and J. P. Holdren (1971) The Impact of Population Growth. *Science* 171, 1212–1217.

Engle, and C. Granger (1987) Cointegration and Error Correction: Representation, Estimation and Testing. *Econometrica* 55, 251–276.

Hendry (1995) *Dynamic Econometrics*. Oxford: Oxford University Press.

Houghton, R. A. (1987) The Flux of Carbon from Terrestrial Ecosystem to the Atmosphere in 1980 due to Change in Land Use: Geographic Distribution of the Global Flux. *Tellus* 39B, 122–139.

India, Govt. of and UNEP (United Nations Environment Programmes) (2001) *State of the Environment*, see <www.envfor.nic.in/soer/2001/ind_land.pdf>

Johansen (1988) Statistical Analysis of Cointegrating Vectors. *Journal of Economic Dynamic and Control* 12, 231–254.

Johansen, S., and K. Juselius (1990) Maximum Likelihood Estimation and Inference on Cointegration with Applications the Demand for Money. *Oxford Bulletin of Economics and Statistics* 52:2, 169–210.

Lori, H. (2000) The Environmental Implication of Population Dynamics. A Rand Programme of Policy—Relevant Research Communication.

Malthus, T. R. (1798) *First Essay on Population*. Reprinted. London: MacMillan.

Meadows, D. H., D. L. Meadows, J. Randers, and W. W. Behrens (1974) *The Limit to Growth: A Report for the Club of Rome's Project on the Predicament of Mankind*. (2nd ed). New York: Universe Book.

Pakistan, Government of (Various Issues) *Economic Survey.* Islamabad: Ministry of Finance.

Repetto, R., and T. Holmes (1983) The Role of Population in Resource Depletion in Developing Countries. *Population and Development Review* 9–4, 609–632.

Rudel, T. K. (1989) Population Development and Tropical Deforestation. *Rural Sociology* 54–3, 327–38.

Trainer, F. E. (1990) Environmental Significance of Development Theory. *Ecological Economics* 2, 277–86.

United Nation (1993) *Long Range World Population Projection: Two Centuries of Population Growth, 1950-2150.* New York: United Nation Population Division, United Nation.

United Nation Development Programme (2005) *Human Development Report*. UNDP.

World Bank (2003) *World Development Indicators C.D.* Washington, D.C.

Yojana (1984) *Rising Population and Environmental Degradation* 28:18, 4–8.

Comments

The objective of the paper is very well achieved which is to investigate long run relationship between demographic variables and environmental indicators. A few suggestions are still provided to highlight the impacts of population increase on natural resources.

The environment has three basic elements, air, land and water. In this paper air in terms of CO2 emission and land in terms of arable land have been tested with demographic variables. To further enhance the impact of population growth on environmental degradation, the same test for data on the third element of the environment, water resources, should also be tested with demographic variables.

As the short run relationship between population variables and CO2 emission in the paper is insignificant, therefore, to establish a short-run relation between the two, suggestion can be made to design and test an intermediate model, for example the relationship between energy and fuel consumption with CO2 emission and energy and fuel consumption with population growth can be tested.

As suggested in the findings section, the poorer and poorer land would be cultivated because of population pressure, to elaborate alternative outcome, relationship between agriculture inputs like fertiliser, pesticides, and herbicides with population variables can be tested. This might verify the Boserupian induced intensification theory. The theory focuses on intensification of use of existing resources, in this case agriculture land.

Further refinement in text material presentation is needed for example spell and grammar check.

For Pakistan accelerating economic and demographic pressure are identified as responsible for the emergence of environmental problems.

The link between population growth and the environment is found somewhere between the view that population growth is solely responsible for all environmental ills and the view that more people means the development of new technologies to overcome any environmental problems. Most environmentalists agree that population growth is only one of several interacting factors that place pressure on the environment.

Some of the other factors that contribute to the environmental decline are:

- high levels of consumption and industrialisation;
- inequality in wealth and land distribution;

- inappropriate government policies;
- poverty; and
- inefficient technologies.

In fact, population may not be a root cause in environmental decline, but rather just one factor among many that multiply the negative effects of other social, economic, and political factors.

Naghmana Ghani

Pakistan Institute of Development Economics,
Islamabad.