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Exploring the Link between Poverty-Pollution-Population (3Ps) in Pakistan: Time Series Evidence

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Abstract

The relationship between poverty, population growth and environment has been widely debated inside the academic circles. There is a general consensus that poverty is a major cause of population growth and environmental degradation and reversely population growth is the major cause of poverty and environmental degradation. The present study examines the impact of poverty on environment (air pollution) and population and reversely the impact of population on environment (air pollution) and poverty in the specific context of Pakistan during a period of 1975-2009. Data is analyzed using Ordinary Least Square (OLS) regression method and Autoregressive Distributed Lag (ARDL)-bounds testing approach to examine the linkage.

The results of the OLS test show that rapid population and air pollution has a significant contributor to poverty in Pakistan. However, the results nullify the conventional view that poverty is a major cause of environmental degradation (or air pollution), while the result supports the hypothesis that population have a deleterious impact on increasing poverty. The results of bounds test show that there is a stable long-run relationship between population, poverty and pollution in Pakistan. On the other hand, results of the causality test show that there is a unidirectional causal flow from population to carbon dioxide emission.

The post reform period is observed with the estimated coefficient of the poverty dummy variable (POVDUM) which shows that poverty in Pakistan has increased due to deprived performance of federal policies on pro-poor reforms in Pakistan. The post reform period is observed with the population dummy variable (POPDUM) reflecting that population growth has increased significantly during the said reform period.

Keywords: Population, Air Pollution, Poverty, Headcount Ratio, Population Dynamics, Carbon Dioxide Emission, Time Series, Bounds Test, Pakistan.

1. Introduction

There is a link exists between poverty-pollution-population and it has been focused in the literature. The relationship between these variables is very complicated. However, a simple equation is that larger population leads to more poverty and pollution and reversely, more poverty increased population and pollution. The available global data suggest that all the three variables have been increasing worldwide.

Poverty is a complex phenomenon and besides other factors such as bad governance, income inequality and weak economic growth; rapid population growth is the main contributor responsible for poverty. Poverty in Pakistan has historically been elevated in rural than urban areas. Poverty rose more harshly in the rural areas in the 1990s, and in 1999 the prevalence of rural poverty (36.3 percent) was significantly higher than urban poverty (22.6 percent). According to the latest estimates, poverty head count ratio was 29.2 percent in 2004-05 which increased to 33.8 percent in 2007-08 and 36.1 percent in 2008-09. About 62 million people are below the poverty line during 2008-09 (GoP, 2009). The overall picture of poverty at national level during the 1964-2006 is given in table 1, while figure 1 shows poverty statistics at rural, urban and at national level of Pakistan during 1979-2006.

Environmental challenges and issues of Pakistan are associated primarily with an imbalanced social and economic development from the last two to three decades. This challenge is further compounded with rapid urbanization due to a shift of population from rural to urban areas. Thus, all major cities of Pakistan face haphazard, unplanned expansion leading to increase in pollution. Main factors causing degradation to air quality are, a) rapidly growing energy demand and b) a fast growing transport sector. In the cities, widespread use of low quality fuel, combined with a dramatic expansion in the number of vehicles on roads, has led to significant air pollution problems. Air pollution levels in Pakistan's most populated cities are high and climbing causing serious health issues. Although Pakistan's energy consumption is still low by world standards, but lead and carbon emissions are major air pollutants in urban centres (GoP, 2010).

Environmental degradation is fundamentally linked to poverty in Pakistan. Poverty is the main impediment in dealing with the environment related problems. Environment generally refers to a natural-resource base that provides sources (material, energy, and so forth) and performs "sink" functions (such as absorbing pollution). The term can include resources that people relied on them in the past but no longer rely on (either because they are depleted or because they have been substituted by some other resource or technology). Similarly, it can include resources that people do not yet use, but could use with a change in knowledge or technology (Leach and Mearns, 1991).

Poverty combined with a rapidly increasing population and growing urbanization, is leading to intense pressures on the environment. This environment-poverty nexus cannot be ignored if effective and practical solutions to remedy environmental hazards are to be taken. Therefore, there has been a dire need to work on poverty alleviation. Pakistan is the world's sixth most populous country. With an estimated population of 169.9 million as at end-June 2009, and an annual growth rate (revised) of 2.05 percent, it is expected that Pakistan will become the fourth largest nation on earth in population terms by 2050. With a median age of around 20 years; Pakistan is also a "young" country. It is estimated that there are currently approximately 104 million Pakistanis below the age of 30 years. Total working age population is 121.01 million, with the size of the employed labor force estimated at 52.71 million as of 2008-09 (GoP, 2010). Due to declines in mortality that began in the 1950s and the consistently high fertility levels of more than 6 births per woman that lasted around 40 years, Pakistan's population growth rate reached a high 3.2 percent by the end of the 1980s, after which it began to decline (see table 2). Pakistan's population of 41 million in 1950 doubled to around 82 million by 1980 and by 2005 had doubled again to around 160 million (UN, 2009).

The above discussion confirms a strong linkage between poverty, population and pollution (3 P's) in Pakistan. In this paper an analysis has been carried out to find a statistical relationship between 3 P's in Pakistan using secondary data from 1975-2009. This paper does not include all dimensions and factors of the poverty-population-pollution problem but limited to the following variables:

- **Poverty:** According to Duraiappah (1996) there are two types of poverty: indigenous poverty is poverty caused by environmental degradation while exogenous poverty is poverty caused by factors other than environmental degradation. In this study both types of poverty were taken into account which is represented by HCR (Head Count Ratio)

- **Population:** According to Marcoux (1999), there is a sharp variance between two main ideas: stabilizing population to protect the environment and slowing population growth to foster 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 is taken into account which is represented by POP.

- **Pollution:** According to the United Nations International Strategy for Disaster Reduction (UNISDR, 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 only carbon dioxide emission was taken into account for the proxy of air pollution which is represented by CO_2.

The objective of this paper is to analyze the link between Poverty-Pollution-Population over the period of

1975-2009. More specific objectives are to find out:

- The impact of poverty on air pollution and population in the long and short run and
- The impact of population on air pollution and poverty in the long and short run.

The paper is organized as follows: after introduction which is provided in Section 1, literature review is carried out in Section 2. Methodological framework is explained in Section 3. The estimation and interpretation of results is mentioned in Section 4. Section 5 concludes the paper.

2. Literature Review

The relationship between poverty-environment and population-environment has been extensively explored in the past. But relatively few researchers have examined the relationship between poverty-pollution-population concurrently of a developing country like Pakistan. The relationship between poverty and environmental degradation has been widely debated inside the academic circles. There is a general consensus that poverty is a major cause of environmental degradation and environmental degradation caused poverty (Zaman et al, 2010). There are different views on population-environment linkages, Mishra (1995); Marcoux (1994) and Bojo and Reddy (2001) all have emphasis the need to slow down population growth for the sake of enabling more productive investment and a higher rate of economic growth. There seems to be three lines of well established empirical research areas dealing with poverty, population and environmental degradation nexus. The first line of research mainly focuses on the relationship between the poverty and environmental degradation.

2.1. Poverty and Environmental Degradation Nexus

The assumption of a vicious circle relationship between poverty and environmental degradation in developing countries has long prevailed in the debate on poverty–environment linkages. The assumptions were first launched in the report of the World Commission on Environment and Development (WCED, 1987) called Brundtland report and has later been echoed by a wide range of organizations (e.g., Durning, 1989; UNEP, 1995; World Bank, 1992).

According to Duraiappah (1998),

> "There is much controversy surrounding the poverty-environmental degradation nexus. The predominant school of thought argues that poverty is a major cause of environmental degradation and if policy makers want to address environmental issues, then they must first address the poverty problem. Another school of thought argues that a direct link between poverty and environmental degradation is too simplistic and the nexus is governed by a complex web of factors (p.2169)".

Dasgupta and Moeler (1994) opine that economic growth and development can increase with environmental problems. They create an index of real net national product (NNP) which takes into account deprecation of the natural resource base. The authors believe that this index may replace traditional measures of economic growth. Ravnborg (2003) examines five environmentally harmful natural resource management practices in the Nicaraguan hillsides. The result does not support the hypothesis that poverty is a major cause of environmental degradation. The result further shows that the immediate agents of environmental degradation are the non-poor farmers, not the poorest. Scherr (2000) examine the downward spiral i.e., negative relationship between poverty and natural resource degradation. According to him,

> "The main strategies to jointly address poverty and environmental improvement are to increase poor people's access to natural resources, enhance the productivity of poor people's natural resource assets and involve local people in resolving public natural resource management concerns" (Scherr, 2000, p.479).

Zaman et al (2010, a) empirically investigate the relationship between agriculture environment and rural poverty in the context of Pakistan by using co-integration and Granger causality over 1980-2009. The

results find that there is unidirectional casual relationship between rural poverty and agriculture environment in Pakistan. Yusuf (2004) pointed out that there are many things working in between in the linkage from poverty to environmental degradation. Some of important ones include the population growth, discount rate, low investment base resources and property right. Thus, according to Yusuf (2004), the linkages between poverty and environment degradation is not so simple to blame poor for environmental degradation. Khan and Khan (2009) contribute to the debate on the links between poverty and forestry degradation by using the case of the forest rich Swat district, Pakistan. The result does not find empirical support for the poverty–environment nexus.

Khan and Naqvi (2000) qualitatively analyzed the relationship between poverty and resource degradation in Pakistan and found that the poor are the most vulnerable to ecological degradation and yet, the absence of basic subsistence makes them predators of natural resources thereby further exacerbating their vulnerability. They argue that the poverty–resource degradation link reflects unavoidable responses. Khan (2009) estimates income and price elasticities of demand for improved environmental quality of two National Parks in Northern Pakistan. The study concludes that environmental improvements are more beneficial to low-income groups than for high-income groups. Aggrey et al (2010) explored the casual relationship between poverty and environmental problems at the district level using econometric analysis in Katanga basin in Uganda. The results of the study show that there is strong correlation of poverty with environmental degradations. Deforestation and wet land degradation have positive relationship with poverty. The results concluded that the welfare of poor districts in Katanga basin would see to be most significant.

2.2. Population and Environmental Degradation

The study of interactions between population growth and the environment has a long history. Malthus (1798) and latter by Boserup (1965) elucidated the relationship between population growth and development. Malthus argued that population growth 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, overgrazing and damage to marine and coastal ecosystem. There is a tremendous pressure on the environmental resources to produce more food for growing population.

A number of theories often subscribed to by demographers who state that population is one of variable that affect the environment and that rapid population growth simply exacerbates other conditions such as bad governance, civil conflict, wars, polluting technologies, or distortionary policies. These include the intermediate (or mediating) variable theory (Jolly, 1994) or the holistic approach (Chi, 2005) in which population's impact on the environment is mediated by social organization, technology, culture, consumption, and values (McNicoll, 1992; Keyfitz, 1991).

According to Shaw (1989), there are two main factors of rapid population growth and environmental degradation i.e., ultimate and proximate. Ultimate causes include polluting technologies, affluence-related wastes, environmental consequences of warfare, land and urban mismanagement policies, and so on. In contrast, proximate causes such as rapid population growth are shown to be more situation-specific, contemporary, and of a confounding nature. Ahmad et al (2005) finds the existence of demographic and environmental indicators in the context of Pakistan during 1972-2001. The result further suggests that in long run both population growth and population density cause to increase in CO_2 emission and Arable Land (AL) 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. Markandya (1998) examines the effectiveness of different environmental regulations in Asia.

He concludes that market based instrument have a clear cost advantage over command and control regulations and that there are considerable gains to be made from moving to a least-cost solution. Brennan (1999) critically examines the population, urbanization, environment, and security linkages in the context of developing countries. His addressed include migration to urban centers, the immediate environmental and health impacts of urban pollution on developing country cities, and the link between crime and security.

According to UNFPA (2007):

> "Governments should increase the capacity and competence of city and municipal authorities……………to safeguard the environment, to respond to the need of all citizens, including urban squatters, for personal safety, basic infrastructure and services, to eliminate health and social problems, including problems of drugs and criminality, and problems resulting from overcrowding and disasters, and to provide people with alternatives to living in areas prone to natural and man-made disasters (p. 15)".

According to UNFPA (2001), human pressure on the environment is a product of three factors: population, per capita *c*onsumption and technology. These determine total resources used and the amount of waste or pollution produced for each unit of consumption. The mediating factors like technology, policy, politics, institutions and culture also pose some concerns for this interlink between population and the environment. Technology has a clear impact on the use of new varieties of agricultural plants and animals, nitrogenous fertilizers, pesticides and modern contraceptives, among others (Cohen, 1995).

2.3. Poverty, Population and Environment Degradation

Population pressure is generally accepted as a prime cause of ozone depletion, deforestation, greenhouse gas accumulation, pollution, and general large scale reductions in environmental quality (Amacher et al, 1998). According to WCED (1987) report emphasis:

> "Poverty is a major cause and effects of global environmental problems…….many parts of the world are caught in a vicious downwards spiral: poor people are forced to overuse environmental resources to survive from day to day, and their impoverishment of their environment further impoverishes them, making their survival more difficult and uncertain (p. 3)".

The downward spiral hypothesis maintains that poor people and environmental damage are often caught in a downward spiral. People in poverty are forced to deplete resources to survive, and this degradation of environment further impoverishes people. Poverty-constrained options may induce the poor to deplete resources at rates that are incompatible with long-term sustainability. In such cases, degraded resources precipitate a "downward spiral," by further reducing the income of the poor (Durning, 1989; Pearce and Warford, 1993). Rapid population growth, coupled with insufficient means or incentives to intensify production, may induce overexploitation of fragile lands on steep hillsides, or invasion of areas that governments are attempting to protect for environmental reasons. Again, a downward spiral can ensue (World Bank, 1992). Bilsbrrow (1992) investigates the interrelationships between poverty, internal migration and environmental changes in rural areas of developing countries, taking case study of Latin America, Indonesia and Sudan. The result opines that environmental factors in areas of origin sometimes influence out-migration, while environmental consequences in areas of destination are often widespread, negative and readily apparent in situations of land extensification associated with migration to marginal lands. A study by Rozelle et al. (1997) on the relationship among population, poverty and environmental degradation in China examined the impact that each had on the China's land, water, forest and pasture resources. They found the government policy to be ineffective in controlling rural resource degradation primarily because of its limited resource and poorly trained personnel. Iftikhar (2003) provide an analytical overview of existing research and approaches adopted to address inter-linkages between population, poverty and environment in the context of Northern Areas of Pakistan. He recommended sustainable livelihoods approach and develop an Enabling Policy and Economic Environment at the Regional and Local Levels.

Poverty, population and environmental degradation have been increasing in Pakistan, hence there is a pressing need to evaluate and analyze the 3 P's and to find out the inter relationship. In the subsequent sections an effort has been made to empirically find out the relationship between poverty, population and environmental degradation in the context of Pakistan.

3. Data Source, Methodological and Conceptual Framework

3.1 Data Source

The statistics used in this study have been collected from various resources including Household Integrated Economic Survey (HIES, 2006), Pakistan Integrated Household Survey (PIHS, 2006), Pakistan Social Living Management (PSLM, 2006) Survey, and Government of Pakistan (GoP, 2011). Base-line for poverty is obtained from Government of Pakistan (GoP, 2010), where 2,350 Calories are referred to cut-off point for Pakistan. An interpolation method is to take the decline or incline in trend between two points in time and fills the data gap between successive annotations. Meanwhile forward interpolation technique is used for the year 2006 onward. The time series data of carbon dioxide emissions per capita (CO2) and total population in percentage growth rate are taken from World Development Indicators (World Bank, 2009a) data base. All these variables are expressed in natural logarithm and hence their first differences approximate their growth rates. The data trends are available for ready reference in figure 2.

3.2. Conceptual Framework

The conceptual framework of this study is explained in the figure 3 which show four main connections i.e., how poverty affects population? how population affects poverty? how poverty affects environment and how population affects environment. In first connection, poverty may affects population via lack of education that means less awareness of family planning methods & benefits and less use of clinics. The official statistics show that the literacy rate in the country is 54% which is much less that many developing countries (GoP, 2011). In the second connection, population affects poverty by unemployment channel i.e., low wages for those in work or overstretching of social services, schools, health centres, family planning clinics, and water and sanitation services. In third connection, poverty affects environment by lack of knowledge about environmental issues and long-term consequences of today's actions. In last, population affects environment by increasing pressure on marginal lands, over-exploitation of soils, overgrazing, and excessive deforestation and over depletion of other natural resources. Migration to overcrowded slums, problems of water supply and sanitation, industrial waste dangers, indoor air pollution, mud slides are also accountable due to rapid population (Khan et al, 2009).

3.3. Methodological Framework

To examine the impact of poverty on environment and population and population on poverty and environment, two models covering the period of 1975-2009 have been developed. A simple non-linear poverty-environment model and population-environment model has been specified as follows:

Model 1: Poverty-Pollution-Population Equation

$$\log(HCR) = \alpha_1 + \alpha_2 \log(POP) + \alpha_3 \log(CO2) + \alpha_4 POVDUM + \alpha_5 TIME + \mu \,.......... \,.......... \quad (1)$$

Model 2: Population-Pollution-Poverty Equation

$$\log(POP) = \alpha_1 + \alpha_2 \log(HCR) + \alpha_3 \log(CO2) + \alpha_4 POPDUM + \mu \,.......... \,.......... \,.......... \,.....(2)$$

Where

    i.   HCR represents head count ratio which is considered the proxy for poverty

    ii.   POP represents population in percentage growth and

    iii. CO_2 represents carbon dioxide emission per capita.

    iv.   POVDUM represents poverty dummy i.e., 0 for pre-reform period (i.e., 1975-1990) and 1 for post reform period (i.e., 1991-2009).

    v.   POPDUM represents population dummy i.e., 0 for pre-reform period (i.e., 1975-1990) and 1 for post reform period (i.e., 1991-2009).

    vi.   TIME represents trend rate of change in poverty due to time.

    vii. μ represents disturbance term.

The dependent and independent variables used in this study are listed in table 3 and 4. Poverty is used as a dependent variable for the study. Poverty is measured in various ways. Generally, concept of absolute poverty is used to measure the poverty. Absolute poverty is based on defining minimum calorie intake for food need and minimum non food allowance for human need required for physical functioning and daily activities and this approach requires assessment of a minimum amount necessary to meet each of these needs (Anwar, 2006). For this purpose, the most prominent approach used in Pakistan is calorie-based approach (Naseem, 1977; Irfan and Amjad, 1984; Cheema and Malik, 1984; Malik, 1988). In this approach, the poverty line is set as the average food expenditure of those households who consume in the region of the minimum required calorific intake. Ercelawn (1990) used calorie consumption function to derive expected total expenditure of those households who consume minimum required calorific intake. This method derives expected expenditure for potential (2550) calorific intake (Sherazi, 1993). Subsequently, this method was modified by adjusting for non-food expenditures (Jafari and Khattak, 1995; Ali (1995); Amjad and Kemal, 1997). These studies used 2550 calories per day per adult as the calorific cut-off point for estimation of absolute poverty. This calorie norm was recommended by Pakistan Planning Commission and supplemented by recommendations of FAO/WHO. The nutrition cell of Planning Commission, Government of Pakistan reduced the calorie cut-off point for Pakistan to 2150 calories per person per day per adult in 2002 but revised this threshold level to 2350 calories per adult equivalent per day in July 2002 (Anwar, 2006). Recently, there are number of studies conducted in Pakistan by different institutions and authors to examine the true picture of poverty in Pakistan. These studies used 2350 calories per adult equivalent per day as threshold point by including food and non food items for measuring absolute poverty (World Bank, 2006; Anwar and Qureshi, 2003; Anwar, et al. 2004 and Jamal, 2005, 2007).

3.4 Pre-reform and Post-reform period

The pattern of change in poverty in Pakistan expose that overall poverty significantly increases from 40.24 percent to 49.13 percent from 1964 to 1972. Poverty fluctuated in the urban areas and declined from 44.53 to 42.55 percent of the population while increase from 38.94 to 53.35 percent in the rural areas during the same period. Afterward, in 1972 to 1979, there was a marked decline in poverty. The major emphasis of the Bhutto regime was to protect the workers, nationalization policies, foreign remittances and rural development programmes which played a major part in decline of poverty. From the start of 1980s, Structural Adjustment Programme (STAP) was launched with the help of the International Monetary Fund and the World Bank. The programme endeavored to correct the instability at its source through the structural transformation of the economy. The main goals of STAP were to generate short and long-term macroeconomic stability, incentive reforms through liberalization, and investment in social development. It was clear that during the period of STAP, society would have to go through painful economic readjustments to long-standing practices. The stabilization measures would reduce the GDP growth rate, and result in low

employment generation and an adverse effect on poverty alleviation. The reduction in the protection provided to domestic industry, as well as the reduction in subsidies and large-scale privatization of nationalized enterprises, was expected to create employment losses in those sectors and an adverse effect on the poverty situation. Auxiliary measures to deregulate major crops, particularly wheat, would reduce the indirect food subsidy to the urban and rural poor, which could also raise the poverty level

The independent variables used in this study to test their relationship are population growth (POP) and Carbon Dioxide Emission (CO_2). Another explanatory variable i.e., Poverty Dummy variable (POVDUM) and Population Dummy variable (POPDUM) with a value of 0 (indicating pre-reform period i.e., 1975-1990) and a value of 1 (indicating post-reform period i.e., 1991-2010) have been included in the equation (1) and (2) respectively, to measure the impact of the economic reforms. One more variable, which is related with time, as some changes in poverty may be explained by many other time dependent factors that are not captured due to uneven time lags between the surveys; therefore, an estimate with a time trend is also made in this study. The time trend adds the number of years lapsed between successive surveys.

In the table 3, the sign of α_2 is expected to be positive as we argue a positive relationship between the population and poverty. The hypothesize results of the coefficient of population is consistent with the previous researches of Khan et al (2009), Marcoux (1999), Klasen and Lawson (2007) etc. Some other studies also supports this hypothesis i.e., if other things being equal, increased household size has been found to consistently place extra burden on a household's asset/resource base and in general is positively related to chronic poverty (McCulloch and Baulch 2000, Jyotsna and Ravallion 1999, 2000, and Aliber 2001). A similar logic applies for increased dependency ratios, number of children (McCulloch and Baulch, 2000, Jyotsna and Ravallion, 1999, 2000). The sign of α_3 is hypothesized to have an indifferent results on poverty and carbon dioxide emission (Khan et al, 2009 and Zaman et al (2010). The sign of α_4 is hypothesizes an indifferent results. As, some time, post reform period may have indirect impact on poverty which shows poverty go down significantly (Zaman and Rashid, 2011) while some another time, it may have a direct impact on poverty which should be reflecting the deprived performance of federal polices on pro-poor reforms of the countries (Zaman et al, 2011). The sign of α_5 is also hypothesis an indifferent results because some changes in poverty may be explained by many other time dependent factors that are not captured due to uneven time lags between the household's poverty related survey. Similarly, table 4 shows the variables which is used for Model 2.

3.5. Econometric Procedure

This paper reviews the impact of poverty on pollution (air) and population and impact of population on poverty and pollution (air) which is examined in the following manners:

- By examining whether a time series have a unit root test; an Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root test has been used.

- If variables are stationary at their level especially dependent variable, then we proceed to OLS test[1].

- If variables are non-stationary at their level or mixture of I(1) and I(0) variables, we may proceed to Multivariate cointegration technique i.e., Bounds testing approach[2].

3.5.1. Econometric Model

Comparable to all other techniques, that utilize time series data, it is essential to distinguish that unless the diagnostic tools used account for the dynamics of the link within a sequential 'causal' framework, the intricacy of the interrelationships involved may not be fully confined. For this rationale, there is a condition

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[1] If dependent variable is stationary at their level and independent variables are non-stationary, we can take the first difference of that variable and run it on OLS regression (the case of Model 1 in particular study).

[2] The case of Model 2 in a particular study, where we adopt another model i.e., POP = f (HCR, CO2) because POP is the only variable in the said model which is integrated at order one or non0-stationary series.

for utilizing the advances in time-series version. The following sequential procedures are adopted as part of methodology used.

3.5.2. Univariate Test

In order to confirm the degree, these series split univariate integration properties; we execute unit root stationarity tests. The DF (Dickey & Fuller, 1979 and 1981) type test is suitable testing procedures, both based on the null hypothesis that a unit root exists in the autoregressive representation of the time series.

3.5.3. Bound Testing Approach

The use of the bounds technique is based on three validations. First, Pesaran et al. (2001) advocated the use of the ARDL model for the estimation of level relationships because the model suggests that once the order of the ARDL has been recognized, the relationship can be estimated by OLS. Second, the bounds test allows a mixture of I(1) and I(0) variables as regressors, that is, the order of integration of appropriate variables may not necessarily be the same. Therefore, the ARDL technique has the advantage of not requiring a specific identification of the order of the underlying data. Third, this technique is suitable for small or finite sample size (Pesaran et al., 2001).

Following Pesaran et al. (2001), we assemble the vector autoregression (VAR) of order p, denoted VAR (p), for the following growth function:

$$Z_t = \mu + \sum_{i=1}^{p} \beta_i z_{t-i} + \varepsilon_t \tag{1}$$

where z_t is the vector of both x_t and y_t, where y_t is the dependent variable defined as Population Growth (POP), x_t is the vector matrix which represents a set of explanatory variables i.e., Poverty (HCR), Pollution (CO2) and t is a time or trend variable. According to Pesaran et al. (2001), y_t must be I(1) variable, but the regressor x_t can be either I(0) or I(1). We further developed a vector error correction model (VECM) as follows:

$$\Delta z_t = \mu + \alpha t + \lambda z_{t-1} + \sum_{i=1}^{p-i} \gamma_t \Delta y_{t-i} + \sum_{i=1}^{p-1} \gamma_t \Delta x_{t-i} + \varepsilon_t \tag{2}$$

where Δz_t is the first difference operator. The long-run multiplier matrix λ as:

$$\lambda = \begin{bmatrix} \lambda_{YY} \lambda_{YX} \\ \lambda_{XY} \lambda_{XX} \end{bmatrix}$$

The diagonal elements of the matrix are unrestricted, so the selected series can be either I(0) or I(1). If $\lambda_{YY} = 0$, then Y is I(1). In contrast, if $\lambda_{YY} < 0$, then Y is I(0).
The VECM procedures described above are imperative in the testing of at most one cointegrating vector between dependent variable y_t and a set of regressors x_t. To derive model, we followed the postulations made by Pesaran et al. (2001) in Case III, that is, unrestricted intercepts and no trends. After imposing the restrictions $\lambda_{YY} = 0, \mu \neq 0$ and $\alpha = 0$, the said hypothesis function can be stated as the following unrestricted error correction model (UECM):

$$\Delta(POP)_t = \beta_0 + \beta_1(POP)_{t-1} + \beta_2(HCR)_{t-1} + \beta_3(CO2)_{t-1} + \sum_{i=1}^{p} \beta_5 \Delta(POP)_{t-i}$$

$$+ \sum_{i=0}^{q} \beta_6 \Delta(HCR)_{t-i} + \sum_{i=0}^{r} \beta_7 \Delta(CO2)_{t-i} + u_t ....(3)$$

where $\Delta(POP)_t$ is the first difference operator and u_t is a white-noise disturbance term. Equation (3) also can be viewed as an ARDL of order (p, q, r). Equation (3) indicates that population growth tends to be influenced and explained by its past values. Therefore, equation (3) was modified in order to capture and absorb certain economic shocks. Dummy variable (DUM) with a value of zero confirms pre-reform period, and a value of one illustrates post-reform period have been included in the equation to measure the impact of reforms in Pakistan:

$$\Delta(POP)_t = \beta_0 + \beta_1(POP)_{t-1} + \beta_2(HCR)_{t-1} + \beta_3(CO2)_{t-1} + \delta DUM_t + \sum_{i=1}^{p} \beta_4 \Delta(POP)_{t-i}$$

$$+ \sum_{i=0}^{q} \beta_5 \Delta(HCR)_{t-i} + \sum_{i=0}^{r} \beta_6 \Delta(CO2)_{t-i} + u_t \dots\dots\dots\dots\dots\dots\dots(4)$$

The structural lags are established by using minimum Akaike's Information Criteria (AIC). From the estimation of UECMs, the long-run elasticities are the coefficient of one lagged explanatory variable (multiplied by a negative sign) divided by the coefficient of one lagged dependent variable (Bardsen, 1989). For example, in equation (3), the long-run inequality, investment and growth elasticities are (β_2 / β_1) and (β_3 / β_1) respectively. The short-run effects are captured by the coefficients of the first-differenced variables in equation (3).

After regression of Equation (3), the Wald test (F-statistic) was computed to differentiate the long-run relationship between the concerned variables. The Wald test can be carry out by imposing restrictions on the estimated long-run coefficients of economic growth, inequality, investment and public expenditure. The null and alternative hypotheses are as follows:

$$H_0 : \beta_1 = \beta_2 = \beta_3 = 0 \quad \text{(no long-run relationship)}$$

Against the alternative hypothesis

$$H_A : \beta_1 \neq \beta_2 \neq \beta_3 \neq 0 \quad \text{(a long-run relationship exists)}$$

The computed F-statistic value will be evaluated with the critical values tabulated in Table CI (iii) of Pesaran et al. (2001). According to these authors, the lower bound critical values assumed that the explanatory variables x_t are integrated of order zero, or I(0), while the upper bound critical values assumed that x_t are integrated of order one, or I(1). Therefore, if the computed F-statistic is smaller than the lower bound value, then the null hypothesis is not rejected and we conclude that there is no long-run relationship between poverty and its determinants. Conversely, if the computed F-statistic is greater than the upper bound value, then GDP and its determinants share a long-run level relationship. On the other hand, if the computed F-statistic falls between the lower and upper bound values, then the results are inconclusive (see, table 5).

4. Empirical Analysis

The standard Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root test was exercised to check the order of integration of these variables. The results obtained are reported in table 6. Based on the ADF and PP unit root test statistic, it was concluded that HCR and CO_2 are stationary at their level. However, POP has non-stationary at their level but stationary at their first difference.

The figure 4 shows the plots of CO_2, HCR and POP in their first difference forms, which sets the analytical framework as regarding the long-term relationship of HCR, CO_2 and POP

4.1. Empirical Testing for Model 1

As table 5 indicates that poverty and carbon dioxide emissions have stationary series, therefore, the present study strict to the OLS regression technique. Population has find non-stationary series at level, but stationary at their first difference, therefore, the present study take the first difference of the said variable and regress it on poverty. The results of OLS regression is shown in table 7.

The empirical results, given in table 7, appear to be very good in terms of the usual diagnostic statistics. The value of R^2 adjusted indicates that 71.4% variation in dependent variable has been explained by variations in independent variables. F value is higher than its critical value suggesting a good overall significance of the estimated model. Therefore, fitness of the model is acceptable empirically. ARCH and LM test indicates that there is no problem of serial correlation in the model. The result suggests that carbon dioxodide emissions have a negative impact on poverty, which negates the conventional view that poverty is a major determinant of environmental degradation. The results are in consistent with the previous researches of Yusuf (2004) and Khan and Khan (2009). On the other hand, population has a positive impact on poverty which supports the conventional view that population is a significant donor for increasing poverty in Pakistan. The result is different with the research of Khan et al (2009). One reason for the difference in results is the use of different research techniques in both papers. Another reason is that in individual country assessments, country shocks are absorbed and data are refined accordingly. The results are consistent with the previous researches of Durning (1989), Pearce and Warford (1993). The post reform period is observed with the estimated coefficient of the poverty dummy variable (POVDUM) which shows that poverty in Pakistan has increased, due to deprived performance of federal policies on pro-poor reforms in Pakistan. There are some changes in poverty has been observed due to time related factors i.e., 0.065 percent.

Due to the presence of a serial autocorrelation in the estimation error, the claim of efficiency of these estimators was not possible except for their unbiasedness. To overcome this problem we applied Cochran-orcutt iterative method and obtained t-values corrected for autocorrelation. The new t-statistics show the significance of the elasticities. Note that we are not using the new values of the estimated coefficients (obtained after correction for autocorrelation), except for their new t-statistics and F-statistics, because interpretation of these GLS estimates thus obtained is not possible easily after the data transformation. By using the old estimates we preserve the elasticity interpretation of the data. We did use first-order Moving Average process for serial correction because residual are correlated with his own lagged value.

4.2. Empirical Testing for Model 2

Based on the ADF test statistic, it was initiated that HCR and CO_2 variables are non-stationary, that is, they are I(0) variables. However, POP variables is non-stationary at level but stationary at their first difference i.e., I(1) variable. Noticeably, the mixture of both I(0) and I(1) variables would not be possible under the Johansen procedure. This gives a good justification for using the bounds test approach, or ARDL model, proposed by Pesaran   et al. (2001).

The estimation of Equation (4) using the ARDL model is reported in Table 8. Using Hendry's general-to-specific method, the goodness of fit of the specification, that is, *R*-squared and adjusted *R*-squared, is 0.629 and 0.505 respectively. The robustness of the model has been definite by several diagnostic tests such as Breusch- Godfrey serial correlation LM test, ARCH test, Jacque-Bera normality test and Ramsey RESET specification test. All the tests disclosed that the model has the aspiration econometric properties, it has a correct functional form and the model's residuals are serially uncorrelated, normally distributed and homoskedastic. Therefore, the outcomes reported are serially uncorrelated, normally distributed and homoskedastic. Hence, the results reported are valid for reliable interpretation.

In table 8, Model criteria 11, the outcomes of the bounds cointegration test show that the null hypothesis of $\beta_1 = \beta_2 = \beta_3 = 0$ against its alternative $\beta_1 \neq \beta_2 \neq \beta_3 \neq 0$ is easily rejected at the 1% significance level. The computed Wald *F*-statistic of 47.93 greater than the upper critical bound value of 5.06, thus

indicating the subsistence of a steady-state long-run relationship among population, poverty and pollution.

The estimated coefficients of the long-run relationship between population, poverty and carbon dioxide are expected to be significant, that is:

$$\log(POP)_t = 0.779 + 0.022(HCR)_t - 0.324*(CO2)_t + 0.029**POPDUM_t \quad (5)$$

Equation (5) indicates that population is positively correlated to poverty, with the estimated elasticity of 0.022. This shows that if there is 1% increase in poverty will result in about 0.022% increase in population growth rate. However, the significance level of the poverty is not sufficient to explain that phenomena. As anticipated, if there is one percent increase in carbon dioxide emission, population growth will be suffered and it will lead to human suffering and mortality rate. However, the present study nullifies the conventional view regarding population and environment degradation. The post reform period is observed with the estimated coefficient of the population Dummy variable (POPDUM), which shows that population increases significantly during the said reform period.

The dynamic short-run causality among the relevant variables is shown in Table 9, Panel II. The causality effect can be acquired by restricting the coefficient of the variables with its lags equal to zero (using Wald test). If the null hypothesis of no causality is rejected, then we wrap up that a relevant variable Granger-caused economic growth. From this test, we initiate that the carbon dioxide emission (CO2) are statistically significant to Granger-caused population (POP) at a 1% significance level. To sum up the findings of the short-run causality test, we conclude that the hypothesis of Population-Poverty-Pollution is valid in the Pakistan economy and short-run causality running from population to pollution.

5. Conclusion

The objective of the study is to examine Poverty, Pollution and Population (3P's) relationship in the context of Pakistan over a period of 35 years. There is general consensus that poverty and population both is the major donor for environmental degradation. The results of the OLS test show that rapid population and air pollution has a significant contributor to poverty in Pakistan. However, the results nullify the conventional view that poverty is a major cause of environmental degradation (or air pollution), while the result supports the hypothesis that population have a deleterious impact on increasing poverty. The results of bounds test show that there is a stable long-run relationship between population, poverty and pollution in Pakistan. On the other hand, results of the causality test show that there is a unidirectional causal flow from population to carbon dioxide emission.

The present study introduces the poverty dummy and population dummy to measure the economic reforms in a country. The post reform period is observed with the estimated coefficient of the poverty dummy variable (POVDUM) which shows that poverty in Pakistan has increased due to deprived performance of federal policies on pro-poor reforms in Pakistan. The post reform period is observed with the population dummy variable (POPDUM) reflecting that population growth has increased significantly during the said reform period.

The results imply that both poverty and population in Pakistan has increased, reflecting the deprived performance of Federal policies on pro-poor reforms in Pakistan. This study thus provides a general outline of poverty behavior in Pakistan and also an insight into the effectiveness of Pakistan's poverty reforms, especially in the light of its recent pro-poor growth policies.

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Table 1:   Headcount Measures for Pakistan (1963-64 to 2005-06)

Years	Malik (1988) 2550 Calories	Amjad and Kemal (1997) 2550 Calories	World Bank (2008) $1.25 per day	FBS (2001) 2550 Calories	Official Poverty Line 2350 Calories
1964	40.24				40.24
1967	44.50				44.5
1970	46.53				46.53
1979	30.68				30.68
1985	24.49				24.57
1988	-	17.32	37.4	-	17.32
1991	-	22.10	34.0	-	22.11
1993	-	22.40	25.7	26.6	24.9
1994	-	-	28.6	29.3	27.7
1997	-	-	24.0	26.3	24.5
1999	-	-	32.6	32.2	30.6
2002	-	-	35.8	-	34.5
2005	-	-	22.5	-	23.9
2006	-	-	-	-	22.3

Source: Anwar and Qureshi (2002), World Bank (2009b) and GoP (2009).

Table 2: Crude Death Rates by Country over Time (1950-2010)

Years	Bangladesh	India	Iran	Pakistan
1950-55	26.6	25.5	22.8	21.7
1955-60	25.0	22.7	20.2	20.0
1960-65	23.3	19.9	18.0	18.3
1965-70	21.3	17.3	15.4	16.5
1970-75	20.2	15.2	13.2	15.1
1975-80	18.8	13.1	11.7	13.4
1980-85	15.9	12.0	10.7	12.3
1985-90	13.3	11.1	8.2	11.1
1990-95	11.1	10.4	6.5	9.8
1995-00	9.1	9.5	5.9	8.5
2000-05	7.6	8.9	5.8	7.6
2005-2010	6.6	8.5	5.7	7.0

Source: Medium   Variant,   U.N.   World   Population   Prospects: 2008   Revision
(http://esa.un.org/uapp/index.asp?panel=1)

Table 3: Variables used for the Model-1

Variables	Symbol	Expected Sign

Dependent Variable: Poverty	HCR	
Independent Variable:		
Population	POP	Positive
Pollution	CO2	Negative / Positive
Dummy	POVDUM	Negative / Positive
Time	TIME	Negative / Positive

Table 4: Variables used for the Model-2

Variables	Symbol	Expected Sign
Dependent Variable: Population	POP	
Independent Variable:		
Poverty	HCR	Positive
Pollution	CO2	Negative / Positive
Dummy	POPDUM	Negative / Positive

Table 5: Bounds Test for Cointegration Analysis

Critical value	Lower Bound Value	Upper Bound Value
1%	3.74	5.06
5%	2.86	4.01
10%	2.45	3.52

Computed F-statistic: 5.61 (Significant at 0.01 marginal values). Critical Values are cited from Pesaran et al. (2001), Table CI (iii), Case 111: Unrestricted intercept and no trend.

Table 6: Unit Root Estimation

ADF Unit Root Test				
Level			1st Difference	
Variables	Constant	Constant and Trend	Constant	Constant and Trend
HCR	-2.956** (1)	-2.851 (1)	-2.723***(0)	-2.702 (0)
CO2	0.434 (1)	-3.308*** (4)	-8.845*(0)	-8.755*(0)
POP	-1.597 (0)	-2.218 (0)	-5.429*(0)	-5.499*(0)
Phillips-Perron Unit Root Test				
Level			1st Difference	
Variables	Constant	Constant and Trend	Constant	Constant and Trend

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HCR	-2.646*** (2)	-2.298 (1)	-2.686***(4)	-2.621 (4)
CO2	0.628 (2)	-3.256*** (3)	-8.763*(2)	-8.673*(2)
POP	-1.623 (3)	-2.234 (2)	-5.428*(1)	-5.496*(2)

Note: The null hypothesis is that the series is non-stationary, or contains a unit root. The rejection of the null hypothesis is based on MacKinnon (1996) critical values i.e., at constant: -3.646, -2.954 and -2.615 are significant at 1%, 5% and 10% level respectively. While at constant and trend: -4.262, -3.552 and -3.209 are significant at 1%, 5% and 10% level respectively. First Difference: at constant: -.3646, -2.954 and -2.615 are significant at 1%, 5% and 10% level respectively and at constant and trend: -4.262, -3.552 and -3.209 are significant at 1%, 5% and 10% level respectively The lag length are selected based on SIC criteria, this ranges from lag zero to lag four. While, the lag length are selected on Bandwidth criteria in Phillips-Perron test which ranges from lag one to lag four.

Table 7: OLS test for Model-1

Dependent Variable: LOG(HCR) Method: Least Squares				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.724285	0.314376	2.303882	0.0286
LOG(CO2)	-2.392356	0.280254	-8.536380	0.0000
DLOG(POP)	1.591873	0.866589	1.836942	0.0765
POVDUM	0.242577	0.073864	3.284090	0.0027
TIME	0.065648	0.009945	6.601353	0.0000
MA (1)	0.396774	0.206701	1.919553	0.0652
R-squared	0.749435	Mean dependent var		3.249131
Adjusted R-squared	0.714874	S.D. dependent var		0.202079
S.E. of regression	0.107904	Akaike info criterion		-1.480091
Sum squared resid	0.337657	Schwarz criterion		-1.255626
Log likelihood	30.16155	F-statistic		21.68462
Durbin-Watson stat	1.657963	Prob(F-statistic)		0.000000

Residual tests:
Jarque-Bera Test   1.060909 (0.585935)
ARCH test   1.388260 (0.247665)
White Heteroskedasticity   1.569928 (0.188674)
Breusch-Godfrey Serial Correlation LM test   2.324075 (0.117869)

Stability Tests:
Ramsey RESET test   2.027418(0.165938)

Table 8: Estimated Model Based on Equation (4) - Dependent Variable: DLog (POP) $_t$

Variable	Coefficient	t-statistics	Probability
Log(POP) $_{t-1}$	-1.232	-11.925*	0.0000
Log(HCR) $_{t-1}$	0.027	0.815	0.4228
Log(CO2) $_{t-1}$	-0.400	-8.515*	0.0000
POPDUM $_t$	0.036	-2.070**	0.0493
β_0	0.779	6.632*	0.0000
Dlog(POP) $_{t-1}$	0.427	4.079*	0.0004
Dlog(HCR) $_{t-1}$	0.005	0.135	0.893
Dlog(CO2) $_{t-1}$	0.307	2.679**	0.0131
MA (2)	1.319	5.661*	0.0000

11. Model criteria / Goodness of Fit:

R-square = 0.629; Adjusted R-square = 0.505; Wald F-statistic = 47.935 [0.0000]*

111. Diagnostic Checking:

ARCH (1) = 2.690 [0.111]; RESET = 1.057 [0.359] WHITE Test = 1.132 [0.392];

JB = 0.637 [0.726]; LM (2) = 1.543 [0.234]

Table 9. Long-Run elasticities and Short-run elasticities of Population in Pakistan Based on Equation (4)

Variable	Coefficient
HCR	0.022
CO2	-0.324*
POPDUM	0.029**

1. Long-run Estimated Coefficient

11. Short-run Causality Test (Wald Test F-statistic):

	ΔHCR	$\Delta CO2$
	0.018	7.180 *
	(0.893)	(0.010)

* denote significant at 1% level. Figures in brackets refer to marginal significance values.
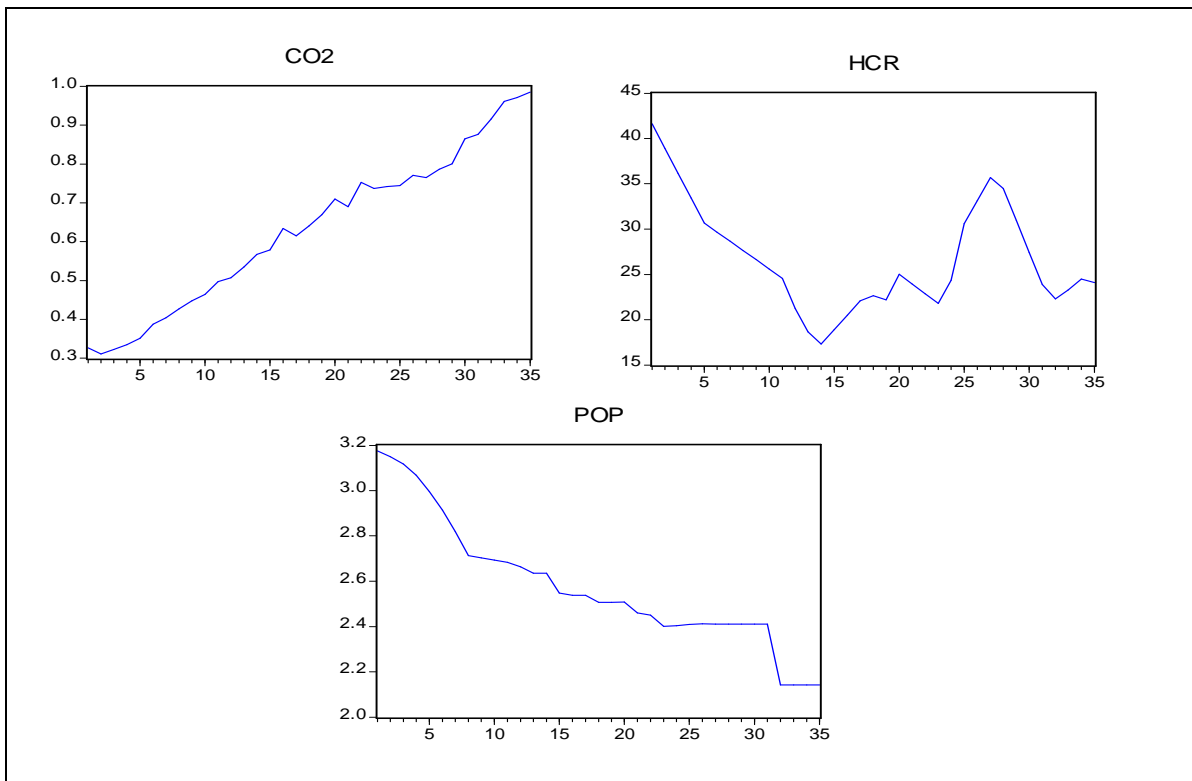Sources: Calculated by the Authors

Figure 1: Poverty Statistics at Rural, Urban and National Level (1979-2006)
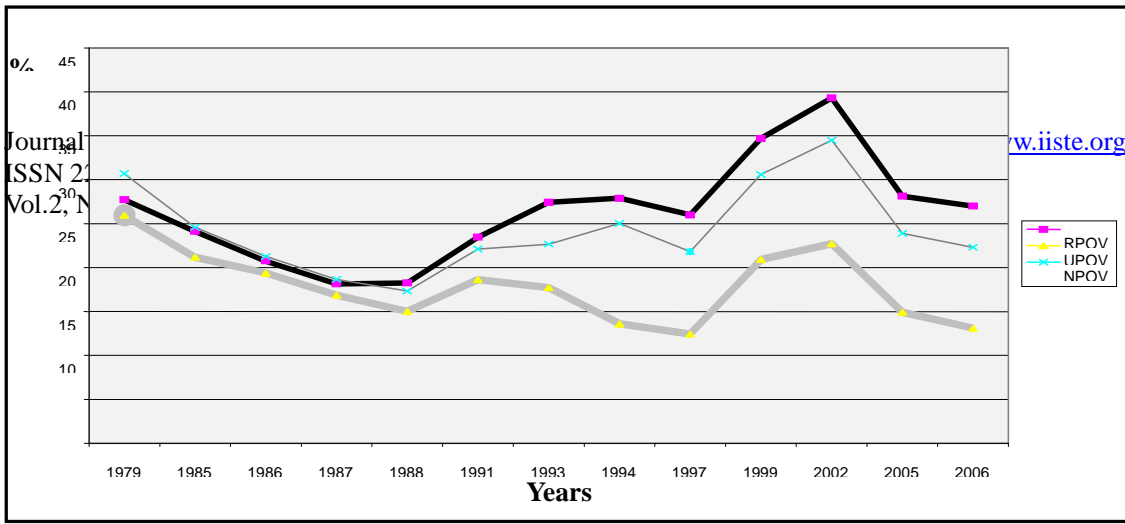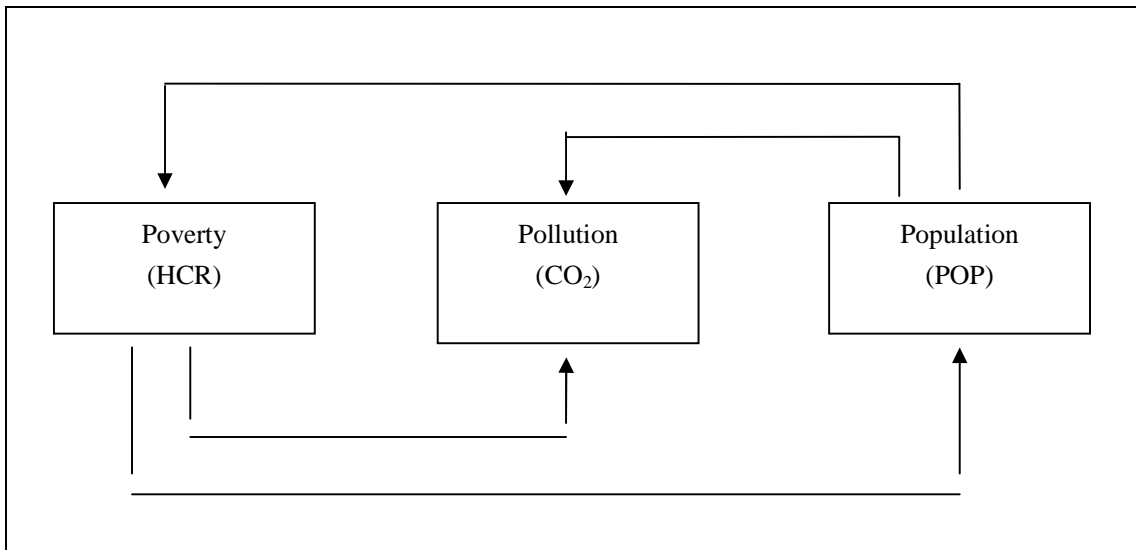
Note: RPOV, UPOV and NPOV represent rural, urban and national poverty

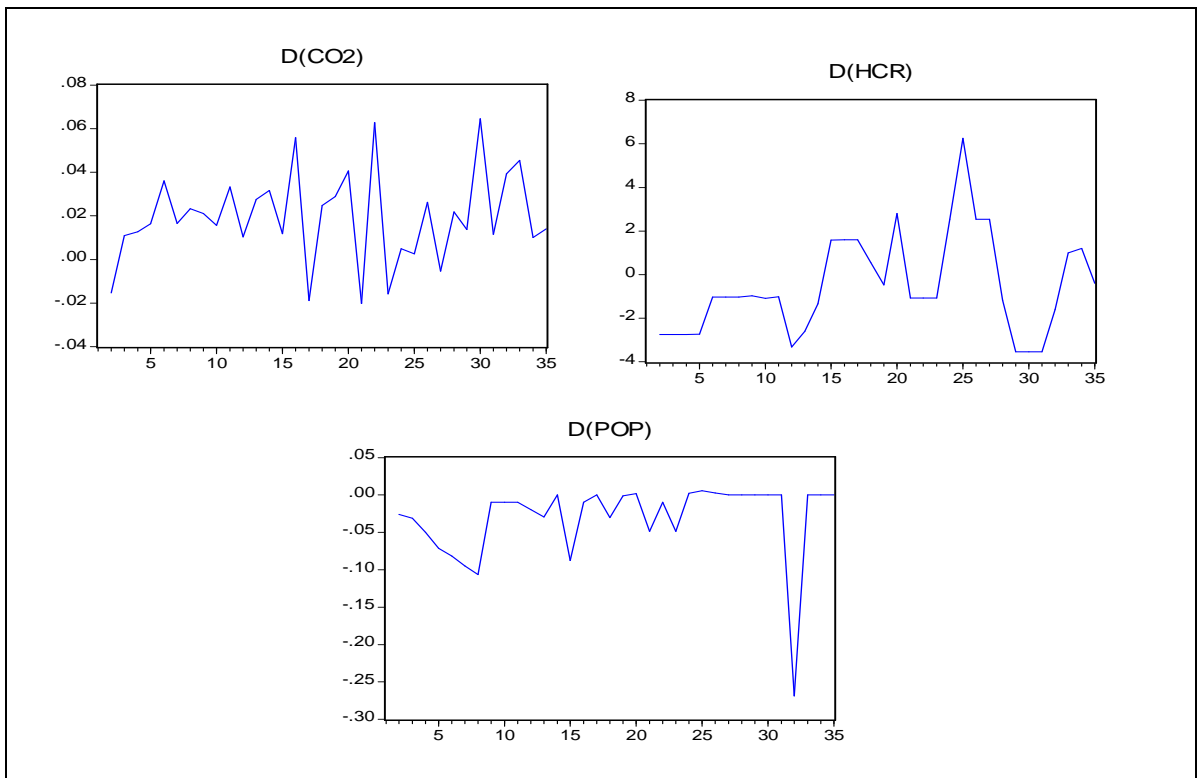**Figure 2:   Data Trend for Poverty, Population and Carbon Dioxide Emissions (1975-2009)**

Source: World Bank (2009) and GoP (2010).

Figure 3: Conceptual Framework

Source: Self Extract

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Figure 4: Data trends at their First Difference

Source: World Bank (2009) and GoP (2010).

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