Journal of Policy Research, 10(3), 399-407
https://jprpk.com
https://doi.org/10.61506/02.00358

Does Urbanization Impede Environmental Sustainability? Panel Data Evidence from South Asia

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Abstract
Climate change and global warming are burning issues in present era and urbanization can be a factor of carbon dioxide emission expansion which erodes environment quality. Considering rapid urbanization in South Asia during last few decades, this study examines the association between urbanization and CO_2 emission. Panel data time series econometric techniques such as; panel DOLS, FMOLS and granger causality are applied by using panel data for 1973-2018. The results show that urbanization increases CO_2 emission in the long run and this finding is also supported by the results of individual country based analyses. Moreover, unidirectional causal linkage from urban expansion to carbon dioxide emission and from energy consumption to carbon emission prevail. Important policy implications are proposed based on the findings. Energy efficient urban public transportation facilities, industrial emission abatement policies, awareness of masses through media etc. can help to reduce carbon emission whereas provision of social amenities in rural areas can lead to ease press of human movement towards urban areas.
Keywords: Urbanization, Carbon Emission, South Asia, Panel Analysis

1. Introduction

Recent past decades witnessed tremendous urbanization both in developed and developing countries. Presently more than 50 percent urbanization has taken place in the world which was just 30 percent in 1950 (United Nation, 2019). It is projected that there will be more than 65 percent urban dwellers all over the world in 2050 (Bahera & Dash, 2017; Wang et al. 2016). Every person can move freely from one place to other within the country as such movement cannot be controlled by law (Ali et al. 2019). Urbanization breeds economic and social modernization. Cities offer better quality public and private services to their dwellers compared to rural areas' residents. There are numerous reasons of surge in urbanization. For instance, urbanization is not only a mirror image of switching labor force from agriculture to industrial sector but also movement of people from rural to urban areas (Poumanyvong & Kaneko 2010). Wage rates in industrial sector are higher than agriculture sector and main industries are situated vicinity of urban areas. Due to unbalance growth, cities have better social amenities such as; education and health facilities in developing countries; therefore, people prefer to reside in urban areas (Ahmed et al. 2020). Natural increase in population growth rate in urban dwellers and conversion of rural areas in surrounding localities of cities to urban areas are also important factors of urbanization.
Economic growth is the primary element of urbanization. To assess the growth of countries, it is an imperative feature. Presently, urban regions produce approximately 80 percent Gross Domestic Product (GDP) of the world. High income in urban areas correlated with more energy consumption which causes environmental problems (Zhao & Zhang, 2018). Without proper planning and poor managed urban expansion coupled with unsustainable consumption and production pattern in urban areas pose serious threat to environment. Urbanization enhances demand for food, housing, infrastructure and transportation which breeds abundant environmental problems such like air pollution due to industrial as well as vehicular emissions, safe drinking water and sanitation problems.
Climate change and global warming are burning issues in recent era which pose threat to human life and increase in carbon dioxide emission is called one the core reasons for global warming. Urbanization, industrializations, energy usage, among others, are potential determinants of carbon emissions. Li et al., (2018) argues that CO_2 emission is a straight consequence of urbanization and industrialization. Expansion in urbanization all over the world increased from 29% to 49% during 1950-2005, however, almost 500% increase in carbon emissions is observed from fossil fuel burning during the same period (UN-Habitat, 2016). There are three possible ways through which urbanization can impede environment quality. First, industrial and residential power utilization. Second, energy consumption that is being utilized by the constructions industry, transportation for urban dwellers etc. Thirdly the alternation of grass land and woodland to permit city progress (Bekhat & Othman, 2017; Zhao & Zhang, 2018). Shahbaz et al. (2015) argue inhabitants of cities are consuming almost 50 percent energy and producing 60 percent CO2 emissions which pose threat of global warming.
Poumanyvong and Kaneko, (2010) discussed three theories on the linkage urbanization and environmental issues namely; ecological modernization theory, environmental transition theory and compact city theory. Ecological modernization theory based at national level while compact city and environmental transition theories based at city level. According to theory of ecological modernization, urbanization is a process of social change which represents modernization. Ecological problems may emerge within low to middle economic development stage as sustainable economic development is not under consideration. However, after achieving a certain level of

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modernization, the societies may realize the severity of environmental problems, which are controlled through technological innovation and transferring to knowledge & service based economy (Crenshaw & Jenkins, 1996; Mol & Spaargaren, 2000). Theory of urban environmental transition associates different environmental issues due to urban expansion at city level. Cities become affluent due to manufacturing base, hence, create environment problems such like contamination of air, water and land. Through structural transformation and regularization measures industrial pollutions are controlled. However, affluent cities generate affluence class in cities, therefore, consumption based demands emerge for more energy induced products which ultimately make hampering impact on environment quality. So the net inference of this theory is inconclusive (Sadorsky 2014). Theory of compact city argues the benefits of urbanization. With urban density, economies of scale are achieved through public transportation system and improved local infrastructure and these advancements help to control environmental degradations (Burton, 2000; Capello & Camagni, 2000).

There is no consensus on the theoretical side as all three theories have different inferences while empirical evidences are also inconclusive. Some studies claims urbanization generates environmental problems (see; Poumanyvong and Kaneko, 2010, Wang et al. 2016; Ahmad, Zhao and Li 2019; among others). However, literature also witnessed insignificant or negative linkage in carbon emission and urban expansions (see; Fan et al.; 2006; Sharma, 2011; Sadorsky, 2014; Saidi and Mbarek, 2017; Lv and Xu (2019).

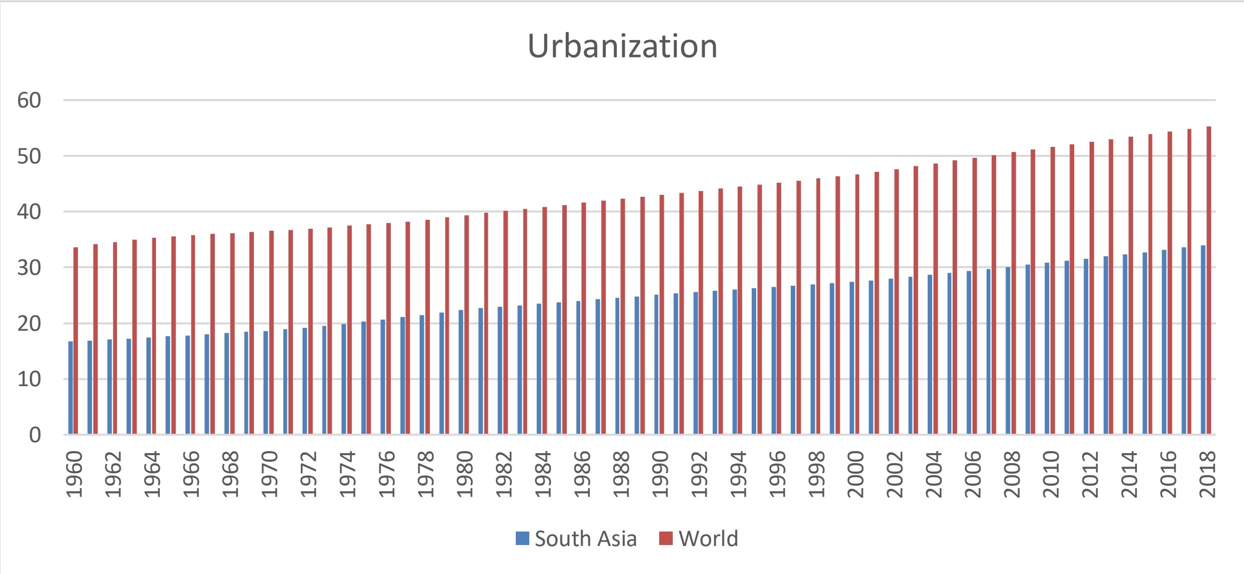

Figure 1: Urban population as percentage of total population

South Asia is one of the most populous region and almost one-fifth of the world population is residing in this region whereas almost 14 percent of the world's urban population settled here (Ellis, & Roberts, 2015). South Asian's urban population steeply increased in recent decade with number of urban dwellers raised by 130 million during 2001 to 2011 and expected to surge upto 250 million in next fifteen years (Ellis, & Roberts, 2015). It is worth mentioning that only one city of South Asia was enlisted in top 20 most populated cities (megacities) in 1970 however this number has increased to five in 2018 (United Nation, 2019). Trend of surge in urbanization all over the World as well as in South Asia during 1960 to 2018 is presented in figure 1. It is evident from this figure that there were less than 17 percent urban dwellers in South Asia and this number has increased upto almost 34 percent in 2018. On the other side, urban population of the world was around 34 percent in 1960 and increased upto 55 percent in 2018. In other words, South Asian witnessed more than 100 percent increase in urbanization as compared to around 65 percent increase all over the globe during the same period. Sharp expansion of urban areas in this region raises numerous problems such as; air & water pollution, water shortage, traffic, congestion and shortage of housing etc. Human relocation from rural to urban is increasing urban slums who are significant cause and victim of environmental deterioration in urban areas. Since last a few decades, significant increasing trend in CO2 emissions is observed in developing countries particularly, in China and South Asia (Huo, et al., 2020; Bahera & Dash 2017). Due to carbon dioxide emissions many problems occur like affecting on human health, agriculture and overall economy.

The main objectives of this study are to find the impact of urbanization on carbon emission both at panel and individual country level along with causal linkage in South Asia. There is dearth of literature on this linkage for South Asia and we traced only three studies (Azam and khan, 2016; Irfan and Shaw, 2017; Afridi et al., 2019). First study applied ordinary least square (OLS) for individual country analysis, second one used data of only three countries of this region and applied parametric approach whereas third study examined the association in urbanization and co_2 emission under the framework of fixed effect panel analysis. Besides, conclusions of these studies are contradictive for South Asian region. Dynamic panel data analysis provides more efficient results. Because, if individual or panel data series contain unit root, the findings of OLS, Pooled OLS, fix and random effect panel estimations may become spurious (Behera & Dash, 2017, Ali et al, 2019). Therefore, the following distinct features are the major differences of this study compared to previous studies on South Asian region. First, a variety of panel dynamic econometric techniques such as panel unit roots, Pedroni cointegration, panel fully modified ordinary least square (FMOLS) and panel dynamic ordinary least square (DOLS) estimators are used to examine long run effect of urbanization on CO_2 emission in South Asia. Second, for short and long run causal linkages, vector error correction model (VECM) is applied and this technique has been widely by researchers (see; Al-Mulali, 2013; Wang, 2016; Kasman & Duman, 2015; Kayani et al., 2020). Third, a large panel data set provides more degree of freedom for panel time series data analysis, hence, greater precision in conclusions can be achieved. In this study, 45 years panel data from 1973 to 2018 is used to have more efficient and robust results. Based on our findings, some important policy implications are devised.

The sections of remaining paper are as follows. Section 2 contains review of some important studies on the subject topic whereas model, data and panel data methodology are given in section 3. Section 4 comprises on results and discussions and section 5 consists of conclusion and policy implications.

2. Literature Review

Uprising trend of urbanization during past few decades and environmental deterioration throughout the global attract researchers to examine the relationship in urbanization carbon dioxide emission. During past couple of decades, numerous researchers examined the impact of urbanization on carbon emission after seminal study of Parikh and Shukla, (1995). However, like theoretical disagreement, empirical literature is also far from unanimous consensus on this relationship.

We reviewed literature in two strands. First strand of literature claims positive influence of urbanization on carbon dioxide emissions. Cole and Neumayer, (2004) argued that urbanization rate as well as household size are potential determinant of carbon omission. Poumanyvong and Kaneko, (2010) examined this relationship on the basis of Stochastic Impacts by Regression on Population, Affluence, and Technology (STIRPAT) model by using panel data of 99 nations for the period 1975-2005 and further classified the selected countries into three groups. They found positive impact of urbanization on CO_2 emission in high, middle and low income countries. Martínez-Zarzoso and Maruotti. (2011) also explored the effect of urbanization on CO_2 emission in developing countries by using STIRPAT model and claimed positive impact of urbanization on CO_2 emissions in less developed regions. Al-Mulali et al. (2013) applied panel DOLS and Granger causality techniques to explore the association in urbanization, energy consumption and carbon emission for MENA countries. They found long run significant effect of urbanization on environmental quality and short run bidirectional causality. This study suggested that prudent measures need to be taken to control the pace of urbanization for environment preservation. According to Wang et al. (2016), urbanization causes CO_2 emission in the long run. Annual data of BRICS countries for 1985-2014 was used whereas Canning and Pedroni and VECM causality methods were applied for causal linkages. Irfan and Shaw (2017) applied non-parametric approach to examine urbanization and carbon emission nexus for three South Asian countries namely, India, Pakistan and Sri Lanka and found inverted U-shape relationship in urbanization and carbon emission. Afridi et al., (2019) applied fixed effect panel analysis and Dumitrescu Hurlin panel causality tests by taking annual data of South Asian Association of Regional Cooperation (SAARC) countries for 1980-2016. The authors found positive effect of urban population expansion on environment degradation whereas bidirectional causality between these variables. Ahmad, Zhao and Li (2019) analyzed the relationship between carbon emission and urbanization by using data of thirty provinces and cities of China for period 2000-2016 and arranged data three zonal classifications. They empirically found significant positive role of urban population expansion on carbon emission. Ahmed et al. (2020) claimed detrimental role of urbanization on environmental quality in G7 countries. Similarly, Islam et al. (2021) found positive impact of urbanization on carbon emission in Bangladesh.

However, second strand of literature found negative or insignificant relationship between carbon emission and urbanization. Fan et al. (2006) applied STIRPAT model and used data of 208 countries and found positive role of urbanization for reducing CO_2 emission in high income countries; however, insignificant effect in low and lower middle income countries. They claimed that negative impact role of urbanization on CO_2 emission is restricted to economic development and energy consumption levels. Sharma (2011) found negative significant influence of urbanization on CO_2 emission in high, middle and low income countries groups. This study used used data of 69 countries for 1985-2005. Sadorsky, (2014) used unbalanced data set of sixteen emerging nations for the period 1971-2009 and empirically claimed negative effect of urbanization on CO_2 emissions in emerging nations however, positive impact of energy intensity. Azam and khan (2016) used time series data of Pakistan, India Sri Lanka, and Bangladesh for 1982-2013. They applied OLS technique and found positive role of urbanization for controlling CO_2 emissions in India and Bangladesh, whereas insignificant positive relationship for Pakistan and Sri Lanka. Saidi and Mbarek (2017) explored the effect of urbanization, trade, income and financial development on CO_2 emission by using data of 19 emerging countries for the time span 1990-2013. By applying GMM panel analysis and this study argued negative effect of urbanization on CO2 emission. By applying panel DOLS and FMOLS techniques, Behera and Dash (2017) claimed insignificant linkage in urbanization and carbon emission for low income countries of Southeast Asian countries. Lv and Xu (2019) studied the effect of urbanization and trade on carbon emission in 55 middle incomes. They applied panel Autoregressive Distributed Lag Model

(ARDL) method and found negative role of urbanization on CO2 emission in the selected countries means urbanization is beneficial for environment quality.

3. Model, Data and Research Methodology

3.1. Model and data source

To examine long run impact and causality between carbon emission and in South Asia, this study adopted the model of Al-mulali et al., (2013) and Wang et al., (2016). They argue that urbanization and energy consumptions are potential factors of carbon dioxide emissions. Following them, the proposed econometric model is as follows:

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

Where CO_2 is carbon dioxide emission, URN is urbanization and ECN is energy consumption. Besides, βs are coefficients of respective variables, ε is error term and subscript i & t represent country and time. As discussed earlier, extensive urbanization has been observed in South Asia in past couple of decades. Numerous studies claim that urbanization exerts negative impact on environment quality in developing countries. Being a developing region, it is expected that urbanization may have positive impact on carbon emission, therefore, expected sign of β_1 is positive. Energy consumption is important ingredient of economic growth. Usually, fossil fuel is the major source of energy production in South Asian countries. It is evident from literature that energy consumption deteriorates environment, therefore, the expected sign of $\beta 2$ is also positive. As far as measurements of the variables are concerned, CO_2 is in kiloton, urbanization is as annual %age growth in urban population and energy consumption measured as primary energy consumption in million tones oil equivalent. Shahbaz et al (2012) argues that conversion of variables into natural logarithm form can exclude any sharpness in the series and helps to interpret results in elasticity. Considering this, energy consumption and CO_2 emission variables are transformed into natural logarithm form whereas urbanization variables is not converted into logarithm form as this variable is already in percentage form.

Non-availability of data constraint for all countries of South Asia, compelled us to select four countries namely; India, Pakistan, Bangladesh and Sri Lanka. However, these are major entities and around 80 percent population of South Asian region are residing in these countries, therefore, sample of these countries can be called as fair presentation of South Asia. Balanced panel data is chosen for the time span 1973-2018. Data for urbanization variable is extracted from World Development Indicators (WDI), published by World Bank and data on primary energy consumption & CO2 emission is extracted from BP Statistical Review of World Energy 2019 (BP 2019).

3.2. Methodology

A bucket of different of panel data analysis techniques is applied to meet the objectives of this study. There are number of advantages of panel data analysis over time series and cross sectional data. Controlling individual heterogeneity, less collinearlity among the variables, more degree of freedom, more variability hence more efficiency are the major hallmarks of panel data analysis (Baltagi, 2005). Pooled OLS, fix and random effect based panel estimations are usual analysis techniques, however, the estimates of these tests will be inconsistent and spurious, if panel data series contain non-stationarity at level. Because integrated panel data series may hold cointegration (Behera & Dash, 2017). Therefore, prior to examining relationship among panel data series, unit root analysis is crucial. Numbers of panel unit roots tests are available based on different assumptions, however, we applied five panel unit tests namely; Levin-Lin-Chu (LLC) test, Breitung test, Fisher-ADF test, Fisher-PP test and Im-Pesaran-Shin (IPS). Breitung and LLC tests are based on the assumption of different cross-section sequences having a common unit root process while Fisher-ADF, Fisher-PP and IPS tests are based on the assumption of cross-section sequences having different individual unit root process.

3.2.1. Pedroni cointegration test

Once it is determined that all panel data series are non-stationary at level $I(0)$ and stationary at first difference $I(1)$, the next step is to examine cointegration among the selected variables because the data series may contain common relationship. For this purpose, this study applied panel cointegration test proposed by Pedroni (1999). If all variables are integrated at order one I(1) then Pedroni cointegration test can be used. Pedroni cointegration equation can be written as follows:

$$y_{it} = \alpha_i + \gamma_i t + \beta_{1i} x_{1i,t} + \beta_{2i} x_{2i,t} + \cdots + \beta_{Mi} x_{Mi,t} + e_{i,t} \quad (2)$$

Where t represent time, and m =1, …M dependent variables in numbers, $\beta_{1,} \ldots \beta_M$ represent slope of coefficients and α is country's specific intercept. It is assumed that intercept and slope of the coefficients can vary across each cross-section. Pedroni (1999) proposed seven tests wherein four tests are based on within dimension (homogenous alternative) and three tests are based on between-dimension (heterogeneous alternative). Through these seven the conclusion can be drawn whether cointegration exists or not?

3.2.2. Panel DOLS and FMOLS tests

After finding cointegration among the variables, we evaluate long run parameters by using panel DOLS and panel FMOLS methods. Panel DOLS technique is a parametric analysis which uses lead and lag together of differenced regressors to control endogeneity, serial correlation and multicollinearity problems (Behera & Dash, 2017). This method can be written as:

$$y_{tt} = \alpha_i + x_{it}\beta + \sum_{j=q^-}^{q^+} \phi_{ij}\, \Delta X_{i,t+j} + \upsilon_{it} \tag{3}$$

Where Δ is first differenced operator, q^+, q^- represent lead and lag and ϕ_{ij} are coefficients of lag or lead first differenced independent variables. The estimation of coefficient in DOLS test is given by:

$$\hat{\beta}_{DOLS} = N^{-1} \sum_{i=t}^{N} \left[\sum_{i=1}^{T} Z_{it} Z'_{it} \right]^{-1} \left(\sum_{i=1}^{T} Z_{it}\, \hat{y}^*_{it} \right) \tag{4}$$

Where Z_{it} represents 2(q+1)1 vector of independent variables.
Besides panel DOLS estimator, this study also applied panel FMOLS estimator which is non-parametric approach. The reason of applying two different tests for estimation is to cross check the findings with both tests for conformity of results beyond doubt. Control the simultaneity bias is one the main advantages of this test (Kasman & Duman, 2015). The panel FMOLS estimator is defined as:

$$\hat{\beta}_{FMOLS} = \left[\sum_{i=1}^{N} \sum_{t=1}^{T} (x_{it} - \bar{x}_i)' \right]^{-1} \left[\sum_{i=1}^{N} \langle \sum_{t=1}^{T} (x_{it} - \hat{x}_i) \hat{y}^*_{it} + T\hat{\Delta}^*_{\epsilon\mu} \rangle \right] \tag{5}$$

Where $\hat{y}^*_{it}$ is the converted variable of y_{it} for achieving the endogeneity correction.

3.2.3. Panel Granger Causality test

Prevalence of cointegration in the model shows existence of causality at least one direction, however, direction of causality does not confirm. To examine the causal linkage among the variables, VECM model is used which help to examine long and short run causality. Short run causality can be determined through F-stat test which is applied on differenced exogenous variable, however, long run causality can be determined with lagged error correction term. Equation forms of VECM are as follows.

$$\Delta CO2_{it} = \alpha_1 + \sum_{i=1}^{m} \beta_i\, \Delta CO2_{it-i} + \sum_{j=1}^{n} \delta_i\, \Delta URN_{it-j} + \sum_{k=1}^{o} \gamma_{it}\, \Delta ECN_{it-j} + \phi_{it} ecm_{it-1} + \varepsilon \tag{6}$$

$$\Delta URN_{it} = \alpha_1 + \sum_{i=1}^{m} \beta_i\, \Delta CO2_{it-i} + \sum_{j=1}^{n} \delta_i\, \Delta URN_{it-j} + \sum_{k=1}^{o} \gamma_{it}\, \Delta ECN_{it-j} + \phi_{it} ecm_{it-1} + \varepsilon \tag{7}$$

$$\Delta ECN_{it} = \alpha_1 + \sum_{i=1}^{m} \beta_i\, \Delta CO2_{it-i} + \sum_{j=1}^{n} \delta_i\, \Delta URN_{it-j} + \sum_{k=1}^{o} \gamma_{it}\, \Delta ECN_{it-j} + \phi_{it} ecm_{it-1} + \varepsilon \tag{8}$$

Where, Δ is differenced operators, α is intercept, β, δ , γ are coefficients of first differenced variables and ecmt-1 is lagged error correction term which shows speed of adjustment. For lag selection, certain lag selection criteria can be used.

4. Results and Discussion

The analysis of present study is based on the panel econometrics methods. First of all, the results of descriptive statistics are given in Table 1.

Table. 1: Descriptive Statistics

Variables	Mean	Max	Min	Std. Dev.
Bangladesh				
CO_2	2.919	4.505	1.344	0.923
ECN	2.132	3.578	0.521	0.902
URN	5.171	10.909	3.186	2.403
India				
CO_2	6.622	7.816	5.392	0.724
ECN	5.503	6.696	4.282	0.719
URN	2.958	3.955	2.309	0.541
Pakistan				
CO_2	4.237	5.277	2.924	0.720
ECN	3.424	4.443	2.078	0.705
URN	3.499	4.505	2.647	0.628

Sri Lanka				
CO_2	1.917	3.078	0.887	0.683
ECN	1.073	2.093	0.065	0.625
URN	1.192	2.463	0.047	0.660
Panel				
CO_2	3.924	7.816	0.887	1.924
ECN	3.033	6.696	0.065	1.813
URN	3.205	10.909	0.047	1.930

Note: Std. dev and CV stands for standard deviation and Coefficient of variations

It is evident from this table, the highest mean value of CO2 emission for India followed by Pakistan, Bangladesh and Sri Lanka. However, difference in minimum and maximum values is higher in Bangladesh that is why standard deviation value for CO2 emission is higher in Bangladesh than other countries. It shows though mean value of CO2 emission is higher in India and Pakistan, however, rapid increase in CO2 occurred in Bangladesh during the study period. As far as, urbanization is concerned, the lowest mean value for Sri Lanka and the highest for Bangladesh. Difference in minimum and maximum values as well as values of standard deviation for Bangladesh is quite high followed by Sri Lanka, Pakistan and India. Mean value of electricity consumption is higher in India compared to other three countries and value of standard deviation is higher in Bangladesh and lower in Sri Lanka. In overall panel, mean value for CO2 is higher followed by urbanization and electricity consumptions and standard deviation value is comparatively high for urbanization than CO2 emission and the lowest value of standard deviation is for electricity consumptions.

Table 2: Unit root test

	CO_2		ECN		URN	
	Constant	Trend	Constant	Trend	Constant	Trend
At Level						
LLC	-1.040	0.181	-2.460*	-0.317	-1.304	0.665
Breitung		0.288		0.308		0.710
IPS	2.052	0.159	0.627	-0.064	-0.201	0.381
FisherADF	2.067	7.438	5.917	7.672	6.904	8.580
Fisher PP	2.959	11.368	9.391	10.494	4.691	8.328
At first differenced						
LLC	-5.751*	-5.594*	-2.778*	-1.890**	-6.360*	-6.505*
Breitung		-3.599*		-5.005*		-2.705*
IPS	-6.502*	-5.525*	-6.631*	-5.959*	-6.618*	-6.122*
FisherADF	57.292*	44.376*	58.252*	47.988*	57.584*	49.162*
Fisher PP	123.418*	122.479*	116.991*	145.478*	57.303*	46.930*

* represents < 1% level

** represents < 5% level

Table 3: Pedroni cointegration test

Alternative hypothesis: common AR coefs. (within-dimension)				
	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	1.154	0.124	0.741	0.229
Panel rho-Statistic	-1.740	0.041	-1.340	0.090
Panel PP-Statistic	-2.279	0.011	-1.851	0.032
Panel ADF-Statistic	-0.999	0.159	-1.582	0.057
Alternative hypothesis: individual AR coefs. (between-dimension)				
	Statistic	Prob.		
Group rho-Statistic	-0.791	0.215		
Group PP-Statistic	-1.755	0.040		
Group ADF-Statistic	-1.429	0.077		

Usually, panel time series contain unit root which means zero mean and constant variance properties for regression analysis may violate. Therefore, prior to finding linkage between dependent and independent variables, it is important to examine where the data is stationary or not? For this purpose, five panel unit root tests (LLC, Breitung, IPS, Fisher ADF, and Fisher PP) are conducted and the results these tests are given at Table 2. It can be observed from this table that all variables are non-stationary at level as the null hypothesis of the unit root for all

series cannot be rejected at level in all tests both at constant and constant with trend. However, all variables are stationary at first difference as null hypothesis is rejected in all tests. Therefore, it can be concluded that all series contain unit root at level and stationary at first difference or integrated at order one *I*(1).
After knowing the stationarity of the variables through panel unit root tests, we applied Pedroni panel cointegration test to find cointegration relationship among the variables of the model. This test based on seven statistics both within and between dimensions. The results Pedroni panel cointegration results are given at Table 3 which shows cointegration exists in among the variables because five out of seven statistics are significant at 5 and 10% level.

Table.4:Results of Panel DOLS and FMOLS (Dependent variable: CO_2)

Country/Panel	DOLS		FMOLS	
	ECN	URN	ECN	URN
Bangladesh	1.134*	0.048*	1.117*	0.043*
India	1.120*	0.145*	1.122*	0.151*
Pakistan	1.129*	0.116*	1.128*	0.108*
Sri Lank	1.448*	0.313*	1.418*	0.314*
Panel South Asia	1.083*	0.038*	1.077*	0.035*

* represents < 1% level

Table 5: Results of causality based on VECM

Dependent Variables	Independent Variables F-stat values of lagged first differenced Variables			ECT_{t-1}
	ΔCO_2	ΔECN	ΔURN	
ΔCO_2	-	0.8412 (0.360)	2.927*** (0.089)	-0.105* [-2.165]
ΔECN	11.148* (0.001)	-	3.449*** (0.065)	-0.012 [-0.541]
ΔURN	0.135 (0.713)	0.004 (0.951)	-	-0.876* [-4.442]

[ ] contains *t*-stat values
( ) contains *p*-values of F- stat
* represents < 1% level
*** represents < 10% level

The results of DOLS and FMOLS tests both for panel as well as individual countries are presented at Table 4 in which carbon dioxide emission variable serves as a dependent variable whereas urbanization and energy consumption as explanatory variables. Long-term coefficients estimates based on DOLS and FMOLS also serve as elasticity estimates. The panel DOLS results reveal that one percent increase in city population results in 0.038 percent rise in CO_2 emission, as the coefficient is highly significant. Panel FMOLS results also aligned with results of Panel DOLS as urbanization positively enhances environment degradation. The results of Table 4 about individual countries' analysis also reveal positive contribution of urbanization in CO_2 emission in all countries. The results of both tests for panel as well as individual countries support each other. Our findings are aligned with Poumanyvong and Kaneko (2010), Wang et al., (2016) and Ali et al., (2019) who found positive impact of expansion in urbanization on CO_2 emission. However, our findings contradictive with Sharma (2011), Behera & Dash (2017) and Lv & Xu (2019) who claimed urbanization has negative impact on carbon dioxide emission. In this study, energy consumptions variable is also used as control variable and results of panel DOLS confirm that one percent increase in energy consumption significantly enhances 1.083 percent in carbon dioxide emission. This findings is supported by the results of Panel FMOLS which has almost same effect. As far as the results regarding individual countries are concerned, there is positive impact of energy consumption on environment degradation in each countries as evident from the result of DOLS and FMOLS available at Table. 4. These findings confirmed hampering impact of energy consumptions on environment quality in South Asian region. To check the casual linkage VECM technique is applied and lag one is used as per Schwarz information criterion. The findings of this technique are given at Table 5. It is evident from this table that long run causal link prevail from urbanization to CO_2 emissions as the value of lagged error correction term is significant. Short run unidirectional causality from urbanization to carbon emission exist as *F*-stat value is significant. Moreover, energy consumption causes carbon emission directionally whereas causality from carbon emissions to energy consumptions also prevails.
Overall findings confirm that expansion in cities is one of the major factors which effect environment quality negatively. The plausible reasons behind positive impact of urbanization on CO_2 emission in South Asia may be that more peoples are becoming urban dwellers for employment purpose as the major industries are situated in the vicinity to the urban centers. Bleak public transportation systems exist in most of urban areas of this region, therefore, extensive vehicular emission is taking place as private vehicles are exponentially increasing day by day. In addition, trees and green fields are reducing gradually in order to absorb more population in urban centers. When population increases in urban areas, demands for food, industrial products, houses, buildings and energy increase. South Asian region witnessed more than 100 per increase in urbanization during last half century which

exerted press on transportation system of urban areas, hence, vehicular emissions increased in manifold. Besides, other negativity such contamination of water and problem of sewages and increase in urban slums, electricity consumption both in industrial sector and household is one the major reasons of environment degradation. As discussed earlier, fossil fuel is the major source of electricity production in this region, which is also one the source of contamination of fresh air. Based on the findings of this study, it can be concluded that expansion in urbanization in South Asia has negative impact on environment quality, hence, some prudent steps need to be taken to control rapid increase in urbanization in order to control the further damage of environment quality. For this purpose, a variety of policy options are available both for the masses and the governments.

5. Conclusion and policy implications

Rapid urbanization is rising trend in developing countries generally and in South Asia particularly. On the other side, sustainable development is the most desirable demand in the world as environmental degradation has some serious repercussions for present as well as future generations. However, numerous empirical evidences available which show negative impact of urbanization on environment quality. The core objective of this research is to explore the impact of urbanization and CO_2 emission in South Asian region by employing panel data set consisting of four South Asian countries for the period 1973-2018. This study applied different panel unit root tests to check the stationarity and Pedroni test to examine cointegration among the variables. To explore long-term association, this study employs DOLS and FMOLS tests both for individual country and panel data set whereas VECM causality test is applied for short run/long run causality analysis. This study found substantial positive long run impact of urbanization on CO_2 emission in South Asia. The results of Granger causality show unidirectional short run causality from urbanization to CO_2 emission and from energy consumption to CO_2 Emission in this region. The findings of this study confirm negative impact of urbanization the environment quality in this region.

Based on the findings, some significant policy implications are devised for the policy makers and the governments. Due to rapid urbanization expansion in some major cities has observed. Out of top 20 mega cities in the world, five are situated in this region and exponential rise in urbanization is still going-on here. Unfortunately, because of the poor condition of local transportation system in most of the cities of South Asia, people prefer to use their private transport, hence, breeding vehicular emission which cause carbon dioxide emission. Policy makers and governments can emphasize on this problem and support energy efficient local public transportation system in cities so that emission through the vehicle can be reduced. Second, Long term rational city planning should be made and threshold point of urbanization should be implemented. Third, people moves to cities for employment, better education and health for their children and family. The governments need to provide social amenities in rural areas so that movement from rural to urban areas can be reduced. Fourth, with the expansion of cities, grass lands, green plants and trees, which absorb carbon emissions, are reducing gradually. Policies need to be devised and implemented for plantation of new trees, green buildings and roof gardening etc in the cities. Fifty, educate urban dwellers for environment preservations through media, educational institutions etc. Sixth, the adaptation of green technologies by industries should be more emphasized.

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