Investigating the Impact of Urbanization on Living Standards, Infrastructure and Environment: A Case Study of Six Major Cities of Punjab, Pakistan

Maria Faiq Javaid[1*], Atif Khan Jadoon[2*], Rimsha Ramzan[3*], Ambreen Sarwar[4*], Liaqat Ali Waseem[5*], Muhammad Shahid Maqbool[6*]

[1,2,4*] Assistant Professor, School of Economics, University of the Punjab, Lahore.

[3*] School of Economics, University of the Punjab, Lahore, Corresponding Author)

[5*] Assistant Professor, Department of Geography, Government College University Faisalabad

[6*] Assistant Professor, Department of Economics, Government Graduate College Gojra

Abstract: *The present research analyzes the impact of urbanization on various dimensions of economic development, i.e. infrastructure, living standards and environment. Using data from years 2002 to 2022, 17 dimensions of selected indicators are identified to study the effects of urbanization on economic development for a panel of six cities in Punjab, Pakistan. Panel ARDL estimation technique is employed to study short-run and long-run effects of urbanization on development. The research concludes that, in the long run, urbanization has a negative and significant effect on economic development through infrastructure, living standards, and environment. However, this impact is insignificant in the short run. The research also establishes a bidirectional causality between urbanization and infrastructure and urbanization and living standards. However, the causal relationship runs from environment to urbanization. Moreover, unidirectional causality also exists from urbanization to economic development.*

Keywords: *Infrastructure, Urbanization, Living standards, Environment, Development.*

I. INTRODUCTION

Urbanization is a demographic process that involves the transfer of rural populations to urban areas over time (Z. Chen, Lu, & Ni, 2019; Peng, Chen, & Cheng, 2011). Urbanization and economic development are closely related (M. Chen, Zhang, Liu, & Zhang, 2014). According to Lewis (1952), economic development began with the rise of industrialization, which necessitated the shift of cheap labor from agriculture sector in rural areas to the modern sector in urban areas. Rural and Urban redistribution of the labor force occurs because different geographical areas are preferred for various types of production

(Li et al., 2023; Narayan, 2014; Seto, Sánchez-Rodríguez, & Fragkias, 2010). Increased population density in cities generates positive externalities that boost efficiency and productivity. Employment structures also evolve as a result of redistribution within industries. According to the World Bank (2015), if managed effectively, urbanization can contribute to long-term economic development by increasing productivity and allowing the emergence of new ideas. Urbanization influences different dimensions of development as it generates employment opportunities, increases technological as well as infrastructural advancement, upgrades communication and transportation system, quality education, and enhances living standards (Ghalib, Qadir, & Ahmad, 2017; Lenzi & Perucca, 2022; Shahbaz, Chaudhary, & Ozturk, 2017; L. Wang et al., 2019; Zhang, Zhao, Zhang, & Feng, 2023). The present study develops an index of development by considering three important dimensions of economic development i.e environment, infrastructure and living standards for major urban cities of Punjab, Pakistan. The present study investigates the impact of urbanization on economic development in the case of a highly populated province of Pakistan i.e. Punjab.

Urbanization, if properly planned, can improve living standards through provision of clean and safe drinking water, better health and education facilities, better housing and transportation. Research has proved that urbanization generates employment opportunities, increase technological as well as infrastructural advancement, upgrade communication and transportation system, increase access to quality education and health services, and enhance living standards (Lenzi & Perucca, 2022; Zhang et al., 2023). In case of poor urban planning and development, living standards may decline due to inequity, social unrest and development of overcrowded informal settlements (Avdeeva, Averina, & Kochetova, 2018; Burger, Morrison, Hendriks, & Hoogerbrugge, 2020).

Urbanization improves infrastructure in metropolitan cities, which enhances productivity. Increased urbanization, improved access to better roads and transportation facilities, and the availability of information and communication technology (ICT) play a crucial role in building an information and knowledge–intensive economy. Improved ICT and infrastructure enable the population to have access to better education, health and employment opportunities, thus enhance income and living standards. Increase in income and living standards of a segment of population will cause positive spillover effects in less developed localities (Ghalib et al., 2017; Shahbaz et al., 2017; L. Wang et al., 2019). Another school of thought believes that urbanization causes hurdles in income generation and economic development if the migration rate from less developed regions exceeds the rate of infrastructural development. In such a case, increased urbanization would cause overcrowding and congestion causing negative externalities like increased cost of housing, overburdened transportation and social services (Castaldo, Fiorini, & Maggi, 2018; Mayer, Madden, & Wu, 2020; Nguyen & Nguyen, 2018).

In developing countries, urbanization and environment degradation has always remained an issue of utmost concern. Although urbanization improves economic growth for many countries, at the same time it poses environmental risks like increased emissions of hazardous gases, increased deforestation and also a reduction in the availability of land for cultivation (L. Wang et al., 2019). Several researchers have found that urbanization puts an adverse impact on environment (Gholami & Baharlouii, 2019; Uniyal, Jha, & Verma, 2015; WEN et al., 2017). Studying urbanization and environment nexus is essential for two reasons. First, suitable urban development strategies can be formulated, and second, environmental risks arising due to increased urbanization can be mitigated.

Pakistan is one of the South Asia's most urbanized countries. Trends of urbanization in different provinces of Pakistan over 1951-2017 are summarized in Table 1.

Table 1: Population Distribution (in Percentages) by Census: 1951-2017

		1951	1961	1972	1981	1998	2017
Punjab							
	Urban	17.4	21.5	24.4	27.6	31.3	36.7
	Rural	82.6	78.5	75.6	72.4	68.7	63.3
Sindh							
	Urban	29.2	37.9	40.4	43.3	48.8	52
	Rural	70.8	62.1	59.6	56.7	51.2	48
KPK							
	Urban	11.1	13.2	14.3	15.1	16.9	18.8
	Rural	88.9	86.8	85.7	84.9	83.1	81.2
Balauchistan							
	Urban	12.4	16.9	16.5	15.6	23.9	27.5
	Rural	87.6	83.1	83.5	84.4	76.1	72.5
Pakistan							
	Urban	17.7	23.1	25.4	28.3	32.5	36.4

Rural	82.3	76.9	74.6	71.7	67.5	63.6

Source: Social Policy and Development Centre 2018

Urbanization is taking place at a faster pace all over Pakistan. As indicated in Table 1, Pakistan has witnessed a rise in urbanization trends during 1951-2017. In 1951, 17.7 percent of the population resided in urban areas, while this percentage increased to 36.4 in 2017. Punjab is the most populated and urbanized province of Pakistan. In Punjab, the urban population increased significantly from 17.4 per cent to 36.7 per cent during the same period. Similar increasing trends in urbanization can be observed in Sindh, KPK and Baluchistan.

Reasons behind fast urban growth in Pakistan are high birth rates i.e., 3.45% in 2019 and migration from rural areas (World Bank, 2020). Some other reasons include internal migration, better employment and education opportunities and conversion of agricultural land (Ghalib et al., 2017). Pakistan faces key challenges of housing quality and affordability, transportation, health, education, water and sanitation etc., arising due to urbanization. Most people are living in slums (Shaikh & Nabi, 2017). These outcomes of urbanization are adversely affecting development on a larger scale (World Bank, 2015). With the higher urban population, people face problems of water scarcity and lack of solid waste management facilities (World Bank, 2015; Shaikh & Nabi, 2017). The highly urbanized cities are unable to meet growing demand for infrastructure and other basic facilities, arising due to increased population. Overall under-performance in service provision and infrastructure scarcity handicap business growth and reduce the productive potential of cities. Poor city transport and unsound traffic management surrender roads heavily squeezed and overcrowded, inhibiting urban mobility (Afzal, Ahmed, & Nawaz, 2018). In Punjab, Lahore, Faisalabad Sialkot, Multan, Rawalpindi, and Sheikhupura contain more than half of the province's population. These urbanized cities of Punjab face a lot of social, infrastructural, and environmental issues which may have effect on economic development in the province. Table 2 presents recent statistics on infrastructure, living standard and environment indicators for these major cities of Punjab.

Table 2: Important Development Indicators for Punjab, Pakistan.

City	years	Road Length (kilometers)	Household with mobile non-mobile telephone and internet (%age)	Literacy rate(10yrs and older) (%age)	Tap water as system of water supply (%age)	Households with electricity connections (%age)	Population (000 person)	CO2 emissions
Lahore	2012-13	1244.41	32	78	74	98.04	9353	3.2
	2016-17	1264.12	55.46	78	85.90	98.52	11036	-1.65
	2019-20	1292	57	76.90	23.29	98.79	12415	-5
Sheikhupura	2012-13	1287.69	33	63	22	98.98	419	12.6
	2016-17	1493.01	32.85	69.60	49.29	99.25	472	7.49
	2019-20	1691	45.92	63	40.15	99.62	510.5	4
Sialkot	2012-13	1968.09	16.06	70	23	98.15	594	11.0
	2016-17	1953.52	36.01	84.10	28.05	99.71	653	6.42
	2019-20	1918	55.98	79	20.15	99.09	698	3
Faisalabad	2012-13	3726.73	31	69	19	98.66	2881	8.05
	2016-17	3160.7	34.70	73	20.36	98.68	3188	11.2
	2019-20	2489	51.13	67	9.89	98.84	3424	15
Rawalpindi	2012-13	3682.75	38.53	82	47	97.68	1941	0.74
	2016-17	3666.01	58.25	81.80	21.02	99.91	2111	0.34
	2019-20	3696	59.07	82	22.84	99.01	2237	1.62
Multan	2012-13	1976.26	14.67	60	52	94.93	1712	1.32
	2016-17	2470.73	31.33	63.90	77	96.47	1885	4.91

2019-20	2611	44.47	61	69	97.01	2015	7.59

Source: Punjab Development Statistics, 2021.

This increased urbanization is increasing environmental risk and pollution in the province. Issues of lack of infrastructure and reduced water supply are also becoming evident over time. Current research examines the effect of urbanization on economic development by constructing an index of development comprising three indicators, i.e. infrastructure, living standards and environment. It is empirically analyzed whether urbanization puts positive or negative influence on each dimension of economic development. Moreover, the present study will also examine the causal relation between urbanization and economic development.

2- LITERATURE REVIEW

Several factors including size of the economy, work opportunities, provision of basic facilities, better infrastructure, anticipation of an improved living standard and trade attract migrators (Belokrenitsky, 2017). Some driving forces of urbanization are globalization, modernization, marketization, industrialization, and institution strength. According to Lewis (1952), economic development starts with the expansion of industrialization which required transfer of cheap labor force from the agriculture sector to the modern sector which is also the basis for urbanization. According to Scott (2002), Global investment, communication technology, and international trade are new driving forces of urbanization. It has also been found that income, infrastructure, and low price of transport and industrial development are the major reason for urban sprawl. Nowadays, the driving forces of urbanization are the green revolution that causes the shift of excess labor from rural to urban areas (Haryanto, Erlando, & Utomo, 2021; Rashid, Manzoor, & Mukhtar, 2018). Education performance is higher in urban areas. The housing demand is incredibly increasing due to the rapid urbanization for the education purpose. As a result, housing prices has increased (Choy & Li, 2017).

Urbanization has positive relation with economic growth, transportation, technology and energy consumption (Shahbaz et al., 2017). Electricity consumption is also increasing with urbanization (Ghalib et al., 2017; Kaur & Luthra, 2018; Shahbaz et al., 2017; L. Wang et al., 2019). It is found that electricity consumption, fossil fuel usage, severity of energy usage and primary power usage have constructive effect on carbon emissions (Anwar et al., 2022; Sun & Huang, 2020). Stable urbanization, which intensify the wellbeing of both the people and place, has increased the economic growth and carbon emissions efficiency. GDP growth and stable urban population growth have a positive influence on the economy (Liddle, 2017; Tripathi, 2021). Research shows that the use of ICT for sustainable urbanization increases socio-economic development in developing countries and also builds an inclusive society, which creates opportunities for development (Goel & Vishnoi, 2022; D. Wang, Zhou, & Wang, 2021). Stable urbanization increases the level of employment in formal and informal sectors (Belokrenitsky, 2017). Urbanization has positive effect on life expectancy (Effiong, Okijie, & Ridwan, 2021).

In contrast, researchers have also found negative effects of urbanization. Unreasonable urbanization destroys green economy and decline carbon emissions efficiency. Manufacturing composition stops the improvement of carbon emissions efficiency. Growth of industries expands the pollution and emissions level in certain cities to a dangerous level. Co2 emissions also effect on Human development index (HDI) (Ghafoor & Akbar, 2022; Sun & Huang, 2020; Tripathi, 2021). Unplanned urbanization is the major reason of land loss and increase the environmental degradation. Unplanned internal urbanization results in a form of polluted environment of the cities, impure drinking water, Loss of green area, and high level of atmospheric and water pollutants. Urban sprawl has also negative impacts on cities as to loss of agricultural lands, deforestation and depletion of natural resources. Some migrators faced the lack of proper sanitation and other basic facilities; therefore, people resort to open defecation and increase the environmental pollution. It is concluded that rise in the CO2 emissions also degraded the surroundings in the long term (Ghafoor & Akbar, 2022; Ghalib et al., 2017; Mannan et al., 2021; Siyal, Khalid, & Qaisrani, 2018; Sun & Huang, 2020). Increasing population give raise to the unemployment and increases poverty, inequality as well as rural-urban gap. In the case of emerging economies lacking social support and infrastructure, urbanization tends to cause disruptions in economic development (Belokrenitsky, 2017; Kuddus, Tynan, & McBryde, 2020; Liddle, 2017; Rashid et al., 2018). Increasing population and urbanization also raises the health-related issues due to burden in urban areas. Contaminated environment also increases the disease spread. Migrators living in slums do not follow the

Standard Operating Procedure (SOP's) and become the reason for spread of fatal diseases (H. Chen, Liu, Li, & Xue, 2017; X. Chen, Liu, & Yu, 2022; Ghafoor & Akbar, 2022; Rashid et al., 2018). More so, increasing industrialization and urbanization deteriorates the quality of water (Wu, 2020). Housing storage and psychological problems also increases with urbanization. Due to lack of housing facilities, number of slums are increasing. Due to the rapid migration in urban areas, education inequality between urban and rural areas has increased (Konuk, Turan, & Ardali, 2016). Urbanization decreases the chances of equal opportunities for all and make the living standards low (Rüger et al., 2023).

Many studies determined a causal relation between urbanization and development. Unidirectional causality between urbanization and energy consumption, that shows as urbanization expands, energy utilization also increases (X. Chen et al., 2022; Shahbaz et al., 2017). Existence of unidirectional and bidirectional causal relationships are found between infrastructure and urbanization. Paved road and state highways are found to cause urbanization which means good quality of roads attracts migrators. Causality is also observed between Co2 emissions and urbanization (Anwar et al., 2022).

An analysis of the literature above reveals that many researchers have discussed the drivers of urbanization and investigated its positive and negative effects on economic growth for different countries, cities and regions. However, there is a gap in the literature about the urbanization and economic development nexus in Pakistan, especially at the provincial level. The present study aims to fill this gap in the literature by analyzing the relationship between urbanization and economic development in six major cities of Punjab, Pakistan. Moreover, it is essential to study the impact of urbanization on development through various channels, including infrastructure, living standards and environment. Therefore, this study investigates the role of urbanization on development and the indicators above for selected major cities of Punjab, Pakistan.

3- DATA AND METHODOLOGY

3.1 Data and Variables

Data from 2002 to 2019 for six major cities of Punjab, Pakistan, including Lahore, Faisalabad, Multan, Rawalpindi, Sheikhupura, and Sialkot, is considered for the analysis. The data was obtained from Punjab Development Statistics (PDS) (various issues), Compendium on the environment, Pakistan ICT Survey and Pakistan Economic Surveys (various issues), World Population Review (multiple issues), Environment Protection Department, and the government of Punjab.

The urbanization-development relation is examined through three dimensions: infrastructure, environment, and living standards. For this purpose, indices of infrastructure, environment, and living standards are constructed. Table 3 shows the variables used to measure each dimension of development. A set of indicators (n=17) for infrastructure, living standards, and environment are selected to develop the index.

Table: 3 Dimensions of development

Infrastructure	Living standards	Environmental dimensions
1-Road network	5- Literacy population (10 years)	12- Rainfall
2-Communication	6- Adult literacy-population (15 years and older)	13- Area under forest
3-Transport	7- Immunization of children	14- Area under agriculture
4-Factories	8- water and sanitation	15- Concentration of CO2 in Air
	9- Gas and fuel	16- Concentration of No2 in Air
	10- Electricity	
	11- Employment	17- Concentration of So2 in Air

The present study uses urbanization, poverty, government income, government spending, inflation, and provincial income as independent variables, while infrastructure, living standards, environment, and development are dependent variables. Table 4 presents definitions of variables and the sources of data.

Table: 4 Definition of Variables

Variable	Definition	Source
Level of urbanization (URB)	Relative number of people survive in urban areas.	Punjab Development Statistics (PDS)

	According to Arriaga (1970) the most common used index for measuring the degree of urbanization has been the percentage of total population living in urban areas: PU=U/P*100 PU: urbanization (measured in percentages) U: urban population of city P: Total population of the country	
Infrastructure (INFR)	Basic organizational and physical facilities and structures measured by road network, communication, transport, and number of registered factories.	PDS
Living standards (LIVSTD)	Refers the quality of life measured by education, health, water sanitation, gas and fuel, employment, and electricity.	PDS
Environment (ENV)	External condition in which organisms inhale and is affected by human activities, measured as Co2 emissions, No2, So2, etc. An index of environment quality is constructed by using above mentioned three indicators of gas emissions. As these are negative indicators, so	Compendium on Environment and Environment protection department

	inverse of the values is considered.	
Development (DEV)	Measured with the HDI index $$Dev = (INFSTR \times LIVSTD \times ENV)^{1/3}$$	PDS
Poverty (POV)	Measured by MPI Multidimensional Poverty Index	Poverty Profiling in Punjab
Government Revenue (GREV)	Natural Log of provincial Government revenue received from tax and non-tax resources	Pakistan Economic Surveys
Government expenditure (GEXP)	Natural log of Purchases of public goods and services for the public consumption	Pakistan Economic Surveys
Inflation (INF)	Natural log of provincial inflation.	PDS
Gross national income (GNI)	Natural log of provincial total earnings	Pakistan Economic Survey

3.2 Methodology

An index of economic development is constructed for the Punjab region by following Morris's methodology of the Human Development Index (HDI). Seventeen indicators are identified, and these indicators are grouped into three sub-groups, namely infrastructure, living standards, and environment. These dimensions are then aggregated to form the Development Index. The indicator values are normalized using the following formula to measure the variables in a standard unit.

$$Dimension\ Index = \frac{Actual\ Value - Minimum\ Value}{Maximum\ \ Value - Minimum\ Value} \times 100$$

A composite index is developed with the help of three individual indexes. The development index is obtained using the geometric mean of infrastructure, living standards, and environment indexes,

$$Development = (Infrastructure \times Living\ standards \times environment)^{1/3} ....I$$

The effects of urbanization are studied on various dimensions of development, including infrastructure, living standards, and environment. For this purpose, four different models are constructed by taking economic development and the three individual indicators as dependent variables and urbanization, poverty, government income, government spending, inflation, and provincial income as independent variables. The model used in the study is as follows:

$$Y= \beta_0 + \beta_1\ URB_{it}+\beta_2 POV_{it}+\beta_3 GREV_{it} + \beta_4 GEXP_{it} + \beta_5 INF_{it}+ \beta_6 GNI_{it} + u_{it} ..... 2$$

Where i and t represents the city and time respectively. β_0 is the drift; β_1 to β_6 all are the parameters to be evaluated; and u_{it} is the error term. "Y" represents the dependent variable such as infrastructure (INFR), living standards (LIVSTD), environment (ENV) and development (DEV) in model 1, 2, and 3 respectively. While independent variable are urbanization (URB), poverty (POV), natural log of government revenue (GREV), natural log of government expenditure (GEXP), natural log of inflation (INF), and natural log of gross national income (GNI). u_{it} is the error term.

The first step in estimating a regression model requires testing the stationarity of the variables. Assumptions of asymptotic variables are violated in the case of non-stationary variables. *For testing unit root in panel data, two assumptions can be made, i.e., either the parameters are common across cross sections (ρi = for all i, where, ρi are the autoregressive coefficients, i = 1, 2,…..N cross sections units or series) or ρi vary freely across cross-sections* (Pesaran et al. 2001) The present study uses individual panel unit root, i.e., the Fisher-ADF test. The null hypothesis of the unit root is tested using the following ADF equation:

$$\Delta y_{it}=\alpha y_{it}-1+\sum\beta_{ij}\ \Delta y_{it}-j+X_{it}\ \delta+v_{it}\ \text{--------}3$$

In the above model, y_{it} is the pooled variable, X_{it}' refers to exogenous variables , e.g. country fixed effects and individual time trends, and v_{it} measures error terms that are assumed to be mutually independent. ADF Fisher (chi-square) allows for individual unit root processes i.e. ρ_i is allowed to vary across three cross sections. ADF Fisher estimates separate ADF regression for each cross section

Pooled mean group technique is used to estimate the short run and long run estimates of the model. In the first step optimal lag length is selected through Akike Information Criteria (AIK), Schwarz Information Criteria (SIC), and Hannan – Quinn criteria (HQ) criteria. The following equations give the lag selection criteria.

(a) $AIC_p= - 2T\ [\ln(\sigma^2_p)] + 2p$ ------------4

(b) $SIC_p = \ln(\sigma^2_p) + [p \ln(T)]/T$ ----------5

(c) $HQC_p = \ln(\sigma^2_p) + 2 T^{-1} p \ln[\ln(T)]$------------6

Studies have shown that the above-mentioned lag length criteria have picked up the correct lag length in half the time for small samples (Liew, 2005).

The PMG model is as follows:

$$Y_{it} = \alpha_i + \sum_{i=1}^{p} \beta_0 Y_{i,t-1} + \sum_{i=0}^{q} \beta_1 URB_{it} + \sum_{i=0}^{q} \beta_2 POV_{it} + \sum_{i=0}^{q} \beta_3 GREV_{it} + \sum_{i=0}^{q} \beta_4 GEXP_{it} + \sum_{i=0}^{q} \beta_5 INF_{it} + \sum_{i=0}^{q} \beta_6 GNI_{it} + u_{it} \ldots\ldots\ldots\ldots 7$$

Reparametrizing the above equation to generate short run coefficients

$$\Delta Y_{it} = \alpha_i + \Phi_i(Y_{i,t-1} - \theta_1 URB_{it} - \theta_2 POV_{it} - \theta_3 GREV_{it} - \theta_4 GEXP_{it} - \theta_5 INF_{it} - \theta_6 GNI_{it}) + \sum_{i=1}^{p-1} \lambda_{il} \Delta Y_{i,t-1} + \sum_{i=0}^{q=1} \lambda'_{il} \Delta URB_{i_{t-1}} + \sum_{i=0}^{q=1} \lambda''_{il} \Delta POV_{i,t-1} + \sum_{i=0}^{q=1} \lambda'''_{il} \Delta GREV_{i,t-1} + \sum_{i=0}^{q=1} \lambda''''_{il} \Delta GEXP_{i,t-1} + \sum_{i=0}^{q=1} \lambda'''''_{il} \Delta INF_{i,t-1} + \sum_{i=0}^{q=1} \lambda''''''_{il} \Delta GNI_{i,t-1} + u_{it} \ldots\ldots\ldots\ldots 8$$

This paper also tests the causal relationship among the variables. For this purpose, improved Granger causality test of Dumitrescu and Herlin is adopted. This paper lists the formulas for the causality test:

$$y_{i,t} = \alpha_{0,i} + \alpha_{1,i} y_{i,t-1} + \cdots + \alpha_{k,i} y_{i,t-k} + \beta_{1,i} x_{i,t-1} + \cdots + \beta_{k,i} x_{i,t-k} + \varepsilon_{i,t} \text{ -------------------9}$$

$$x_{i,t} = \alpha_{0,i} + \alpha_{1,i} x_{i,t-1} + \cdots + \alpha_{k,i} x_{i,t-k} + \beta_{1,i} y_{i,t-1} + \cdots + \beta_{k,i} y_{i,t-k} + \varepsilon_{i,t} \text{ -----------------10}$$

Where $x_{i,t}$ and $y_{i,t}$ are the observed value of units i in period t, respectively, and k represents the number of lags of the individual units.

After estimating the model, some post-estimation tests are applied. Panel LR test is applied to check if the residuals are homoscedastic. The Panel LR test, or the panel likelihood ratio test, analyses the goodness-of-fit of fixed effects and random effects model for panel data. In short, it helps us select an appropriate model for individual- specific heterogeneity in panel datasets. Panel LR statistic can be written as:

$$LR = -2.[\ln(LRE) - \ln(LFE)] \text{--------------------------11}$$

Where: LRE represents the likelihood of the random effects model, and LFE represents the likelihood of the fixed effects model. The null hypothesis states that there are no random effects. The presence of autocorrelation is tested using the Breusch-Pagan LM test. The test first estimates the simple regression model:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_K^* X_K + \varepsilon \text{-------------------- 12}$$

Residuals are obtained from the regression and then an auxiliary regression is estimated.

$$\varepsilon^2 = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \ldots + \alpha k^* Xk + u \text{------------------} 13$$

LM Statistic is calculated by using coefficients of the above regression. If the LM statistic results reject the null hypothesis, then the model confirms the presence of heteroscedasticity and vice versa.

Jarque-Berra normality test is applied to check whether data matches a normal distribution. The null hypothesis represents that the data is normally distributed It can be calculated using the sample skewness and sample kurtosis as follows:

$$\text{Jarque-Berra} = (n/6)^* (S^2 + (1/4)(K-3)^2 \text{-----------------} 14$$

Where S is the sample skewness, K is the sample kurtosis, N is the sample size. The test follows a chi-squared distribution with 2 degrees of freedom under the null hypothesis.

4-RESULTS

4.1 Unit Root Test

Augmented Dicky Fuller (ADF) test is used to check the stationarity of the variables. The results are presented in Table 5.

Table 5: ADF Fisher Test

Variables	Level	First difference
INFSTR	17.5939 (**0.1286**)	52.7696 (**0.000**) ***
LIVSTD	23.1808 (**0.2262**)	61.8955 (0.0002) ***
ENV	19.9629 (**0.1678**)	58.5385 (**0.000**) ***
DEV	15.4361 (**0.2184**)	35.8258 (**0.0003**) ***
URB	15.1753 (**0.2320**)	42.3494 (**0.0000**)***
POV	5.43234 (**0.9420**)	88.4379 (**0.0000**)***
GREV	12.7168 **0.3900**	33.9776 (**0.0007**)***
GEXP	10.4551 (**0.5765**)	81.4005 (**0.0000**)***
INF	0.42065 (**1.0000**)	28.7498 (**0.0043**)***
GNI	7.63450 (**0.8130**)	40.5573 (**0.0001**)***

Probabilities are shown in parenthesis where *** indicates level of significance at 1%.

According to the unit root test, all the variables are stationary at the first difference, so it is appropriate to apply the panel Autoregressive distributed lag (ARDL) technique in the analysis (Pesaran, Shin, & Smith, 2001).

4.2 Lag Length Selection

A RDL requires suitable lag selection. Results of AIC SC and HQ are presented in Table 6. An optimal number of lags is 1, according to the results of the AIC and HQ lag selection criteria.

Table 6: Lag Selection Criteria:

Lags	AIC	SC	HQ
0	29.30586	29.44548	29.36047
1	22.69481*	23.95292	23.18788*
2	22.97385	23.67046*	23.24538
3	22.81996	24.63506	23.52995

4.3 Long run and Short Run Estimates

Table 7 presents short-run and long-run estimates of the four models discussed earlier.

Table 7: Panel ARDL Results

Variables	MODEL 1 INFSTR	MODEL 2 LIVSTD	MODEL 3 ENV	MODEL 4 DEV
Long run results				
URB	-2.94123 0.0015***	-6.750578 0.0452**	-0.16878 0.7304	-2.410847 0.0004***
POV	-0.627454 0.0038***	----	-0.05327 0.0010***	-0.335408 0.0511*
GREV	6.214002 0.0000***	-1.685142 0.1219	0.140263 0.3687	-0.619786 0.0986*
GEXP	2.319572 0.0003***	3.937033 0.0000***	-0.198803 0.0780*	1.725638 0.0000***
INF	-19.46193 0.0000***	7.245956 0.223	1.634045 0.0013***	3.909048 0.0410**
GNI	-11.37644 0.0000***	0.680444 0.6184	1.331357 0.0000***	1.34875 0.0150**
ECM	-0.998916 0.0016***	-0.749192 0.0002***	-0.802358 0.0000***	-0.636995 0.0001***
SHORT RUN RESULTS				
URB	-21.79198 0.733	23.02308 0.2369	13.67487 0.7196	19.42596 0.134
D POV	1.11254 0.3309	-0.943327 0.2422	-0.060528 0.8047	0.256855 0.7451
D GREV	-2.983176 0.0316**	0.239508 0.7346	0.177043 0.6047	0.347359 0.4122
D GEXP	0.416774 0.699	-0.837406 0.0792*	0.610799 0.0786*	0.666368 0.1052
D INF	-66.45007	30.29583	28.83066	45.29586

	0.0066***	0.0876*	0.0000***	0.0000***
D GNI	10.1156	1.128889	-1.087438	0.259314
	0.0000***	0.5045	0.0310**	0.8151

Source: Authors' calculations. ***, **, * indicates level of significance at 1%, 5% and 10% respectively.

Some interesting results on the urbanization and infrastructure nexus can be drawn from Model 1. The negative and significant coefficient of urbanization shows that urbanization adversely affects infrastructure in the long run. A 1% increase in urbanization deteriorates infrastructure by 2.94% in the long run. This outcome is similar to the conclusion of L. Wang et al. (2019) , who postulated that an increase in unplanned urbanization increases road sector energy consumption due to increases in vehicle ownership, which devastates road infrastructure in the case of China. Moreover, commuting time also increases in some big cities. Besides this, this finding is also closer to the results of Poumanyvong, Kaneko, and Dhakal (2012) and Lin and Du (2015), who argued that urbanization increases road sector energy consumption and wrecks the infrastructure in lower-income and middle-income countries. The coefficient of poverty is negative and significant, implying a 1% increase in poverty worsens infrastructure in the province by 0.627%. These results are similar to those of, who argued that poverty adversely affects infrastructural and industrial development in Pakistan. Government expenditure and revenue positively and significantly impact infrastructure in the long run. These findings are similar to Babatunde (2018), , who claimed that increased government spending in Nigeria directly affects transport and communication infrastructure, boosting economic growth. Results show that an increase in inflation negatively and significantly affects infrastructure in the short and long run. This conclusion is similar to that of Magweva and Sibanda (2020) for emerging economies and Mohseni and Jouzaryan (2016) in the case of Iran, who proposed that a rise in inflation is considered a negative signal for infrastructural development. This research also reveals the long-term negative association between infrastructure and GNI. However, GNI and infrastructure are positively related. The negative and significant value of the Error correction Term (ECT) shows that the speed of adjustment toward long-run equilibrium is 99.89%.

Model 2 confirms a negative relationship between urbanization and living standards as more people shift to urban areas, adversely affecting living standards. Urbanization decreases the quality of life by affecting the environment, health of the people, education, and electricity consumption. It also increases psychological problems and several viral diseases in the urban public, as Ebeke and Etoundi (2017) concluded in case of Africa. The relationship between government spending and living standards is significantly positive. An increase of 1% in government expenditure is linked with a 3.933% increase in living standards. This result is consistent with Gertler, Martinez, and Rubio-Codina (2012), who claimed that cash transfers by the government increase the consumption and investment of the public as well as productivity and living standards. Inflation and GNI have insignificant impacts on living standards. ECT in this model is negative and highly significant, indicating that the speed of convergence of the model towards long-run equilibrium is 74.9%.

In Model 3, it is found that higher urbanization has an insignificant environmental impact. An increase in poverty significantly deteriorates the environment in the long run. This is consistent with a study conducted in China by Rozelle, Huang, and Zhang (1997), which confirmed that poverty increases water pollution, deforestation, destruction of grasslands, and soil erosion. Results also indicate that government expenditure and the environment are negatively related. A 1% increase in government expenditure decreases environmental quality by 0.198%. An increase in inflation raised environmental quality significantly both in the short and long run. Ullah, Apergis, Usman, and Chishti (2020) also showed that an increase in inflation reduces NO2 emissions. This is because when inflation increases, people prefer public transport to own vehicles, which reduces pollution in Pakistan. GNI relates positively and significantly to the environment in the long run. In the short run, the relationship is significantly negative. ECT has a coefficient value of -0.802%, significant at 1%, showing an 80.23 percent convergence towards equilibrium in the long run.

Model 4 exhibits a negative relation between urbanization and development with a coefficient value of 2.41% for the long run. This result is similar to that of Kuddus et al. (2020) in the case of developed and developing countries. An increase in urbanization reduces per capita facilities for the masses in the long run. Slums are formed that reduce living standards, and overpopulation reduces per capita infrastructure and availability of health care. However, urbanization has little impact on development in the short run. Secondly, poverty negatively and significantly impacts development in the long run. Poverty increases homelessness, lack of access to healthcare, food insecurity, and basic facilities, which affect economic development. This finding is similar to that of Visaria (1980) for Asian countries and Tariq et al. (2014) in the case of Pakistan. An increase in government revenue decreases the development in the long run. Hall et al. (2021) also found that more government revenue increases the availability of clean water, health facilities, sanitation, and education facilities, which affects economic development. An increase in government expenditure increases the development significantly in the long run. These findings are similar to many researchers. In developing countries, government expenditure is considered the primary source of provision of social overhead capital, which is indispensable for economic development (Babatunde, 2018; Gertler et al., 2012). 1% increase in inflation increases development by 3.90% in the long run. Results indicate that a 1% increase in GNI increases economic development by 1.248%. An increase in GNI is positively and significantly associated with higher expenditure on health, education, environment quality, and infrastructure (Liu, Yan, & Zhou, 2016). ECT's significant and negative value, i.e. -0.636, shows the 63.6% adjustment towards equilibrium in each period.

4.4 Dumitrescu and Herlin panel causality test

The Dumitrescu and Hurlin (2012) is used to determine the direction of causality. Results are presented in Table 8.

Table 8: Panel Causality Test

Null hypothesis	W-satistic	Zbar-Statistic	P-Value
URB does not granger cause INFSTR	4.95092	2.00360	0.0451**
INFSTR does not granger cause URB	8.78734	5.07032	0.0000***
URB does not granger cause LIVSTD	6.90398	3.56482	0.0004***
LIVSTD does not granger cause URB	5.24748	2.24067	0.0250**
URB does not granger cause ENV	2.86957	-0.56522	0.5719
ENV does not granger cause URB	15.4946	5.74728	0.0000***
URB does not granger cause DEV	5.01985	2.05870	0.0396**
DEV does not granger cause URB	3.68739	0.99357	0.3204

Source: Authors' calculations. ***, ** indicates level of significance at 1% and 5% respectively.

The results reveal that there is a bidirectional causality between infrastructure and urbanization. The present research also found the bidirectional causality between living standards and urbanization. These results are consistent with the findings of Liddle (2017). Their study established a bidirectional causal relation between electricity consumption and urbanization for a panel of 105 countries. The present research also exhibits a unidirectional causality from environment to urbanization, which means people migrate to seek a better quality of environment Similar findings are obtained from causality analysis conducted by Iheonu, Anyanwu, Odo, and Nathaniel (2021) in case of Africa Finally, the study establishes that urbanization causes development.

4.5 Diagnostic Tests:

Results of different diagnostic tests are presented in Table 9.

Table 9: Diagnostic Test

Test	Null Hypothesis	P-Value
Jarque-Berra	Errors are normally distributed	0.88091
Panel Period Hetroscedasticty Test	Residuals are Homoscedastic	0.4622
Breusch-Pagan LM test	No Serial Correlation	0.6629

Source: Authors' calculations

The P-value of Jarque-Berra normality test is significant at 5 percent significance level so the null hypothesis is accepted meaning that errors are normally distributed. The P-values of panel period hetroscedasticity test and Breusch-Pegan LM test are also significant at 5 percent significance level showing that there are no issues of hetroscedasticty and serial correlation.

5- Conclusion and Policy Implications

The present study carried out a comprehensive analysis of the impact of urbanization on economic development in case of six major cities of Punjab, Pakistan. A new index of development is constructed by including environment, infrastructure and living standards. Panel ARDL approach was employed to evaluate short run and long run impact of urbanization on development. Overall, the findings substantiate the insights of empirical literature that urbanization obstructs development. The study demonstrated that urbanization had a negative impact on infrastructure, living standards, and environment, and thus, on the overall economic development in the long-run. In contrast, it has an insignificant impact on development in the short-run. This negative effect is evident because the increased number of people, their interests, and the rising demands for resources, all influence the living standards. Urbanization significantly affected infrastructure and environment primarily due to pollution and overcrowding. However, apart from a panel ARDL analysis, this study also tested for bidirectional causality between urbanization and development. The results highlighted that the causal link between urbanization and economic development relied on the indicators, namely infrastructure, living standards, and environment. An evidence of two-way causality between urbanization and infrastructure and between urbanization and living standard was observed. Meanwhile, a unidirectional causality ran from environment to urbanization, and another from urbanization to development.

Apart from highlighting the negative association between urbanization and development, the findings reveal the importance of formulating policies that manage people's migration and raise urban city development. This is because all the estimated panel ARDL regressions explain the dependency of development on urbanization. In fact, in all the estimations, urbanization significantly but negatively influences economic development in the long run.

Numerous policy implications can be derived from this analysis. Urbanization is a reason for deteriorating infrastructure in big cities. To cope up with this pressure on existing infrastructure, there is a need for planned investment in urban infrastructure including road networks and transportation and communication. Development of more efficient and affordable transportation system is inevitable to deal with road congestion. Policies should be formulated to reduce the pace of urbanization from rural areas so that environmental degradation and pollution in cities can be controlled. Suitable energy policies are needed for upgraded energy use to reduce carbon and sulphur emissions. Government and urban stakeholders should collaborate to deliver basic facilities like housing, education, health, clean and safe water, sanitation and food.

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