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Urban Sustainability and Economic Performance: Empirical Insights from Smart Cities in India

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Abstract

This study examines the relationship between urban sustainability and economic outcomes across major Indian cities. Economic performance is measured through GDP per capita, while urban sustainability is represented by three dimensions of the Ease of Living Index (2020): Economic Ability, Quality of Life, and Sustainability. The analysis covers 40 Indian cities whose corresponding districts have an urban population exceeding 50 percent. Population and area are included as control variables, proxied by the latest Census data and municipal area, respectively. Employing a cross-sectional design for the year 2019, the study applies a log-linear Ordinary Least Squares (OLS) regression model. The results indicate that Economic Ability exerts a strong positive and statistically significant impact on per capita income, suggesting that cities with greater economic capacity achieve higher income levels. Conversely, the Sustainability dimension shows a negative and significant association, reflecting potential short-term trade-offs between environmental initiatives and income growth. Although Quality of Life exhibits a positive relationship, its effect is statistically insignificant. Diagnostic tests confirm that the model satisfies key OLS assumptions, with no evidence of serious multicollinearity, heteroscedasticity, or influential outliers. Overall, the findings emphasize that while economic capacity remains the strongest determinant of urban income, sustainability efforts may initially constrain growth but promise long-term welfare gains. The study highlights the importance of integrated urban planning that balances economic dynamism with sustainable and inclusive development goals.

Key Words: *Economic ability, Quality of life, Urban Sustainability, Smart citifies.*

Introduction

All forms of studies and scientific inquiries are to enhance the welfare of humanity. Particularly concern of economics and development disciplines, are to enhance the material well - being of individuals and society. The classical economics is centred around the materialistic well- being. It is explicitly observable in consumption, production and distribution of goods and services. All these economic outcomes are the results of human effort and resource utilized. The more the quantity and quality of goods and services that individuals or nations produce and consume, the higher their standard of living tends to be. Within an economy the aggregate production of goods and services is measured through

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national income indicators, most notably the Gross Domestic Product (GDP). A sustained increase in GDP represents economic growth, which is generally interpreted as an improvement in the capacity of an economy to produce more value over time. Higher growth rates are often associated with increased employment opportunities, better access to resources, technological advancement, and rising per capita incomes—all of which contribute to enhancing the well-being of people. Consequently, economic growth is widely regarded as a key mechanism for achieving collective prosperity and individual utility maximization (Samuelson & Nordhaus, 2010; Todaro & Smith, 2020).

But this early measure Gross Domestic Product (GDP)—as an indicator of welfare ignores the size of the population and, therefore, the distribution of income among individuals. To address this limitation, per capita income (PCI) emerged as a more refined measure, reflecting the average income available to each individual within an economy. Yet even this indicator provides only a partial picture of well-being. But the growth in GDP or PCI doesn't guarantee that each and every person is getting benefited. It often benefits only a limited section of society, particularly those who already possess economic, educational, or social advantages. In many developing economies, a large portion of the population remains excluded from the benefits of economic expansion due to inequitable resource ownership, regional disparities, and structural inequalities. On the ground of social justice and ethics such improvement cannot be said developmental and welfare enhancing (Sen, 1999).

To address these shortcomings, the concept of inclusive development or inclusive growth has emerged as an improved framework. Inclusive development emphasizes not only the pace of economic growth but also its distributional dimension, ensuring that all sections of society—especially the socially disadvantaged, marginalized, and backward groups—benefit from the development process. This approach integrates principles of equity, social justice, and participation, aiming to create opportunities for all individuals to contribute to and share in the prosperity of the nation (World Bank, 2018).

However, alongside the remarkable achievements of industrialization and economic expansion, humanity began to witness a series of environmental crises that exposed the vulnerabilities of the growth-cantered development model. Early industrial cities experienced severe pollution events, such as the London Smog of 1952, which caused an estimated 12,000 premature deaths in just a few days. The expansion of economic activities such as industrialization induced greenhouse gas emissions which causes increase in temperature. Intergovernmental Panel on Climate Change (IPCC), global temperatures have already risen by approximately 1.1°C above pre-industrial levels by to the Intergovernmental Panel on Climate Change (IPCC). The global warming and climate change, increased frequency of heatwaves, floods, hurricanes, and droughts, and increased melting of glaciers and polar ice caps.

All these threats highlighted a reality, economic development without environmental stewardship is inherently self-limiting. The benefits of growth, if achieved at the expense of limited natural capital, cannot be sustained for future generations. Recognizing this, social and environmental activist, global policymakers and scientists advocated for a new paradigm of development that balances human welfare with environmental preservation. This resulted in the publication of the Brundtland Report (Our Common Future, 1987), which formally defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." This report laid the foundation for further international agreements, including the Rio Earth Summit (1992), the Johannesburg Summit (2002), and ultimately the United Nations Sustainable Development Goals (2015), embedding environmental, economic, and social considerations into a coherent global development agenda.

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Urbanization, often considered a by-product of industrialization or a tangible manifestation of economic development, has profound implications for sustainable development. Rapid and unplanned urban growth leads to higher resource consumption, increased population density, and elevated demand for housing, transportation, energy, and water, often exceeding the capacity of local infrastructure. This concentration of population in urban areas frequently results in hygiene, sanitation, and public health challenges, as well as increased air and water pollution, waste generation, and ecological degradation (UN-Habitat, 2020). Given the growing importance of cities in national economies, the Sustainable Development Goals (SDGs) explicitly highlight Goal 11: Sustainable Cities and Communities, emphasizing the need for urban planning that is economically efficient, socially inclusive, and environmentally resilient. Urbanization thus provides both the motivation and the context for research into how different aspects of sustainability interact with socio-economic outcomes.

Urbanization has become a defining feature of modern economic transformation, with cities emerging as central engines of growth, innovation, and employment. Globally, over 56% of the world's population now resides in urban areas, a share projected to approach 70% by 2050 (United Nations, 2019). Cities account for more than 80% of global GDP, reflecting their pivotal role in shaping economic outcomes, yet they also concentrate environmental and social challenges. Rapid and often unplanned urban expansion has intensified pressures on infrastructure, resources, and ecosystems, generating congestion, inequality, and pollution that threaten the long-term sustainability of development (Pope, Annandale, & Morrison-Saunders, 2004UN-Habitat, 2020). In India, this duality between prosperity and pressure is especially pronounced. The country's urban population has risen from 17% in 1951 to over 35% in 2021 and is projected to continue growing rapidly in the coming decades. Metropolitan centres such as Delhi, Mumbai, Bengaluru, Hyderabad, and Pune have emerged as engines of national economic growth, contributing substantially to GDP and employment. Yet, these very cities also exemplify the darker side of urban expansion—high population densities, deteriorating air quality, traffic congestion, and widening social inequality. According to global environmental assessments, several Indian metros, including Delhi and Mumbai, consistently rank among the most polluted and densely populated cities worldwide, even as they remain at the forefront of economic performance. This paradox underscores the complex interlinkage between economic advancement and environmental degradation in India's urban landscape.

Empirical evidence highlights the complex relationship between urban sustainability and economic performance. In developing countries, studies have shown that economic growth does not automatically translate to improved environmental outcomes. For instance, an analysis of developing nations revealed an inverted-U relationship between economic growth and environmental sustainability, indicating that higher levels of economic activity can sometimes degrade environmental quality (Ahmad Jafar Samimi et al., 2011). This finding emphasizes the need for policies that decouple economic growth from environmental harm in urban planning.

Evidence from India suggests that larger cities exhibit superliner scaling of GDP with population, reflecting positive agglomeration effects and enhanced economic performance in urban areas (Sahasra Aman & Bettencourt, 2020). However, the lack of consistent city-level economic data limits precise measurement, underscoring the importance of developing functional urban units and standardized indicators for sustainable economic assessment.

Experiences from China provide additional insights relevant to Indian cities. Studies using panel data of 285 cities showed that coordinated development of economic, social, and environmental subsystems improves urban sustainability, though regional disparities persist (Jinking Wang et al., 2020). Similarly, sustainable urban initiatives, including smart city technologies, green infrastructure,

and inclusive governance, are empirically associated with increased urban resilience, liveability, and economic performance (Shahjahan Khamdamov & Anvar Usmanov, 2020).

Together, these empirical studies suggest that Indian smart cities can enhance economic outcomes while promoting sustainability by leveraging urban scale, improving governance, and integrating social and environmental considerations into economic planning.

Recognizing these challenges, national initiatives such as the Smart Cities Mission and the Ease of Living Index (EoLI) by the Ministry of Housing and Urban Affairs (MoHUA, 2022) aim to reorient urban growth toward sustainability. These frameworks evaluate and enhance city performance across four critical dimensions—Economic Ability, Social Well-being, Environmental Sustainability, and Citizen Perception—reflecting an integrated approach to development. While economic growth remains a fundamental measure of progress, its quantitative expansion alone cannot capture the broader dimensions of human welfare. The reality that India's most economically vibrant cities are also among its most polluted and unequal highlights the need to examine how urban sustainability and economic outcomes interact. Understanding this relationship is essential for shaping future cities that not only drive prosperity but also safeguard environmental quality and social equity (World Bank, 2023; UNDP, 2015).

The study seeks to explore how urban sustainability dimensions interact with economic performance across Indian cities. While the expansion of goods and services remains a traditional indicator of material progress, it often overlooks the qualitative dimensions of human welfare—such as equity, environmental quality, and inclusiveness. This study positions economic growth within a broader sustainability framework, aiming to assess whether cities that perform better on sustainability parameters also achieve stronger economic outcomes. By empirically analyzing these linkages, the paper contributes to the ongoing discourse on how India's urban development can transition toward a model that is not only economically productive but also environmentally and socially sustainable.

Data and Methodology

This study aims to empirically analyses the impact of urban sustainability using the data of Ease of Living Index, Census, area and GDP of respective state. Out of the 110 Smart Cities, only those cities were selected where more than 50 percent of the population is urban. In cases where multiple cities belong to the same district, only the city with a higher level of urbanization was considered. Some cities were excluded due to data unavailability or ambiguity regarding population or area statistics.

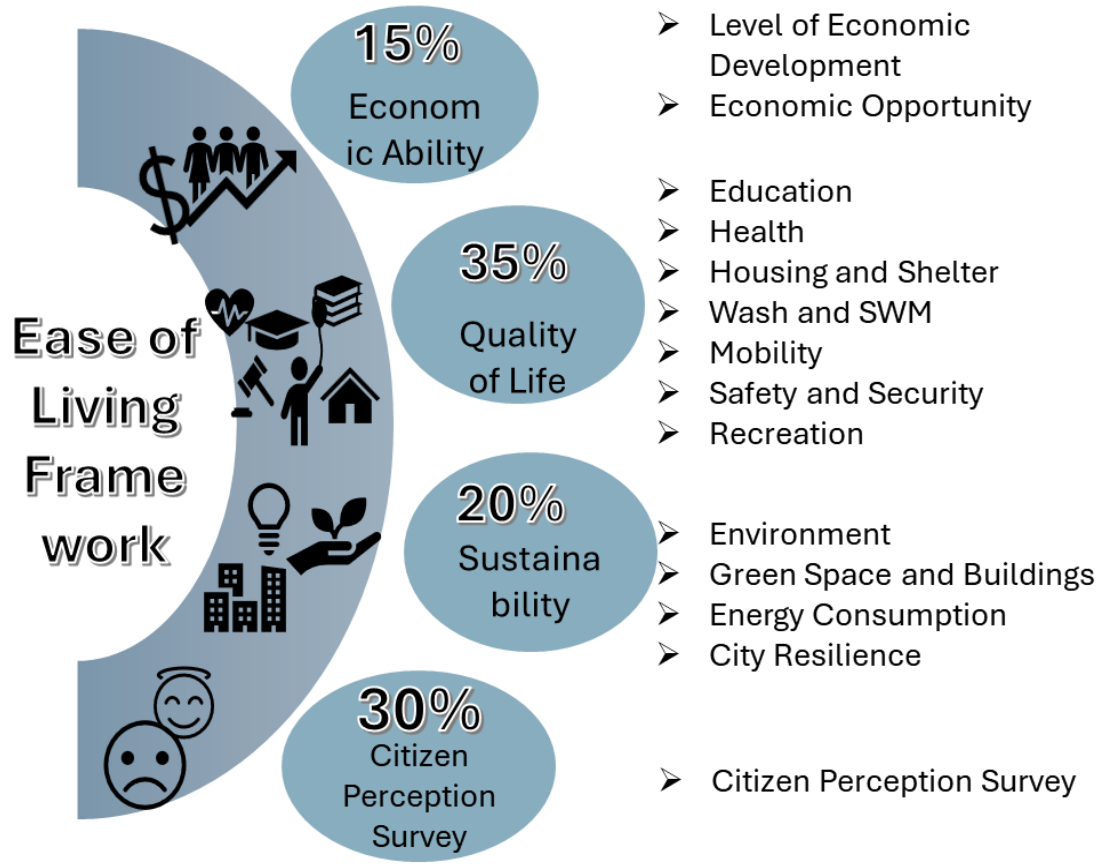
Population data were collected from the Census of India at the municipal level. Since GDP data were not available at the municipal level, district-level GDP was used as a proxy. The GDP data were obtained from the Economic Survey of the respective states and are expressed at constant prices (base year 2011–12) for the year 2019. For states where district-level GDP data were unavailable for that year, interpolation and extrapolation techniques were applied using the state's GDP growth rates.

The Ease of Living (EoL) Index, launched in 2018, evaluates the quality of life in 111 Indian cities, including Smart Cities, state capitals, and large urban centres. It aligns with the UN Sustainable Development Goals (SDGs) and serves as a national benchmark for urban performance. Initially covering 78 indicators across 15 thematic areas—such as governance, health, housing, and environment—the index now follows a dual-framework model. The revised version focuses solely on outcome indicators to capture citizens' lived experiences, while input indicators are assessed separately through the Municipal Performance Index (MPI). For this study, the 2020 Ease of Living Index has been used, as it is the only year for which city-level scores are publicly available. Although the 2020 Index includes a citizen perception dimension, this component is excluded from the present

study due to the inherent subjectivity of human responses and the lack of a strong empirical association with GDP

The current EOL Index evaluates cities across four key pillars Quality of Life (35%), Economic Ability (15%), Sustainability (20%), and Citizen Perception Survey (30%). These pillars are further broken down into 14 categories, covering a total of 49 carefully selected indicators.

Figure 1: Ease of Living Framework



The cross-sectional design is adopted, as the study examines multiple cities at a single point in time. The dependent variable is per capita income (PCI), which is unbounded and represents the average income of the population within each city. Independent variables include three dimensions of sustainability: Economic Ability, Quality of Life, and Sustainability, all measured on a 0–100 scale. Additionally, city population and area are included as control variables to account for demographic and spatial heterogeneity among cities.

A log-linear Ordinary Least Squares (OLS) regression model is employed to estimate the effects of the independent variables on per capita income. To improve interpretability and reduce skewness, the dependent variable (PCI) and the control variables (population and area) are transformed using the natural logarithm. The regression model is specified as:

$$\ln(\text{PCI}_i) = \beta_0 + \beta_1 \text{EcoAbl}_i + \beta_2 \text{QltLife}_i + \beta_3 \text{Sst}_i + \beta_4 \ln(\text{Ar}_i) + \beta_5 \ln(\text{Popl}_i) + u_i \quad \text{.....1}$$

where EcoAbl denotes Economic Ability, QltLife denotes Quality Life, Sst denotes Sustainability, In(Ar) denotes logarithmic of Area, In(Popl) denotes logarithmic of population $i$denotes city i, and $u_i$is the error term capturing unobserved factors affecting per capita income.

To address potential multicollinearity among predictors, Variance Inflation Factor (VIF) statistics were calculated. Variables with VIF greater than 10 typically indicate problematic multicollinearity; however, in this study, all variables had mean VIF well below this threshold, suggesting no significant multicollinearity. Interaction effects between Economic Ability and Quality of Life were also tested by including a multiplicative term, to explore potential synergistic effects, although the interaction was not statistically significant.

The standard OLS assumptions were evaluated. Homoscedasticity, or constant variance of residuals, was visually inspected using residual versus fitted value scatter plots. Normality of residuals was assessed using the Shapiro-Wilk test, which confirmed that residuals did not significantly deviate from normality. Although robust standard errors were used to account for potential heteroscedasticity, diagnostic checks indicated that heteroscedasticity was not a serious concern. Cook's distance was used to identify influential observations, and no single observation was found to disproportionately affect the regression results.

Results and Discussion

Descriptive statistics show that the average per capita income across the 40 cities is 204,480 (with a standard deviation of 106,702), indicating considerable variation in income levels. Economic Ability scores ranged from 1.14 to 78.82, Quality of Life from 41.03 to 62.42, and Sustainability from 38.38 to 75.74. The average city population was 1,603,762, and the average city area was 225.78 km².The correlation analysis reveals that per capita income shows a moderate positive relationship with the Economic ability (r = 0.4047) and Ease of Living (r = 0.3061), indicating that cities with stronger economic conditions and better living ease tend to have higher income levels. A weaker positive association is observed with the Quality-of-Life dimension (r = 0.2720), suggesting that improvements in living standards are modestly linked to income growth. In contrast, the Sustainability dimension exhibits a weak negative correlation (r = -0.1104), implying that higher-income cities may face challenges in maintaining environmental sustainability.

The log-linear regression results are summarized in Table 1. The overall model is statistically significant, with an F-statistic of 9.46 ($p < 0.001$) and an R^2 of 0.353, suggesting that approximately 35% of the variation in per capita income is explained by the predictors.

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Table 1 : OLS Regression Results for Per Capita Income

Variable	Coefficient	Robust Std. Error	t-value	p-value
EcoAbl	0.01685	0.00401	4.20	0.000
QltLife	0.01045	0.01445	0.72	0.475
Sst	-0.02621	0.01197	-2.19	0.036
ln(Ar)	-0.21972	0.11783	-1.86	0.071
ln(Popl)	0.05617	0.11887	0.47	0.640
Constant	13.0528	1.21788	10.72	0.000

Significance levels: p<0.01, p<0.05, p<0.10

Source: Census of India (2011); State Economic Surveys (2019, constant prices, 2011–12 base year); Ease of Living Index 2020, MoHUA.

Economic Ability has a positive and statistically significant effect on per capita income at the 1% significance level. A one-unit increase in Economic Ability is associated with a 1.68% increase in per capita income, holding other variables constant. This confirms that cities with stronger economic capacity contribute positively to higher income levels. Quality of Life, while positively associated with income, is not statistically significant at conventional levels, indicating that the measured variation in Quality of Life does not have a robust effect on per capita income in this dataset. Sustainability has a negative coefficient (-0.0262) that is significant at the 5% level. This may reflect that higher sustainability scores—possibly indicating higher resource allocation toward environmental or social programs—could be associated with short-term reductions in per capita income, although long-term benefits are not captured in this cross-sectional study. Control variables: Area is negative and weakly significant at the 10% level, suggesting that larger urban areas may have slightly lower per capita income, possibly due to the dilution of economic resources over larger geographical areas. Population is positive but not statistically significant, indicating that population size does not strongly influence per capita income when other factors are controlled.

The interaction term between Economic Ability and Quality of Life was tested in a separate model but was not significant, implying that the combined effect of these variables does not significantly differ from their individual contributions.

The diagnostic tests indicate that the regression model meets key assumptions. Variance Inflation Factor (VIF) values ranged from 1.39 to 4.26, well below the conventional threshold of 10, suggesting no serious multicollinearity among predictors. Scatter plots of residuals against predicted values did not reveal any discernible patterns, indicating the absence of heteroscedasticity, while robust standard errors were applied to account for any potential non-constant variance. Normality of residuals was confirmed through the Shapiro-Wilk test, which produced a p-value of 0.903, supporting the validity of hypothesis tests based on t and F statistics. Cook's distance was examined to identify influential observations, and no data point exceeded standard thresholds, confirming that results were not unduly affected by extreme cases. The model demonstrated moderate explanatory power, with an R^2 value of 0.353, which is typical for cross-sectional urban studies where multiple unobserved factors may affect per capita income, and the overall model was statistically significant, as indicated by the F-statistic of 9.46 ($p < 0.001$)

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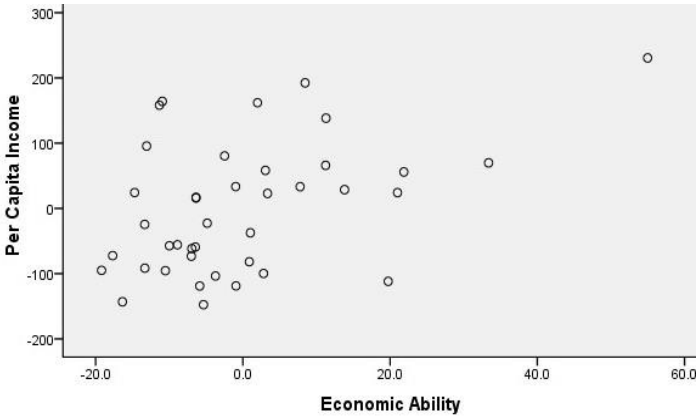
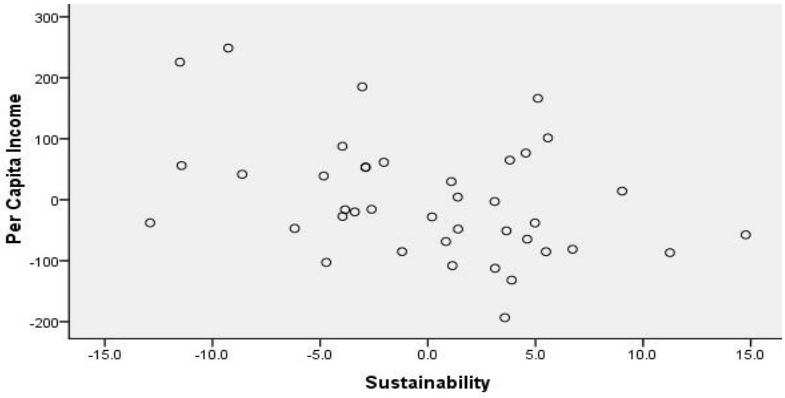
The analysis provides clear evidence that economic capacity, measured as Economic Ability, is a key determinant of per capita income in urban settings. The strong positive association aligns with prior literature emphasizing the role of financial resources, investments, and local economic development in shaping income distribution. This underscores the importance of policies aimed at strengthening economic infrastructure and enhancing fiscal capacity at the city level.



The lack of significance for Quality of Life may suggest that improvements in social or cultural amenities do not directly translate into higher incomes, or that the variation across the sample is insufficient to detect an effect. It is possible that Quality of Life contributes indirectly to income by attracting skilled labor or fostering productivity over time, which a cross-sectional study cannot capture.

The negative effect of Sustainability on per capita income is intriguing. One explanation could be that cities with higher sustainability scores invest more in long-term environmental or social programs, which might reduce immediate economic outputs. Alternatively, some sustainability initiatives may initially impose costs on businesses or require reallocation of resources from income-generating activities. Future longitudinal studies could explore whether sustainability investments lead to higher income in the long run, beyond the short-term cross-sectional snapshot.



Control variables reveal interesting insights. The negative association between city area and per capita income suggests that larger cities, despite potential economic advantages, might face inefficiencies in infrastructure, transportation, or service delivery. Population size did not have a significant effect, implying that density alone does not predict income once other factors are accounted for.

The study's diagnostic checks confirm that the regression results are robust. Residuals are approximately normally distributed, there is no severe multicollinearity, and heteroscedasticity has been accounted for through robust standard errors. Interaction effects between economic and social factors were explored but found to be non-significant, highlighting that the individual effects of Economic Ability and Quality of Life are sufficient to explain variations in per capita income.

Overall, the findings contribute to the understanding of urban sustainability and economic performance. They suggest that while economic capacity directly drives per capita income, social and environmental dimensions, while essential for holistic urban development, may have complex or delayed effects on immediate income outcomes. Policymakers should consider prioritizing economic

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development initiatives while integrating sustainability goals in a manner that does not compromise short-term economic performance.

Conclusion

The study set out to examine how urban sustainability dimensions—Economic Ability, Quality of Life, and Sustainability—shape economic outcomes across Indian cities. Using data from the Ease of Living Index census, economic survey, the analysis reveals that economic capacity remains the most decisive factor influencing per capita income. Cities with stronger economic ability exhibit higher income levels, reaffirming the centrality of financial strength, investment climate, and productive capacity in driving urban prosperity. Conversely, the negative association between sustainability and income suggests that while cities investing in environmental or social programs may experience short-term trade-offs, these initiatives are crucial for ensuring long-term resilience and welfare. Quality of Life, although positively related, does not significantly affect income in the short run, implying that its benefits may materialize indirectly through improved human capital, liveability, and productivity over time. The findings suggest sustainable cities must balance economic dynamism with environmental and social responsibility. Urban policies should aim to integrate sustainability as a complement, not a constraint, to economic performance. While short-term income gains may appear slower in more sustainable cities, such strategies lay the groundwork for inclusive, equitable, and resilient urban economies in the long run.

The cross-sectional nature of the study limits causal interpretation. Future research should employ panel data or dynamic modelling to capture temporal shifts and long-term effects of sustainability investments on economic well-being. Nevertheless, the evidence underscores that achieving sustainable urban growth in India requires a holistic approach—one that strengthens economic foundations while embedding sustainability and quality of life as integral pillars of development.

Policy Implication

Since Economic Ability has a direct and significant impact on citizen income, policymakers should focus on enhancing city-level economic infrastructure, supporting entrepreneurship, and promoting investment in high-value industries.

Strengthening municipal financial systems and fostering innovation-driven sectors can sustain urban economic resilience.

The negative short-term relationship between sustainability scores and income highlights the need for a phased approach. Environmental policies should be designed to balance ecological protection with economic competitiveness.

Although not statistically significant in the short run, improving social and cultural amenities can attract skilled labour and improve productivity. Cities should invest in education, healthcare, and urban amenities to strengthen human capital and long-term liveability.

Programs like the Ease of Living Index and Smart Cities Mission should include more cities and more dimension like inequality in terms of opportunity to serve as evidence-based tools for benchmarking and policy design.

Integrating real-time data systems and citizen feedback can enable adaptive governance and better resource allocation.

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Since the study is cross-sectional, future policy frameworks should emphasize consistent data collection over time to evaluate the long-term economic impacts of sustainability interventions and guide evidence-based adjustments.

Limitations of the study

The study collects data at a single point in time, which prevents establishing the direction of relationships between variables and limits the ability to make causal inferences. Which is further subject to study? Since the study provides only a snapshot of the variables, it may not capture seasonal, cyclical, or long-term trends. Conditions or behaviours in cities can change over time, so the findings may not fully represent ongoing dynamics or future outcomes.

There is a possibility of reverse causation, where the dependent variable could influence the independent variables. This can affect the interpretation of relationships and limits the strength of conclusions about cause-and-effect. Unmeasured or confounding variables for instance, factors such as local policies, migration patterns, or informal economic activities that are not included in the study may influence the observed relationships.

Differences in city size, demographic composition, governance, or infrastructure may affect whether the results apply elsewhere. Data sources, particularly secondary data or self-reported measures may contain inaccuracies or inconsistencies.

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