# Sustainable Urban Construction Strategies: Impacts of Urban Land Use and Road Traffic Indicators

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## Abstract
Urban sustainability indicators have received much attention in recent years due to their basis for sustainable urban construction strategies. Urban road traffic and urban land are important components of cities. This review identifies and evaluates key sustainability indicators related to urban road traffic and land use within the context of sustainable supply chain strategies in construction. It aims to analyze how these indicators reflect the environmental, social, and economic pillars of sustainability and to explore their interrelationships for guiding urban sustainability assessment and planning. The study utilised a systematic literature review approach, accessing databases like the Web of Science (WoS) to collate relevant research papers. Initially, 47 papers were collated and it was narrowed down to 17 papers with clear findings related to urban land use and road traffic indicators. Data were organised using Microsoft Excel and analysed with NVivo software, categorising indicators under environmental, social and economic codes. The findings highlight the critical role of urban road traffic, land use and their interactions in shaping sustainability outcomes. It finds that indicators of each road in the urban road network and indicators of land use intensity, particularly their spatial relationships are rarely used to evaluate the sustainability of the cities. This paper contributes original insights into the interconnected nature of urban land use and road network indicators, offering a holistic view essential for policymakers and urban planners to advance urban sustainability practices and support global efforts towards resilient and inclusive urban development.

**Keywords:** Land Use, Road Traffic, Road Network, Use Intensity, Urban Sustainability


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# INTRODUCTION

Accelerating urbanization and the increasing sophistication of urban systems have turned the quest for urban sustainability into a worldwide imperative. In response, researchers and policymakers are increasingly turning towards urban sustainability indicators—measurable parameters applied to assess the environmental, social, and economic performance of cities [1]. These indicators are critical to monitoring progress, informing policy, and aligning development practices with sustainable objectives [2]. But, While increasing amounts of sustainability metrics are in use, there are still considerable gaps in the selection, classification, and utilization of these indicators—particularly their potential to represent interdependent systems like land use and transportation [3]. Urban sustainability is inherently of a plural nature. To measure it effectively, indicators need to capture the three aspects of sustainability: environmental conservation, social justice, and economic sustainability [4]. Most existing frameworks, however, overemphasize economic and environmental aspects and underrepresent social ones. Additionally, urban problems seldom occur in solitude [5]. Traffic on roads affects air quality, public health, and accessibility, whereas decisions on land use determine demand for infrastructure, mobility, and spatial equity [6]. Nevertheless, these areas are frequently evaluated independently without realizing their interdependencies that are essential to address [7]. There is a need for combining indicators that reflect the aggregate effects of road traffic and urban land use [8]. For instance, land use intensity and road distribution can directly influence traffic congestion, emissions, and service accessibility [9]. When assessed collectively, these indicators provide greater understanding of urban unsustainability's structural drivers and identify possible synergies between transport and urban planning measures [10]. Without this coordinated analysis, policymakers stand to adopt piecemeal solutions that do not address the root causes or overlook potential co-benefits [6]. This research fills this gap by detecting and integrating urban sustainability indicators directly associated with road traffic and land use. It seeks to make these indicators not only exhaustive but also evenly spread out among the environmental, social, and economic pillars. The outcomes will aid in the establishment of more integrated sustainability evaluation systems and guide policy that addresses the interdependent dynamics of urban systems. The emphasis on interplay between road traffic and land use in this study adds a dimensionally relevant and much-needed approach to the creation of more resilient and equitable cities.

# LITERATURE REVIEW

## Urban Sustainability Chain

Urban land use impacts urban sustainability. Due to environmental concerns and stricter laws, urban construction demands sustainable development strategies. Liu*, et al.*[11] explored how municipal land use and car traffic affect construction supply chain sustainability. Resource distribution, ecological footprint and sustainability may be optimised via land use planning [12]. Numerous studies suggest that sustainable supply chain management and land use planning may minimise carbon emissions, pollution and energy consumption. The environment is greatly affected by urban land use whereby effective land use planning, logistics optimisation and transportation route simplification decrease construction project environmental impacts. Li*, et al.*[13] found that smart land use planning may reduce carbon emissions by 15-20% in which better material transport and shorter travel can achieve this. Locating close suppliers and materials reduces long-distance transit, aiding the environment. Urban land use greatly affects resource efficiency whereby effective building land allocation maximises resource management and waste reduction [14]. Integrated land use planning may boost local resource usage and minimise remote supplier use, enhancing resource efficiency and reducing the environmental impacts and costs of sending construction materials to vast distances [15]. Sustainable development impacts urban land use whereby strategically placing building sites for reuse and recycling improves resource efficiency. Green spaces and urban planning in building projects emphasise sustainability in land use and construction supply chains. Subiza-Pérez*, et al.*[16] examined how green roofs and parks promote building sustainability in urban land use planning whereby these natural places reduce urban heat islands, enhance air quality and increase mental wellness.

Road traffic congestion, pollution and transit efficiency impact urban sustainability and resilience whereby it increases emissions and fuel use, reducing the environmental advantages of sustainable urban building [17]. Minimising a structure's environmental impact requires efficient transportation management, highlighting the importance of traffic management to mitigate these effects. Environmental impact can be reduced via congestion pricing, traffic signal optimisation and vehicle lanes [18]. Transportation efficiency depends on road traffic metrics, i.e. transportation efficiency, supply chain routing and timetable management may benefit the environment. Zhou*, et al.*[19] claimed that real-time traffic monitoring and adaptive logistics planning can enhance transportation whereby GPS and traffic data analytics can help construction companies to improve operations and eliminate congestion which in turn reduces fuel use and pollution. Urban planning must consider road traffic indications and delivery schedules as traffic may affect building material transport, increasing costs and causing project delays. Tokunova, and Rajczyk[20] recommended road traffic lights to ensure timely delivery, suggesting to add traffic data in helping construction companies to estimate and reduce delays which in turn assures timely supply delivery and project completion.

Urban sustainability requires urban land use and road traffic in the process of urban construction whereby a comprehensive strategy can boost the economy and improve the environment. Zeng, *et al.*[21] created a procurement, transportation and land use-limited supply chain planning system, underlining the need for procurement managers, transportation authorities and urban planners to collaborate on long-term sustainable urban goals. Tamym, *et al.*[22] investigated many case studies to demonstrate how integrated solutions can accomplish long-term sustainable urban goals. Effective processes and planning yielded knowledge in which a famous urban initiative reduced garbage and emissions by incorporating eco-friendly shopping into land use planning [23]. Sustainable urban construction policy alignment was emphasised in the research where future research should evaluate sustainable construction and complicated links between land use and urban road traffic.

# METHODOLOGY

## Data Collection

This review focuses on sustainable urban construction approaches using the Web of Science (WoS) database's wide collection of academic publications and research papers. Web of Science (WoS) was chosen for its wide range and high-quality peer-reviewed scientific content. Articles search was performed using 'sustainable urban development' or 'urban sustainability' and relevant metrics or indices. Table 1 shows the keyword search criteria. The initial search phrases were 'sustainable urban development' or 'urban sustainability', then 'indicator' or 'index'. The initial term was unspecified, allowing for the examination of current and basic studies. The search included several topics, yielding a wide selection of urban sustainability and urban construction literature. Figure 1 shows the analytical process diagram of the study.

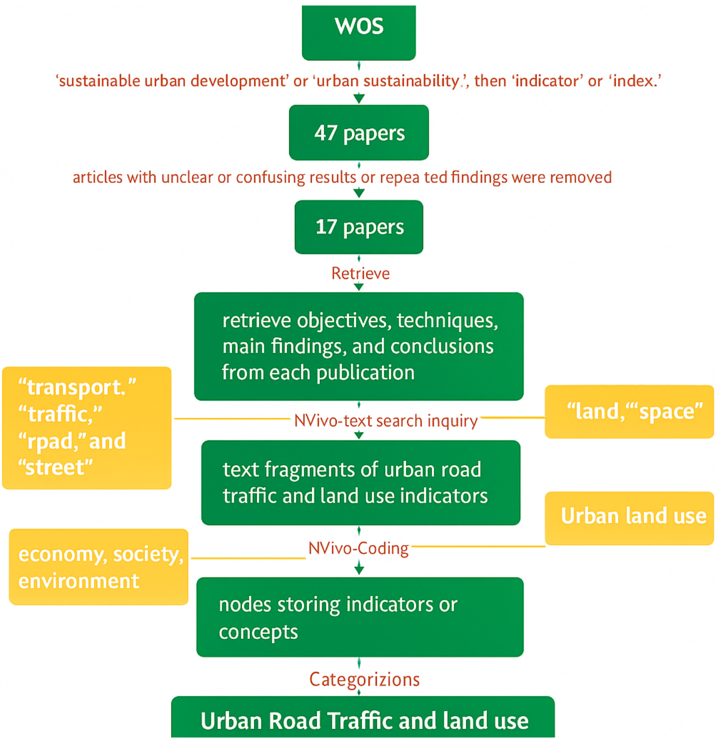


**Figure 1:** Analytical process diagram.

**Table 1:** Literature search words combination.

| **Search Criteria** | **Keywords** |
|---|---|
| Sustainable urban development | 'Sustainable urban development', 'urban sustainability' |
| Urban indicators | 'Urban indicators', 'urban index', 'urban metrics' |
| Environmental indicators | 'Environmental indicators', 'environmental metrics' |
| Social indicators | 'Social indicators', 'social metrics', 'social sustainability' |
| Economic indicators | 'Economic indicators', 'economic metrics', 'economic growth' |
| Urban road traffic indicators | 'Urban road traffic', 'traffic congestion', 'vehicle emissions' |
| Urban land use indicators | 'Urban land use', 'land consumption', 'land use intensity' |

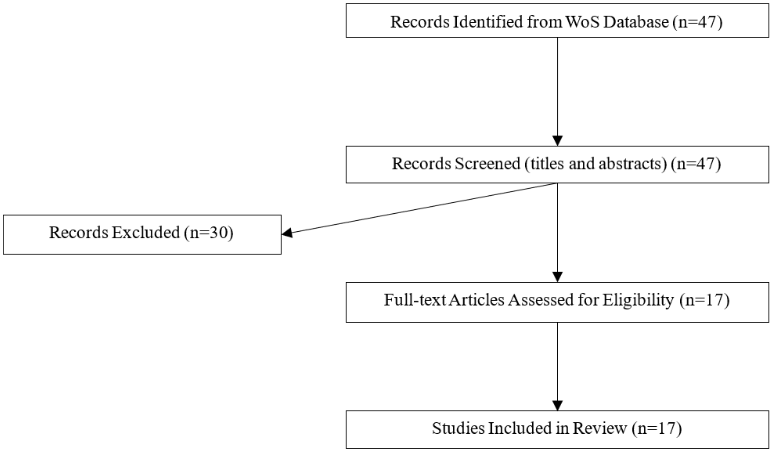


**Figure 2:** PRISMA Flow Diagram

A preliminary WoS database search was done using these parameters. This search found 47 articles that might answer the sustainable construction of a city. Each document was extracted for additional analysis. The 47 selected papers were preliminarily assessed for clarity and relevance. This preliminary review examined each work's abstracts, introductions, methods, findings and conclusions. The goal was to evaluate how well each article explains urban sustainability indicators, the three pillars of sustainability, urban road traffic indicators, urban land use indicators and their interconnections. This screening removed many papers based on the criteria in which papers that did not highlight urban land use and road traffic indicators on sustainable urban construction were excluded. To ensure that the final selection comprised only unambiguous and meaningful investigations, articles with unclear or confusing results were excluded. To ensure a diverse perspective and prevent repetition, articles that have repeated findings from previous research were removed in which 30 articles were rejected owing to the rigorous evaluation process. Finally, 17 articles were selected for a detailed examination because they offered clear, relevant and substantial findings that supported the review's goals. These 17 articles were reviewed in-depth where empirical, theoretical and case studies were included in the review, offering a solid foundation for the review and analysis. The 30 articles were excluded because they lacked direct focus on urban sustainability indicators relevant to construction, had limited methodological clarity, or focused on unrelated sectors. Some were overly theoretical, regionally irrelevant, or offered redundant insights. Only 17 papers provided clear, applicable, and well-supported findings aligned with the study's objectives. Table 2 shows the summary of reviewed articles.

**Table 2:** Summary of reviewed papers.

| **Article ID** | **Titles** | **Main Findings** | **Authors** |
|---|---|---|---|
| 1 | A comparative review on the mitigation strategies of urban heat island (UHI): a pathway for sustainable urban development | Guides building planning and sustainable urban development. | Han, *et al.*[24] |
| 2 | Urban traffic congestion in twelve large metropolitan cities: A thematic analysis of local news contents 2009–2018 | Links traffic congestion to air pollution and public health concerns. | Huang, and Loo[25] |
| 3 | The value of scenario discovery in land-use modelling: An automated vehicle test case | Discusses the social equity implications of high-density land use. | Engelberg[26] |
| 4 | Economic Benefits of Green Procurement Policies | Analyses the economic advantages of sustainable procurement practices. | Chersan, *et al.*[27] |

**Table 2 (continued):** Summary of reviewed papers.

| | | | |
|---|---|---|---|
| 5 | The Transition of Land Use and Road Safety Studies: A Systematic Literature Review | Examines how land use planning influences traffic patterns and vice versa. | Iamtrakul, *et al.*[28] |
| 6 | Urban flood risk management needs nature-based solutions: a coupled social-ecological system perspective | Explores the resilience benefits of green spaces in urban areas. | Zhou, *et al.*[19] |
| 7 | AI perceives like a local: predicting citizen deprivation perception using satellite imagery | Discusses disparities in access to transportation infrastructure based on socioeconomic factors. | Abascal, *et al.*[29] |
| 8 | Exploring the potential impact of smart urban technologies on urban sustainability using structural topic modelling: Evidence from Belgium | Analyses the relationship between economic growth and sustainable urban development strategies. | Margherita, *et al.*[4] |
| 9 | Optimisation of the subsidy for university faculty relocation in campus suburbanisation | Examines the energy efficiency benefits of green building certifications in urban environments. | Yang, *et al.*[30] |
| 10 | Big data analytics-based approach for robust, flexible and sustainable collaborative networked enterprises | Assesses the environmental impacts of urban road construction projects. | Tamym, *et al.*[22] |
| 11 | Using green infrastructure as a social equity approach to reduce flood risks and address climate change impacts: A comparison of performance between cities and towns | Highlights social benefits, such as improved accessibility and social inclusion through public transportation. | Reu Junqueira, *et al.*[15] |
| 12 | Integrated impact of urban mixed land use on TOD ridership: A multi-radius comparative analysis | Discusses economic incentives and policies to promote sustainable transportation options. | Gu, *et al.*[31] |
| 13 | Integrating sustainability indicators and governance structures via clustering analysis and multicriteria decision-making for an urban agriculture network | Analyses green procurement practices and their adoption in the construction industry. | Valencia, *et al.*[3] |
| 14 | Prosperity and inclusion: The impact of public housing supply on urban inclusive growth in China | Examines the effectiveness of land use policies in managing urban growth. | Wang, *et al.*[32] |
| 15 | Static and dynamic resilience assessment for sustainable urban transportation systems: A case study of Xi'an China | Quantifies the economic costs associated with traffic congestion in urban areas. | Chen, *et al.*[33] |
| 16 | Transportation in urban land change models: a systematic review and future directions | Explores public attitudes and acceptance towards sustainable urban planning initiatives. | Ahasan, and Güneralp[34] |
| 17 | Identifying, projecting and evaluating informal urban expansion spatial patterns | Provides a comprehensive evaluation framework for urban sustainability indicators. | Tellman, *et al.*[35] |

**Data Analysis**

The shortlisted 17 articles were systematically arranged and examined utilizing Microsoft Excel and Nvivo software. Preliminary information from every research—e.g., the context of the study, aims, research method, and major findings—was listed in Excel to provide an organized overview. This ensured uniformity in the initial organization stage and facilitated greater inter-study cross-comparison. In order to conduct an in-depth content analysis, qualitative coding was conducted using Nvivo on the chosen articles. A deductive coding method was adopted with codes being pre-determined against the three pillars of sustainability: environmental, social, and economic. Nonetheless, as the resulting data presented new themes and indicators, inductive sub-coding was also utilized to incorporate subtle insights. Every indicator drawn from the literature was then allocated to one of the three pillars according to clearly articulated conceptual rationales:

- Environmental indicators were allocated according to their applicability to ecological systems and utilization of natural resources. These consisted of parameters such as carbon emissions, waste production, energy use, recycling of material, land cover with greenery, and effects on air and water quality. These indicators were deemed environmental as they directly affect or indicate the construction industry's interaction with the physical environment and natural capital.

- Social indicators were determined and coded according to how they affected human welfare, quality of life, equity, health, and community building. These included the likes of urban accessibility, noise pollution, public satisfaction, stakeholder participation, social inclusion in contracting opportunities, and workplace safety. These were rationalized under the social pillar since they pertain to societal outcomes and how much construction activity benefits or impacts communities and people.

- Economic indicators were coded according to their focus on financial efficiency, economic feasibility, cost analysis, and sustainability in the market. Indicators that include project cost minimization, transport effectiveness, life-cycle cost reduction, and procurement value were labeled as economic because of their core focus on economic performance and future financial effects on stakeholders.

This open explanation for classifying indicators made sure that the coding was theory-driven in terms of sustainability and was consistent with existing empirical frameworks (e.g., triple bottom line, ISO 37120 indicators, and urban sustainability taxonomies). After all the indicators were coded and grouped by category, sophisticated queries were executed in Nvivo to analyze patterns, interrelations, and co-occurrence among various indicators across studies. These searches enabled the exploration of interrelations between environmental, social, and economic indicators, such as the way urban planning for land use impacts both emissions (environmental) and accessibility (social), or the way traffic congestion has a dual impact on both project delay (economic) and public health (social). These interlinkages were significant for grasping the multi-dimensional dynamics of sustainable supply chains in construction and facilitated the study beyond disconnected analysis to a more integrative view. The marrying of thematic coding and relational querying provided a robust basis for integrating the literature within a structured and interpretive way.

# RESULTS

The results section presents a detailed analysis of the indicators discussed in the 17 articles, focusing on urban road traffic and urban land use indicators. The data representation includes summary tables that show the number of articles containing each type of indicator categorised under the three pillars of sustainability, i.e. environmental, social and economic. The distribution of articles discussing urban road traffic and land use indicators is also included in the summary tables.

### Indicator Categories for Urban Road Traffic

From Table 3, it can be seen that many indicators related to urban road traffic were used to evaluate the sustainability of cities in the 17 reviewed papers. For example, indicators related to urban road traffic, such as Traffic Congestion, Vehicle Emissions, Public Transportation Accessibility, Road Infrastructure Quality, Noise Pollution, Cycling and Pedestrian Infrastructure as well as Economic Impact of Traffic Congestion, were used, and each indicator was used in multiple papers. Among them, Traffic Congestion, Vehicle Emissions, Public Transportation Accessibility and Road Infrastructure Quality were used in seven, five, six and four papers, respectively, accounting for 41.18%, 29.41%, 35.29% and 23.53% of all reviewed papers. It can be seen from Table 3 that urban road traffic indicators are closely related to the three pillars of sustainable development, with the greatest impact on the urban environment, followed by social impact, and the least impact on the urban economy. Of the seven indicators reviewed, six and five are related to urban environment and society, respectively, although only one indicator is related to urban economy, which is also discussed in four of the literature.

Additionally, Iamtrakul, *et al.*[28], Abascal, *et al.*[29], Chen, *et al.*[33], Yang, *et al.*[30] and Ahasan, and Güneralp[34] used indices related to urban road networks when evaluating the sustainability of urban road traffic, such as road area ($m^2$), road density ($km/km^2$), number of roads, total length of urban roads (km) and so on.

**Table 3:** Urban road traffic indicators following sustainability pillars and their referenced articles.

| Indicator | Environmental | Social | Economic | Number of Papers | Percentage of Total Articles | Article References |
|---|---|---|---|---|---|---|
| Traffic Congestion | Yes | Yes | No | 7 | 41.18% | Reu Junqueira, *et al.*[15], Han, *et al.*[24], Huang, and Loo[25], Iamtrakul, *et al.*[28], Gu, *et al.*[31], Wang, *et al.*[32], Chen, *et al.*[33] |
| Vehicle Emissions | Yes | No | No | 5 | 29.41% | Zhou, *et al.*[19], Han, *et al.*[24], Huang, and Loo[25], Gu, *et al.*[31], Chen, *et al.*[33] |
| Public Transportation Accessibility | Yes | Yes | No | 6 | 35.29% | Valencia, *et al.*[3], Margherita, *et al.*[4], Reu Junqueira, *et al.*[15], Abascal, *et al.*[29], Gu, *et al.*[31], Wang, *et al.*[32] |
| Road Infrastructure Quality | Yes | Yes | No | 4 | 23.53% | Zhou et al. (2024), Reu Junqueira, *et al.*[15], Abascal, *et al.*[29], Yang, *et al.*[30] |
| Noise Pollution | Yes | Yes | No | 3 | 17.65% | Han et al. (2023), Zhou et al. (2024), Huang & Loo (2023) |
| Cycling and Pedestrian Infrastructure | Yes | Yes | No | 2 | 11.76% | Margherita, *et al.*[4], Reu Junqueira, *et al.*[15] |
| Economic Impact of Traffic Congestion | No | No | Yes | 4 | 23.53% | Iamtrakul, *et al.*[28], Yang, *et al.*[30], Gu, *et al.*[31], Chen, *et al.*[33] |

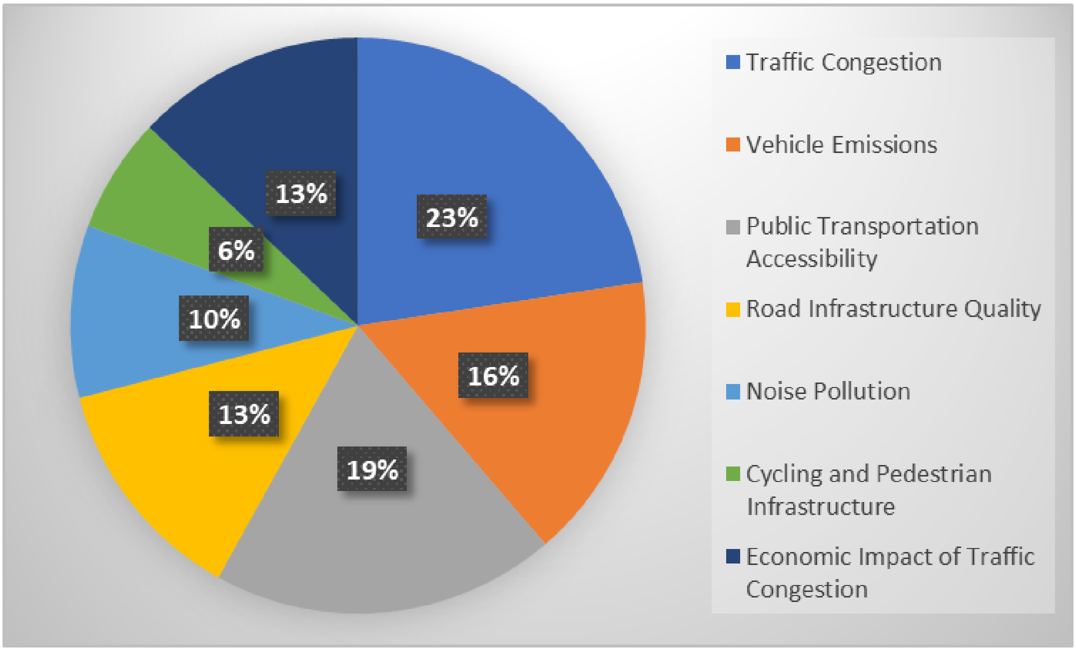


**Figure 3:** Graphical representation of Urban road traffic indicators following sustainability pillars

**Indicator Categories for Urban Land Use**

From Table 4, it can be seen that the land use-related indicators Land Consumption, Green Space Availability, Mixed Land Use, Urban Density, Accessibility to Public Amenities, Social Housing Availability and Economic Impact of Land Use Policies have been used in multiple papers. Of these indicators, Land Consumption, Green Space Availability, Mixed Land Use and Urban Density have been used in six, five, three and four papers, respectively, accounting for 40%, 33.33%, 20% and 26.67% of all reviewed papers. Urban land use indicators are closely related to the three pillars of sustainable development, with a significant impact on the urban environment and society as well as a smaller impact on the urban economy. Of the seven indicators reviewed, five are related to the urban environment and society, although only one is related to the urban economy. Engelberg[26] also provided a detailed discussion of this indicator. Additionally, Engelberg[26,]Iamtrakul, *et al.*[28,]Abascal, *et al.*[29,]Gu, *et al.*[31] and Tellman, *et al.*[35] used indicators related to urban land use when evaluating urban land sustainability, such as land area, MLU(mix land use index), FAR (Floor Area Ratio), land use characteristics (such as diversity and density), land cover, land availability, land use layout, land prices and so on.

**Table 4:** Urban land use indicators by sustainability pillars and their referenced articles.

| Indicator | Environmental | Social | Economic | Number of Papers | Percentage of Total Articles | Article References |
|---|---|---|---|---|---|---|
| Land Consumption | Yes | No | No | 6 | 40% | Valencia, *et al.*[3,]Zhou, *et al.*[19,]Han, *et al.*[24,]Engelberg[26,]Iamtrakul, *et al.*[28,]Wang, *et al.*[32] |
| Green Space Availability | Yes | Yes | No | 5 | 33.33% | Valencia, *et al.*[3,]Margherita, *et al.*[4,]Reu Junqueira, *et al.*[15,]Zhou, *et al.*[19,]Han, *et al.*[24] |
| Mixed Land Use | Yes | Yes | No | 3 | 20% | Valencia, *et al.*[3,]Engelberg[26,]Gu, *et al.*[31] |
| Urban Density | Yes | Yes | No | 4 | 26.67% | Han, *et al.*[24,]Engelberg[26,]Abascal, *et al.*[29,]Gu, *et al.*[31] |
| Accessibility to Public Amenities | Yes | Yes | No | 3 | 20% | Margherita, *et al.*[4,]Reu Junqueira, *et al.*[15,]Wang, *et al.*[32] |
| Social Housing Availability | No | Yes | No | 2 | 13.33% | Valencia, *et al.*[3,]Wang, *et al.*[32] |
| Economic Impact of Land Use Policies | No | No | Yes | 1 | 6.67% | Engelberg[26] |

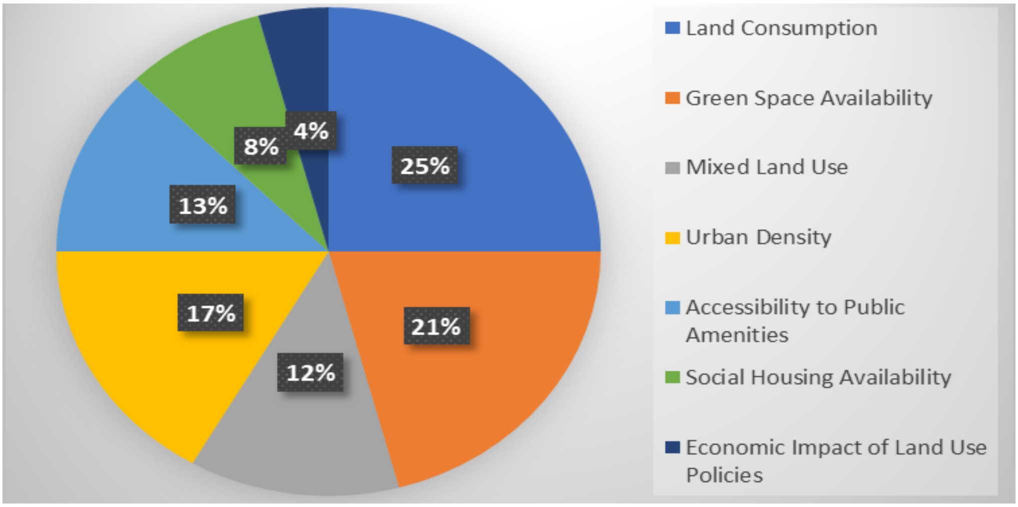


**Figure 4:** Graphical summary of Urban land use indicators by sustainability pillars

## Interrelationship of Indicators

Upon further analysis of the 14 indicators of urban road network and land use, it was found that six indicators were used in the same literature to evaluate both urban traffic and land use. The indicators are listed in Table 5. The Land Consumption indicator is mostly represented by the Area of land used by transportation facilities in the literature, while the Green Space Availability indicator is represented by the number of green areas accessible to the public. Urban Density is represented by population density in urban areas. These indicators were cited in six, five and four articles, respectively, to evaluate the sustainability of cities. The Traffic Congestion indicator is represented by the degree of congestion on urban roadways and the Noise Pollution indicator is represented by the levels of noise generated by urban traffic. The Economic Impact indicator is represented by the economic costs and benefits of urban transportation. These indicators were cited in seven, three and four articles, respectively, to evaluate the sustainability of cities. This shows that there is a close relationship between urban road networks and land use.

**Table 5:** Overlapping indicators between urban road traffic and land use.

| Indicators | Descriptions | Sustainability Pillar(s) | Number of Articles | Article References |
|---|---|---|---|---|
| Land Consumption | Area of land used by transportation facilities | Environmental, Social, Economic | 6 | Valencia, *et al.*[3], Zhou, *et al.*[19], Han, *et al.*[24], Engelberg[26], Iamtrakul, *et al.*[28], Wang, *et al.*[32] |
| Traffic Congestion | Degree of congestion on urban roadways | Environmental, Social, Economic | 7 | Reu Junqueira, *et al.*[15], Han, *et al.*[24], Huang, and Loo[25], Iamtrakul, *et al.*[28], Gu, *et al.*[31], Wang, *et al.*[32], Chen, *et al.*[33] |
| Green Space Availability | Amount of green areas accessible to the public | Environmental, Social | 5 | Valencia, *et al.*[3], Margherita, *et al.*[4], Reu Junqueira, *et al.*[15], Zhou, *et al.*[19], Han, *et al.*[24] |
| Urban Density | Population density in urban areas | Environmental, Social | 4 | Han, *et al.*[24], Engelberg[26], Abascal, *et al.*[29], Gu, *et al.*[31] |
| Noise Pollution | Levels of noise generated by urban traffic | Environmental, Social | 3 | hou, *et al.*[19], Han, *et al.*[24], Huang, and Loo[25] |
| Economic Impact | Economic costs and benefits of urban transportation | Social, Economic | 4 | Iamtrakul, *et al.*[28], Yang, *et al.*[30], Gu, *et al.*[31], Chen, *et al.*[33] |

**Table 6:** Under-researched indicators in urban sustainability studies

| Indicator | Sustainability Pillar(s) | Notes on Underutilization |
|---|---|---|
| Accessibility of individual roads | Social, Economic | Rarely included in integrated sustainability frameworks; limited spatial analysis. |
| Land use intensity (FAR, MLU) in sustainability assessments | Environmental, Economic | Mentioned in few studies; little operationalisation in policy tools. |
| Road network redundancy/robustness metrics | Environmental, Economic | Discussed conceptually, but not empirically applied in sustainability evaluations. |
| Real-time traffic flow metrics linked to sustainability | Environmental, Social | Lacks empirical linkage to environmental or health outcomes in reviewed studies. |
| Cost-efficiency of compact land use policies | Economic | Economic pillar underrepresented; calls for more cost-benefit analyses. |

# DISCUSSION

The results of a review of 17 literature are focused on three issues: First, the evaluation of urban sustainability requires urban road traffic and land use indicators, which can fully reflect the three pillars of sustainable development. Second, there is a close relationship between urban road traffic and urban land use. Third, the application of urban road network indicators and land use intensity indicators in the evaluation of urban sustainability.

## The Significance of Urban Road Traffic Indicators for Urban Sustainability

An overview of urban road traffic indicators across the sustainability pillars shows their different effects on urban settings. The analysis found that automobile traffic impacts economic vitality, social fairness and environmental well-being. The environmental pillar examines how urban automobile traffic affects energy consumption, noise pollution and air quality [35]. Metropolitan regions' sustainability is threatened by environmental impacts whereby automotive emissions are the key elements responsible for urban air pollution. Emissions deteriorate air quality and contribute to climate change [24]. The analysis suggested to increase public transportation, pollution limitations and ecologically friendly vehicle technology, like electric and hybrid automobiles. Improving air quality not only has great benefits for the environment but also has a significant influence on public health by lowering respiratory and cardiovascular ailments caused by air pollution [15]. Another crucial environmental indicator is urban automobile traffic's energy use whereby 6 studies examined transportation network energy efficiency and urban mobility energy demand (Table 3). These studies underlined the importance of minimising energy use by applying approaches, such as integrating renewable energy sources into public transportation infrastructure, supporting other modes of transportation (such as cycling and walking) and improving traffic flow [3]. Furthermore, these solutions not only increase energy security and resilience in urban environments but also help to lessen environmental implications [32]. Though seldom discussed, 3 articles emphasised urban automobile traffic noise pollution as a major environmental issue. Traffic noise pollution in densely populated cities can cause stress, sleep difficulties and cognitive impairment. Noise barriers, verdant buffers and quieter road surfaces help to minimise noise pollution whereby mitigating noise pollution promotes the urban atmosphere and health [33].

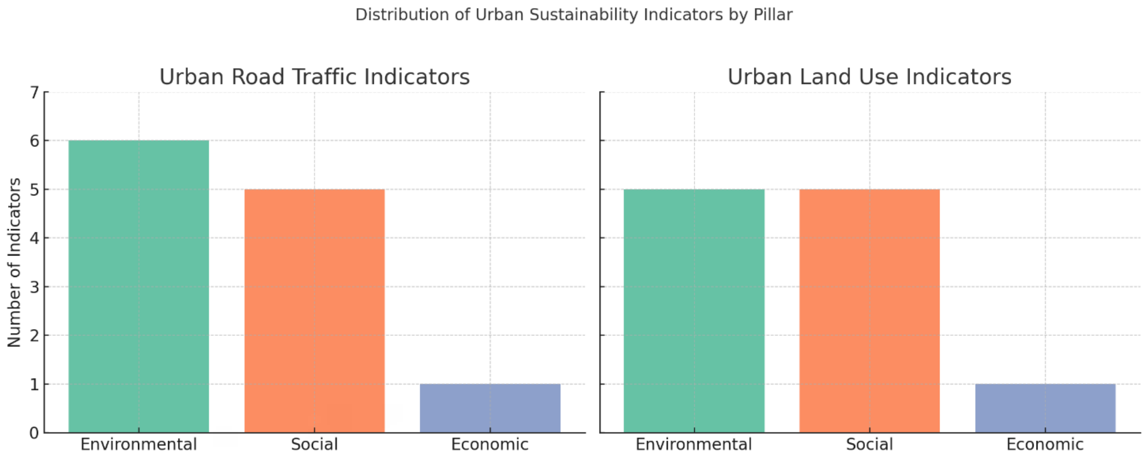


**Figure 5:** Distribution of Urban sustainability indicator by pillars

There are 9 articles focused on the social effects of urban road traffic on public health, accessibility, safety and quality of life whereby these social factors demonstrate the importance of equitable and comprehensive transportation networks in sustainable urban communities [32,33,35]. There are 7 articles addressing urban vehicle traffic-related public health problems, showing that vehicle-caused air pollution causes cardiovascular illness and respiratory ailments, including asthma and bronchitis (Table 3). The recommended initiatives are to improve green infrastructure, physical activity and air quality by cutting car emissions and boosting walking and cycling [30]. Providing safe settings and clean air to all urban residents improves social equity by reducing public health risks. There are 6 articles that discussed how urban car traffic affects socially important accessibility whereby accessibility is the ease with which people can access places and use services regardless of income or ability [22]. The study emphasises the importance of pedestrian infrastructure and accessible public transit in reducing mobility obstacles and promoting social inclusion.

Accessibility improves mobility for vulnerable persons including the elderly and disabled and boosts economic and social prospects in cities [31]. There are 5 articles that emphasised the necessity of improving traffic management, road design and traffic law enforcement to minimise urban road traffic accidents and deaths. Uneven road traffic injuries affect pedestrians, cyclists and motorcyclists. Promote safer driving, improve visibility and signs and reduce traffic in which social justice requires tackling safety issues to make cities safer and more inclusive for all road users [3]. There are 4 articles that discussed how urban road traffic affects residents' well-being, happiness and quality of life. Traffic congestion, noise pollution and air quality affect residents' well-being and everyday life. Congestion pricing to reduce traffic and sustainable urban design techniques that promote green spaces, active transportation and human-friendly settings can improve quality of life [33]. Creating cohesive and resilient communities that allow inhabitants to thrive and enjoy a high quality of life promotes social sustainability.

There are 4 studies that analysed urban automotive traffic's infrastructure investment, economic output and cost-effectiveness. These figures demonstrate the necessity of good transportation infrastructure for urban economic growth and competitiveness [34]. There are 3 articles that analysed the economic effects of urban vehicle traffic, including lower production, congestion delays and increased petroleum usage. Congestion pricing, public transit marketing, carpooling and telecommuting have economic benefits. Improved traffic flow and travel times can enhance economic output and reduce corporate and commuting costs [30]. There are 2 articles that examined how effective transportation networks boost innovation and economic growth by affecting traffic congestion and economic productivity. Transportation infrastructure improves access to labour markets, products and services, boosting economic growth and commercial activity. Urban productivity and competitiveness increase with sustainable transportation and public transit investments [29]. There are 2 articles that examined how urban vehicle traffic affects transportation infrastructure investment, an important economic indicator. To support sustainable urban expansion and long-term economic success, the literature emphasises strategic investments in bicycle infrastructure, public transportation and highways [32]. Improving infrastructure improves city transit and communication raises property prices and creates jobs. New finance techniques and public-private partnerships are suggested for urban transportation planning infrastructure projects to ensure their long-term viability [4]. Economic measures were relatively less represented; however, incorporating financial performance metrics—like construction cost per square meter, life-cycle infrastructure cost, and costs saving due to lower congestion—would give a more comprehensive sustainability assessment. These measures not only express economic viability but also the effectiveness of investments in transportation infrastructure or in compact land development. For instance, cost-benefit analysis of mixed-use zoning or intelligent traffic management systems registers positive environmental dividends through the reduction of emissions, increasing land productivity, and less dependence on fossil-fueled transport.

**The Significance of Urban Land Use Indicators for Urban Sustainability**

Environmental factors dominate urban land use indicator analysis, as 7 articles emphasised biodiversity protection, green areas and land conservation. The articles emphasise land protection and urban green spaces as environmental indicators [3,4,15,19,24,26,32]. There are 5 articles that stressed the need to protect environmentally sensitive areas from development, minimising urban expansion and preserving natural ecosystems. These studies advocate for sustainable land use planning that prioritises green spaces which maintain biodiversity, store carbon and strengthen climate resilience [3,19,24,26,32]. Green corridors, parks and urban forests can improve environmental sustainability and provide urban residents with enjoyment. There are 3 papers that examined biodiversity preservation as an environmental indicator [19,24]. The literature stresses keeping a variety of urban habitats to support local plant and animal populations. Urbanisation threatens ecological services and biodiversity by fragmenting and destroying habitats. The articles recommended habitat restoration, green infrastructure and natural area-protecting zoning to incorporate biodiversity into urban development [3,15,26]. Urban biodiversity conservation can increase environmental sustainability and ecological resilience in the face of urban growth limits and climate change. Table 4 shows the urban land use indicators by sustainability pillars.

The are 4 articles focused on the social effects of urban land use on cultural heritage, public health and community development. There are 3 articles emphasised community formation sociologically [3,4,15]. Community-oriented planning, affordable housing and mixed-use activities promote lively and inclusive communities in urban land use. Han, *et al.*[24] underlined the importance of walking-friendly communities, supporting local businesses and fostering social togetherness. These programmes use participatory planning to ensure fair access to urban facilities and services as well as include different community stakeholders in decision-making. Urban land use patterns impact city people's well-being, mental health and physical exercise [25]. Recreational facilities, parks and green areas improve health [24,25]. The amenities promote exercise and reduce stress-related disorders. Gu, *et al.*[31] recommended incorporating health impact studies into urban planning to emphasise public health results and offer supportive environments that increase residents' quality of life.

Urban land use's economic effects on infrastructure investment, property prices and economic production are studied. Valencia, *et al.*[3] examined economic growth and property prices. Land use restrictions and development constraints affect urban real estate markets, investment patterns and economic growth. Wang, *et al.*[32] examined the economic benefits of transit-oriented development, smart growth and mixed-use complexes that create walkable, densely inhabited neighbourhoods. These policies boost property prices, private investment, local company growth and economic prosperity. To encourage sustainable urban expansion and economic success, land use policy must align with economic development goals. Urban development promotes equal access to housing, transportation and critical services for all residents, especially underprivileged populations, through social equity land use design. Table 4 shows the articles discussing urban land use indicators.

**Interconnectedness of Sustainability Indicators**

Table 5 presents an insightful overview of the indicators related to urban road traffic and land use across the three sustainability pillars: environmental, social and economic. It reveals that the environmental pillar encompasses the highest number of indicators, totaling seven, which include critical factors, such as traffic congestion, vehicle emissions and noise pollution from road traffic, along with land consumption and green space availability in urban areas. This underscores the significant environmental implications of both urban traffic and land use practices [19,25]. In contrast, the social pillar includes six indicators, highlighting the interconnectedness of traffic conditions and public transport accessibility with land use elements like urban density and green spaces [29,31]. Lastly, the economic pillar is represented by only two indicators, reflecting a narrower focus on the economic impacts of traffic congestion and land use policies [30,33]. This disparity suggests a need for further research and policy emphasis on the economic dimensions of urban sustainability.

This review shows how sustainability metrics are distributed across environmental, social and economic pillars. Urban sustainability is diverse and this distribution emphasises the intricate interaction between various factors in affecting sustainable urban development. The research highlights the interconnected nature of various sustainability issues, such as the relationship between improved air quality and the availability of green spaces, underscoring the necessity for coordinated policies and initiatives to achieve multiple sustainability goals. Urban sustainability frameworks should incorporate these diverse factors, which can lead to reduced transportation costs, improved connectivity and the attraction of businesses and talent to urban areas.

Urban road transportation, like other urban functions, ultimately depends on land use, establishing a clear interdependence between the two. The relationship between land use and transit accessibility also significantly influences property values and real estate development. Properties located near transit routes tend to be more valuable, thereby attracting investment. Implementing mixed-use and transit-oriented development (TOD) around public transportation hubs can optimise land use efficiency and facilitate higher-density development, which in turn enhances property values and fosters sustainable growth [31]. This research contributes to current urban sustainability frameworks by combining urban road traffic and land use indicators under one integrated, triple-bottom-line framework—something that has been underrepresented in recent publications from 2024 and 2025. While the majority of frameworks compartmentalize environmental or economic effects, our overview transcends these and highlights their interdependence, especially through indicators such as traffic congestion, green space supply, and land consumption. By emphasizing how these interlinked indices correlate with environmental resilience, social equity, and economic efficiency, this research bridges an important knowledge gap in recent urban sustainability studies (e.g., Zhou, *et al.*[19]). It presents a revised evaluation framework that enables more holistic policy-making and planning measures consonant with existing global sustainability imperatives.

### Indicators of Urban Road Network and Indicators of Land Use Intensity

Indices related to urban road networks were used to evaluate the sustainability of urban sustainability. Ahasan, and Güneralp[34] used urban density to express road area and accessibility to the road network, assuming that the higher the road density, the closer to major roads. Chen*, et al.*[33] adopted urban road area ($m^2$), road density ($km/km^2$), total length of urban roads (km) and number of roads are used to describe the robustness and redundancy characteristics of urban road networks. Average travel distance (km), per capita area of paved roads ($km^2$) and number of employed persons in road transportation (10,000 persons) were adopted to describe the adaptation and resourcefulness of urban road networks. High-density urban road networks can reduce the impact of disturbances on the road network. Increasing the length of roads in the city can improve the redundancy of the road network. Additionally, some indicators related to urban land use were used to evaluate urban sustainability.

Iamtrakul*, et al.*[28] pointed out that there are many opportunities and various urban activities in cities, including housing and roads, which require a certain amount of land to support. Gu*, et al.*[31] used the MLU (mix land use index) and FAR (floor area ratio) to express land use patterns and diversity. FAR reflects the intensity of development and building density on a given piece of land. MLU measures the diversity of land use structures and functions within a certain area. Land availability is considered an important component of sustainable urban transportation.

Abascal*, et al.*[29] cited the indicator land cover, which is the physical material at the land surface of the earth. It is a typical concrete physical phenomenon. However, the accessibility and flow potential of each road in the urban road network, land use intensity and their spatial relationships are rarely studied to evaluate the sustainability of urban areas. GIS-based research offers robust capabilities to visualize, quantify, and examine spatial patterns, including road density, mix of land use, and proximity to infrastructure, that are essential to evaluate accessibility, congestion points, and land development intensity. For example, planners are able to map road network connectivity and how this relates to land use typology or population density and identify areas of inefficiency or imbalance. Advanced spatial modeling techniques—kernel density estimation, spatial autocorrelation (Moran's I), and spatial regression models—are able to identify causal connections between urban form and sustainability outcomes such as emissions, travel demand, and accessibility to public services. Geospatial analysis techniques, meanwhile, underpin the simulation of policy scenarios and infrastructure development effects on land use efficiency and mobility through tools such as ArcGIS, QGIS, and spatial syntax. These GIS-based analyses when integrated into sustainability assessments not only lead to improved spatial precision and contextual applicability but also equip policymakers with actionable information for effective interventions. In order to connect research and practice, these indicators need to be developed into action-focused tools for municipalities and urban planners. Road congestion may be quantified using real-time traffic flow measurements from IoT sensors, whereas land consumption is monitored through cadastral mapping and satellite imagery. Municipalities are able to integrate these measures into dashboards for real-time monitoring, urban performance benchmarking, and project assessment. Standardization of indicator thresholds (e.g., satisfactory road density or green area per capita) will help cities bridge local policy with international sustainability objectives.

## FUTURE DIRECTIONS FOR URBAN SUSTAINABILITY

The study illuminates the evolving nature of urban sustainability objectives, emphasising the need for a balanced approach that reconciles environmental health, social equity and economic viability. By integrating these critical characteristics into urban policy frameworks, cities can establish resilient sustainability strategies that effectively address contemporary challenges while laying the groundwork for future growth. Thoughtful urban design can minimise the environmental impact of vehicular traffic and land use by incorporating parks, green roofs and urban woodlands. Such green infrastructure initiatives can improve air quality, sequester carbon and provide habitats for urban wildlife, ultimately enhancing biodiversity. Integrating these elements into city design fosters urban sustainability. Enhancing the economic aspect of sustainability frameworks is essential for enabling cities to develop integrated and equitable policies that promote urban sustainability. By studying the spatial relationship between the indicators that can cover the three pillars of urban sustainable development, such as the indicators of urban road network and land use intensity, the policy basis for urban sustainable development can be provided. Through this approach, urban areas can work towards achieving a sustainable future that benefits all residents.

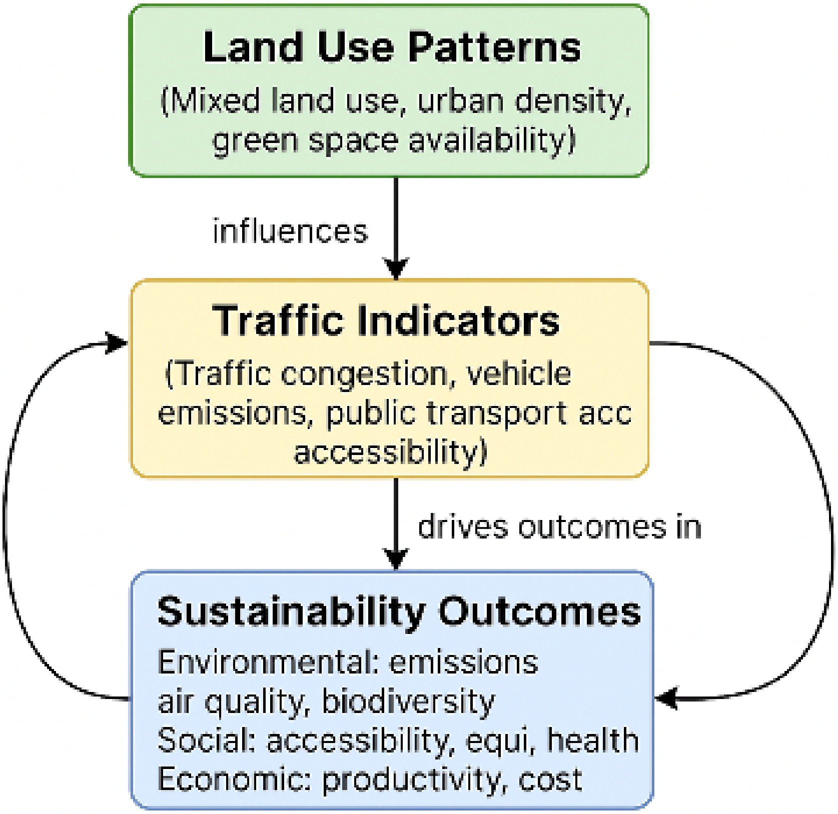


**Figure 6:** Conceptual framework illustrating the influence of land use patterns on traffic indicators and their subsequent impact on sustainability outcomes

## IMPLICATIONS FOR THEORY AND POLICYMAKING

The review emphasises the necessity for comprehensive evaluation methodologies that account for the complex linkages between urban sustainability indicators, such as land use and road traffic. Effective urban policymaking involves broad evaluation frameworks that consider these intricate environmental, social and economic connections. Data on economic productivity, social inequality, carbon emissions and air quality can help policymakers to craft informed urban strategies. This approach enables the avoidance of shocks and the selection of activities that enhance multiple areas simultaneously. Customising solutions to urban demands and constraints using local experience can increase public and stakeholder acceptance of sustainability projects. Good urban policy is data-driven whereby credible urban indicators, demographic trends and environmental data enable policymakers to evaluate and improve programmes. Cities can manage population growth, transportation and sustainability through smart analytics and modelling. Data analysis helps cities to enhance operations, sustainability and resource management. For sustainable urban expansion, Reu Junqueira, *et al.*[15] advocated compact and multifunctional development whereby these strategies boost land use efficiency, limit urban sprawl and promote cycling and walking. Mixed-use zoning, transit-oriented development and infill development reduce traffic, increase services and lower car dependency. These programmes foster inclusive and active communities, enhancing urban life and social harmony. Another policy goal is long-term investment in environmentally friendly transportation infrastructure. Sustainable commuting is also promoted by pedestrian-friendly architecture, public transit and bike infrastructure which reduce greenhouse gas emissions and air pollution while improving urban mobility and accessibility. Urban trees, green roofs and parks help cities to adapt to climate change in which urban ecosystem services and green spaces can boost biodiversity, air quality and health. Huang, and Loo[25] indicated that local creativity and knowledge exchange could boost sustainable urban development. Policy priorities for sustainable technology, urban design and community-engaged research build innovation ecosystems. By exchanging knowledge, experiences and best practices, urban centres can promote community education and collaboration. Whereas, policymakers can encourage the success and sustainability of local projects through innovation and information exchange.

**Way Forward**

Future studies should focus on the complex links between urban vehicle traffic and land use issues, particularly the relationship between urban road network parameters, urban land use and urban construction strategies. Extensive research is needed to discover how land use patterns affect urban traffic dynamics, congestion and transportation demands. A longitudinal study may examine how transportation infrastructure investments and land use restrictions affect urban mobility and environmental quality over time. Comparing urban regions will reveal contextual factors affecting land use and vehicle traffic, resulting in a compendium of sustainable urban development best practices.

Land use and traffic restrictions should be evaluated using empirical criteria and standards in future research. There is a need for sustainability standards and quantitative indicators addressing economic, social and environmental issues. Environmental concerns, such as noise pollution, air quality deterioration, greenhouse gas emissions and urban heat islands should be evaluated to inform regional emission objectives and laws. Social variables include equitable transportation, service accessibility and community well-being. Economic factors encompass infrastructure investment returns, regional economic growth and real estate values. Policymakers can review programmes, assess their performance and make informed decisions to support sustainable urban development using specific benchmarks and criteria.

Understanding urban road traffic and land use requires both qualitative and quantitative study. Stakeholder interviews and interactive mapping can reveal how transportation and land use policies impact community dynamics, behaviour and perceptions. Incorporating qualitative observations with quantitative data on traffic, environmental and economic aspects will improve sustainability assessments. This comprehensive approach supports data-driven decision-making by tailoring policies to meet the needs and goals of urban residents and stakeholders.

Analytics and modelling can enhance the accuracy and predictability of urban sustainability assessments. Future studies should analyse transportation and land use decisions using geospatial analysis, machine learning and scenario planning. Simulations can predict urban growth, transportation demand and environmental impacts, enabling policymakers to anticipate challenges, make informed decisions and assess the resilience of urban systems to climatic and demographic changes. Data analytics can improve urban planning and adaptation.

Scalable sustainable urban development ideas and policy efficacy evidence necessitate long-term studies and urban comparisons. Long-term research initiatives can reveal policy effects by tracking changes in transportation behaviour, environmental quality and socioeconomic outcomes. Analysing cities with varying governance structures, economic conditions and cultural contexts can help urban practitioners and policymakers worldwide to exchange knowledge and learn from each other.

Enhancing urban sustainability research requires cooperation and information sharing among researchers, policymakers, professionals and community members. Digital data-sharing platforms, international conferences and multidisciplinary research networks can improve collective learning, innovation and capacity building. Debate and collaboration across sectors and disciplines can expedite global sustainable urban development goals in future research. This cooperative approach ensures that research findings lead to practical solutions and effective policies that create sustainable, inclusive and liveable cities for future generations.

## CONCLUSION

Numerous indicators of urban sustainability have been discussed in earlier studies, which serve to assess the sustainability of cities. However, a significant number of these indicators fail to cover the three fundamental pillars of sustainable development. This study examined urban road traffic and land use indicators which can cover three pillars of sustainable development. A comprehensive systematic literature review showed that urban road traffic and land use indicators are essential for the evaluation of urban sustainability and there is a close relationship between them. It also highlights that urban road network indicators, land use intensity indicators and their spatial relationships are rarely used to evaluate the sustainability of cities. By analysing these indicators and their spatial connections, urban policymakers can gather valuable information to aid in their decision-making regarding sustainable land use and transportation strategies. Nonetheless, many other indicators of urban sustainability are also interrelated, many of which are even closely tied to land use and transportation indicators. Further investigation is necessary to uncover these relationships and create additional methodologies for examining them, thereby offering more comprehensive data for sustainable urban construction strategies.

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