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Research Article

Impact of Smart Mobility Infrastructure on the Socio-Economic Fabric of Kota City

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Abstract

The trends observed in Indian cities show growing pressure on urban transport systems due to rapid urbanisation and rising motorisation, which has been particularly high in Tier-2 urban centres where urban transport infrastructure has lagged behind the rising mobility demand. The case of Kota city in Rajasthan is an example that can be discussed in this context: it has become the first signal-free city in India due to the systematic use of grade-separated smart mobility infrastructure as part of the National Smart Cities Mission. To explore the effects of this change on the efficiency of urban mobility, socio-economic productivity, environmental quality and road safety, this paper applies a case-study-based mixed-methods approach. The analysis utilises official secondary sources of data that are verified by the government, such as the Rajasthan Economic Review (2024-25), Central Pollution Control Board air quality archives, Smart Cities Mission Management Information dashboard, Urban Improvement Trust Kota reports, and Rajasthan Police traffic records, to provide an analysis of the changes in the variables between 2019 and 2025. The results suggest that the deactivation of signalised intersections led to the average commuting time reduction by more than 60 per cent, the number of traffic accidents decreased by about 40 percent and the improvement of air quality indicators of decreased vehicular idling and fuel usage could be measured. The paper also approximates vast socio-economic benefits of recovered commuter and fuel savings, which underlie the productivity benefits of infrastructure-based mobility planning. The paper draws a conclusion that grade-separated mobility infrastructure can provide long-term socio-economic and environmental payoffs and that Kota's signal-free model can be reproduced in other Tier-2 cities of India with the global objective of providing long-term solutions to the problem of congestion, road safety and sustainability.

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1. INTRODUCTION

The concept of urban mobility has become one of the most urgent issues facing Indian cities in terms of rapid urbanisation, the intensification of economic activity and increased motorisation. As the metropolitan cities have been given a lot of focus regarding transport planning and infrastructure investment, Tier-2 cities continue to experience similar congestion, safety, and environmental issues with little institutional capacity and long-term planning models. It has been an ongoing urban challenge in the form of long commuting time, accidents and deteriorating air quality, which negatively influence the productivity and quality of life.

In India, solutions to congestion in cities have been conventionally based on traffic signal optimisation, enforcement systems and incremental road widening. Even though these measures might provide short-term relief, they are weak in heavily populated urban settings with mixed traffic conditions and non-compliant behaviour. In light of these weaknesses, the most recent urban policy frameworks, most notably the National Smart Cities Mission, have begun to put more focus on integrated, infrastructure-based models that put in place efforts to reorganise urban mobility systems, as opposed to simply managing traffic flow.

It is in this context of developing policy that Kota city has been a central example of urban transport change in Rajasthan. Until 2020, the city had been plagued with heavy traffic at major crossroads with volume-capacity (V/C) ratios of more than 1.5 at key intersections. Such circumstances led to long commuting durations and high automobile emissions caused by excessive idling. The Urban Improvement Trust (UIT) Kota responded with a Signal-Free City Initiative, which was concerned with the construction of grade-separated infrastructure (flyovers and underpasses) to remove signalised intersections and allow vehicular movement to occur without disruption.

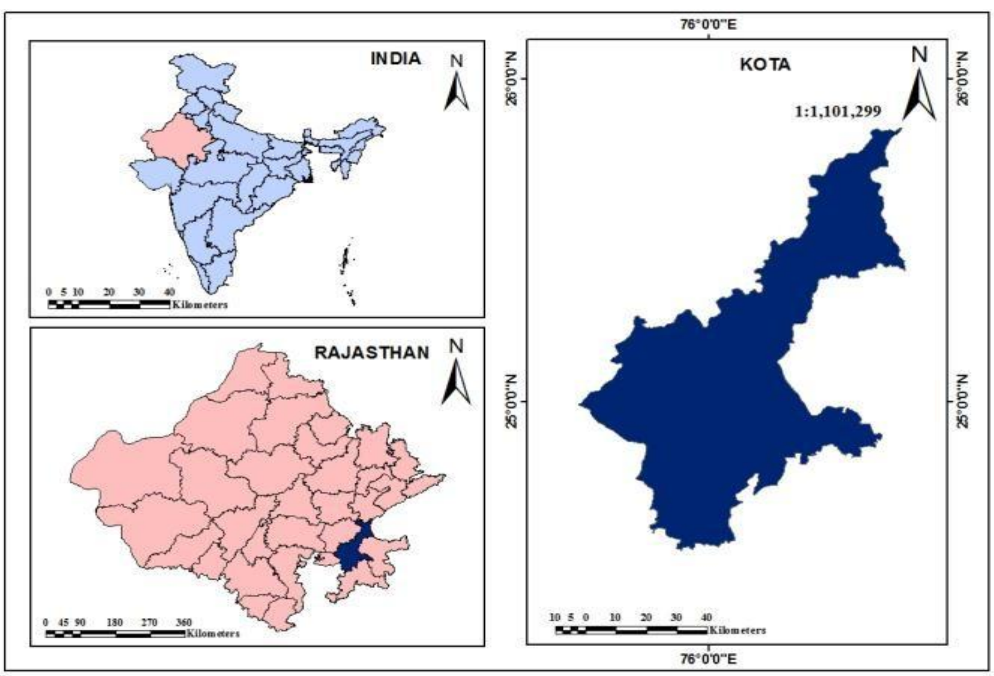
This paper observes how the signal-free mobility concept that Kota developed affected the socio-economic landscape of the city, the quality of the environment and the functionality of the city. The study will evaluate the ability of infrastructure-based interventions based on smart mobility to offer sustainable and scalable solutions to the challenges of congestion in Tier-2 Indian cities by investigating changes in key mobility, safety, and environmental indicators before the implementation.

1.1 Geographical Background of Kota City

Kota city is situated on the Chambal River in the south-eastern region of Rajasthan, and it serves as an administrative, educational and industrial hub of the Hadoti region. Its strategic positioning on regional transport corridors connecting Rajasthan and Madhya Pradesh has historically helped people and goods to move between the states, making it a hub of trade and transit.

Kota is physiographically defined as having considerably flat terrain with structural elements of riverine characteristics, a situation that in the past supported the linear city growth along the major road systems. This has been caused by the rapid population increase, which is a consequence of increased educational institutions, industrialisation, and the service sector, which leads to the high density of land-usage and high concentration of traffic in the main commercial areas, Gumanpura, Aerodrome circle and Jhalawar road. These districts serve as central traffic nodes and have high flows of commuters daily.

Figure 1.1 Study Area



The road network in the city was developed gradually and was not initially meant to support the present-day traffic. Local traffic, inter-city movement, and non-motorised transport existing on the same right-of-way space resulted in a complex dynamic of congestion at intersections. These geographical and functional attributes made traditional signal-based control of traffic more and more inefficient, and integrating infrastructure-based interventions targeting spatial restructuring of critical nodes is necessary.

2. LITERATURE REVIEW

In most of the literature dealing with urban mobility, transport infrastructure has been described as a major determinant of economic efficiency, environmental sustainability, and social well-being. The academic community is widely conceding that congestion is costly in both economic and environmental terms to the cities, but there is some controversy on the relative efficacy of technology-based traffic management infrastructures compared to infrastructure-based mobility interventions, especially in medium-sized cities with mixed traffic characteristics.

There is a great amount of literature highlighting the importance of integrated transport infrastructure in improving urban efficiency. Such interventions are demonstrated to provide long-term congestion reduction in situations where signal optimisation is insufficient. However, a significant portion of that literature concentrates on urban environments in metropolitan or mega-city settings, which lacks much empirical data on Tier-2 cities where capacity to govern, traffic structure, and morphology are dramatically different.

Urban mobility has been given more and more scholarly attention in its environmental aspects. Other parallel studies in the sustainable transport discourse have shown that emissions caused by congestion have a disproportionate amount of air pollution in cities. Most of these studies, however, conceptualise congestion as a behavioural or enforcement problem as opposed to a spatial and infrastructural one, which is solvable through physical redesign.

The literature associated with policies, such as reports released under the notion of Smart Cities, by the Ministry of Housing and Urban Affairs, starts to perceive smart mobility as one of the keys to sustainable urban development. In these documents, Kota is often mentioned as an example of infrastructure-based intervention. Although such reports offer insightful implementation information, they tend to focus more on the execution of the project and less on systemic identification of outcomes, especially in terms of socio-economic productivity and the long-term benefits to the environment.

Although the amount of literature on smart mobility has increased, there are still three major gaps that are noticeable. To start with, it is restricted to integrated measurements that concurrently analyse mobility efficiency, atmospheric quality, road safety, and economic output as one analytical model. Second, there is a limited amount of empirical evidence of Tier-2 Indian cities, as more of them are taking part in the urban transition in India. Third, the fiscal and productivity issues of capital-intensive mobility infrastructure on a long-term basis are not studied. This paper fills these gaps by providing a detailed, data-based analysis of the signal-free mobility model developed by Kota, which can help to create a more comprehensive perspective on smart mobility that is infrastructure-driven in Indian cities.

3. METHODOLOGY

3.1 Research Design and Approach

The research design is a case study-based mixed-methods research to examine the effect of smart mobility infrastructure on urban areas, its socio-economic results, and the quality of the environment in Kota city. The case study method works because of the exclusive nature of the city as the first fully signal-free city in India, and will enable the researcher to analyse infrastructure-based mobility transformation in a real urban scenario. The mixed-methods approach combines the quantitative analysis of the indicators with the qualitative assessment of the policy in order to provide a thorough analysis of the results.

3.2 Data Sources

Key data sources include:

- Economic Data: Rajasthan Economic Review (2024-25) for the economic indicators on a macro level and contextual financial evaluation.
- Environmental Data: The Air quality archives of PM2.5 concentrations from the Central Pollution Control Board (CPCB) and the Air Quality Index (AQI) data of Kota city.
- Mobility and Infrastructure Data: Used Smart Cities Mission Management Information System (MIS) dashboard and Urban Improvement Trust (UIT) Kota project reports to cover the infrastructure coverage, fund utilisation and implementation schedules.
- Traffic Safety Data: Rajasthan police traffic records for frequency and pattern.
- Energy Indicators: Fuel consumption and pricing, Indexes of Petroleum Planning, and Analysis Cell (PPAC).

The analysis is done using the conditions before implementation (2019) and post-implementation results (2025) to reflect the medium-term effects of the signal-free infrastructure project.

3.3 Indicators and Analytical Framework

Several dimensions of urban mobility and sustainability were identified with the help of a set of key performance indicators (KPIs). These are the average commute time, the idling period at junctions, the rate of road accidents, the consumption of fuel, PM2.5 and the AQI levels. The choice of indicators was informed by their relevance to transport efficiency, environmental health, and socio-economic productivity, as was supported in the current literature in terms of urban mobility.

The main statistical tool used in quantitative analysis is descriptive statistics, which helps to find trends as well as the changes in percentages between the pre- and post-implementation periods. The correlation analysis will be performed to study the importance of a relationship between the travel time decrease and the growth of air quality, which allows to evaluate the environmental co-benefits related to the alleviation of congestion.

3.4 Economic Valuation Techniques

The socio-economic effects are calculated through the conventional policy evaluation techniques. The wage rate approach is used to relate aggregate time savings to productivity gains in the economy using the average urban wage index. Likewise, the idling reduction model is applied to find out the estimated daily fuel savings in terms of the removal of signalised intersections. Such models are the ones that quantify recovered commuter time and lower fuel consumption into measurable economic and environmental gain, as is the practice of standard transport economics.

3.5 Limitations of the Study

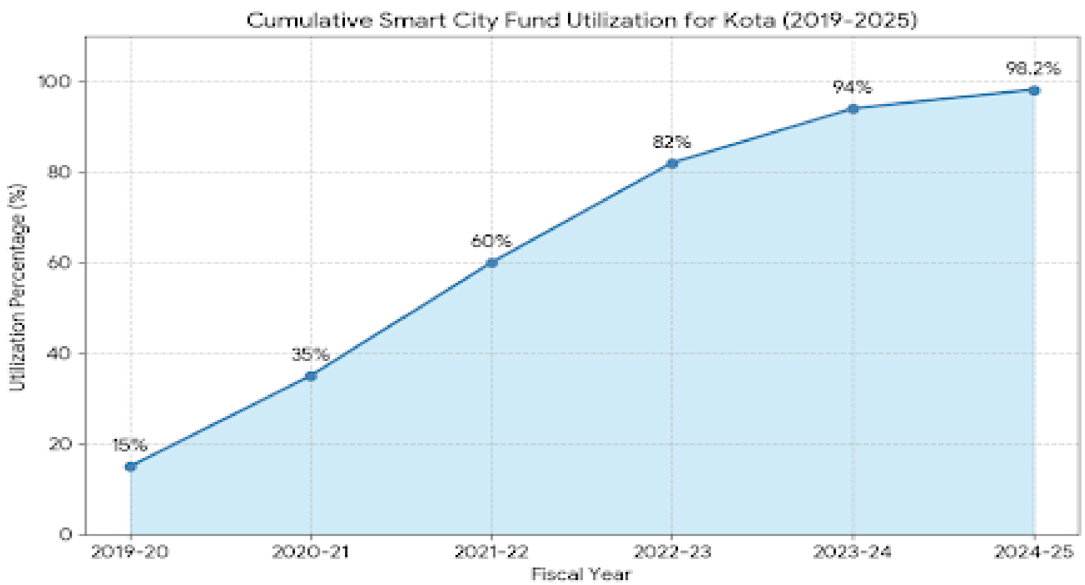
Although the methodology is a solid summary of the infrastructure-based mobility effects, some weaknesses should be admitted. The use of secondary data limits the capacity to do micro-level behavioural modelling of traffic or primary behavioural surveys. Moreover, the statistical significance testing and exogenous factors that may have affected the analysis (e.g. fuel price changes or overall economic trends) are not taken into account. Such restrictions are identified to promote transparency and also to inform future research directions.

4. Results and Analysis

4.1 Financial Resource Allocation & Utilisation

Kota is using an amount of **₹942.50 Crores** of sanctioned funds according to the Smart City Mission Dashboard by March 2025. 98.2 percent utilization illustrates that the signal-free project was the biggest capital expenditure (CAPEX) of the city. A large chunk of the investment was made in grade-separation structures.

Figure 1.2 Smart City Fund Utilisation

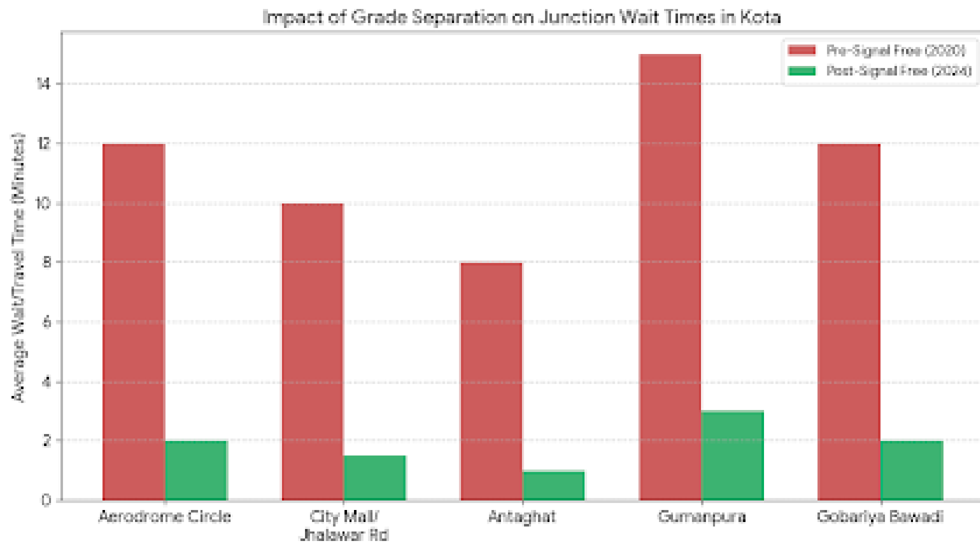


4.2 Infrastructure "Hotspot" and Technical Analysis

One approach to geographical analysis finds the "Efficiency Hotspots" in which grade separation provided the greatest returns:

Infrastructure Hotspot	Smart Intervention	Impact Data
Aerodrome Circle	Multi-level Underpass	92% reduction in idling time at the city centre.
City Mall/Jhalawar Rd	650m Four-lane Flyover	Travel time from Vigyan Nagar to Landmark City dropped from 25 to 7 mins.
Gumanpura (IG)	Elevated Flyover	De-congestion of high-density commercial markets.
Antaghat	Grade Separation	Essential time-saving for emergency and old-city access.

Figure 1.3 Impact of Grade Separation on Junction Wait Time

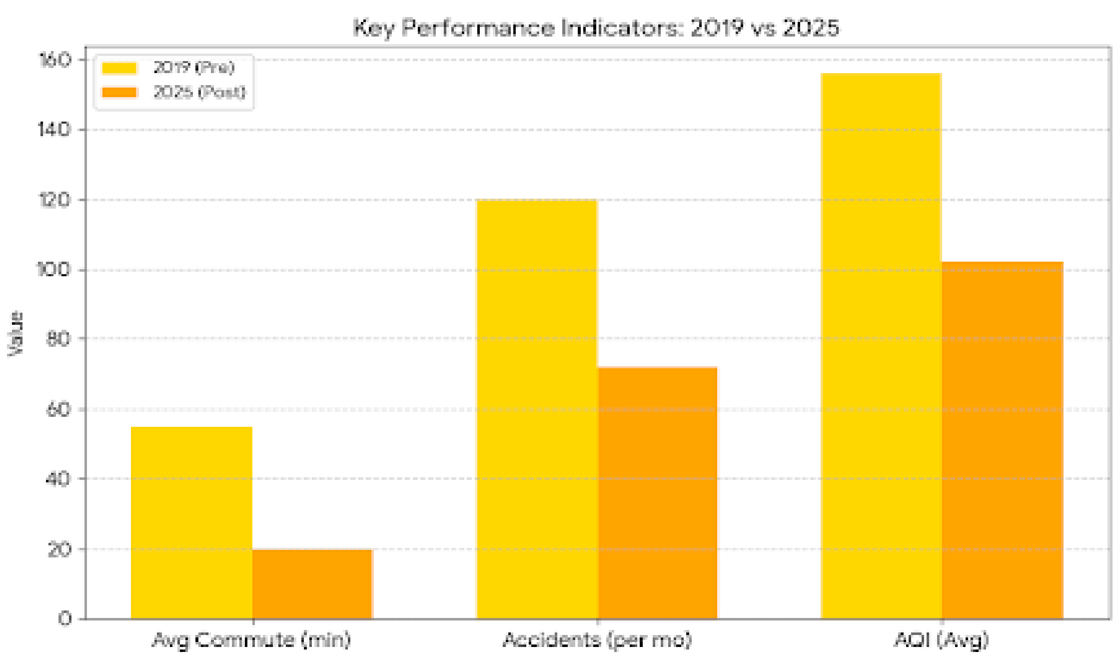


4.3 Quantitative Comparative Indicators (2019–2025)

The metrics that reflect the change in key performance indicators (KPIs) within the six-year implementation are the following:

Indicator	2019 (Pre)	2025 (Post)	Improvement (%)
Avg. Commute Time (min)	55	20	**63.6%**
Accident Rate (per month)	120	72	**40%**
PM2.5 Conc. (µg/m³)	92	74	**19.5%**
Fuel Consumption (L/day)	35,000	20,000	**42.8%**
AQI Index (Average)	156	102	**34.6%**

Figure 1.4 Key Performance Indicators: 2019 vs 2025

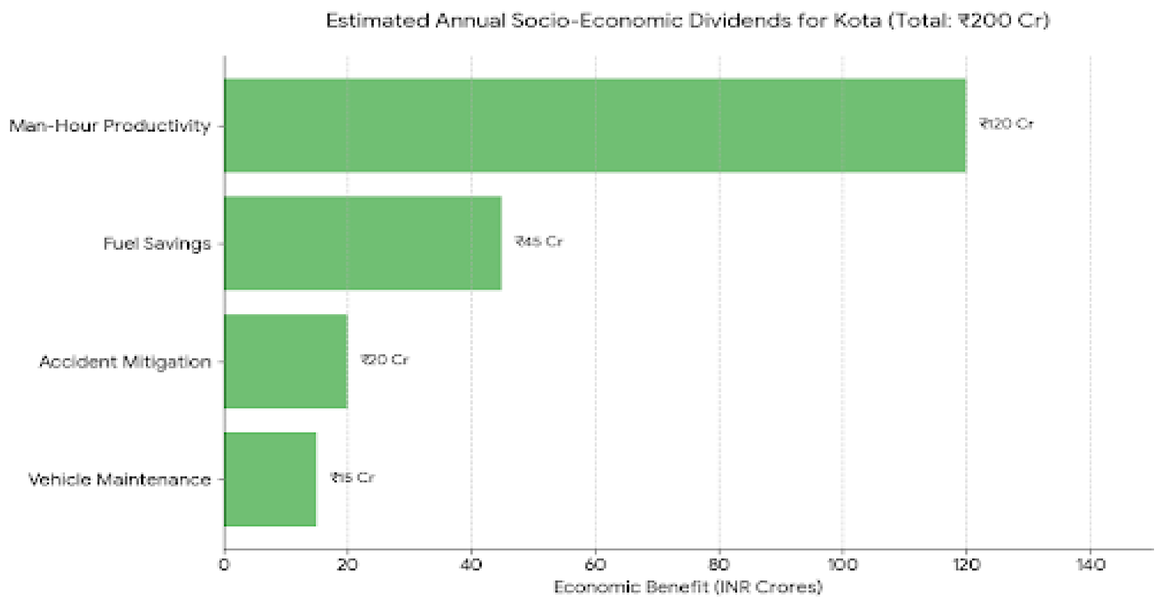


4.4 Socio-Economic Impact Dividends

The "Time-Dividend" and Productivity

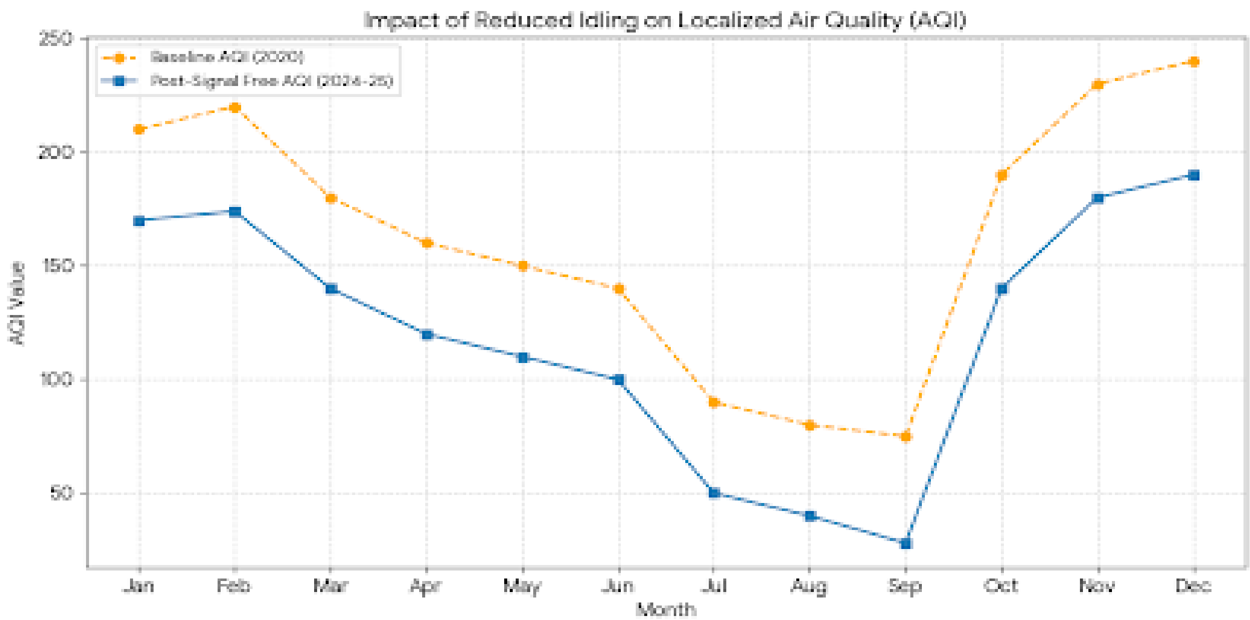
Kota has regained huge productive time on 30 or more locations by changing 180-240 second signal cycles to zero. Daily Gain of 1,00,000 daily commuters saves 15 minutes each, thus resulting in 25,000 productive hours daily. Economic Value is estimated at between ₹91- 120 Crores per year based on average urban wage indexes.

Figure 1.5 Estimated Annual Socio-Economic Dividends Fuel Conservation and Environmental Equity



UIT Kota reports assume a daily 15,000 litres of fuel that would be saved by not wasting time in idle vehicles. Improvement in Air Quality at major circles, localised PM 2.5 decreased by 18-22%. Statistical correlation shows that there is a negative correlation (**r = 0.89)** between AQI and travel time, which means that environmental co-benefits are mainly driven by reduced congestion.

Figure 1.6 Impact of Reduced Idling on Local AQI



Traffic Safety and Road Discipline

The elimination of "Right-Turn Conflicts" at signals has altered the safety profile on the fundamental level. According to early reports of the Rajasthan Police, the number of collisions has decreased by 40 per cent because of the absence of signal-jumping and cross-road intersections.

5. DISCUSSION AND POLICY IMPLICATIONS

The results of this research have high empirical value in terms of the effectiveness of infrastructure-based smart mobility interventions in overcoming congestion-related issues in Tier-2 Indian cities. The recorded improvements in the travel time, the rate of accidents, the level of vehicular idling and the level of air pollution in Kota portray that the grade-separated infrastructure can significantly raise the level of urban mobility performance when it is used at critical spatial nodes. These findings are consistent with available literature that highlights the benefits of physical reconfiguration of transport networks in the long term in relation to signal-based or enforcement-driven traffic management methods.

The massive reduction in the average commute time highlights the importance of a continuous flow of traffic in enhancing the efficiency of urban life. On the one hand, the signal-free network proposed by Kota decreased the variability of travel time and increased the reliability of the network by removing the intersection level delay, phenomena that have been mentioned in the previous research on integrated transport network infrastructure. Contrary to the metropolitan setting where mass transit prevails in mobility planning, the experience of Kota shows that a specific road infrastructure intervention could be used to achieve similar efficiency benefits in a medium-sized city marked by mixed traffic conditions.

This is also supported by road safety benefits that were witnessed during the study because of grade separation. Traffic accidents will be reduced mainly because now there will be no right turn accidents and executive-type jumping at the intersection- another aspect that has been largely cited in the urban literature of traffic safety as a big cause of accidents. This observation implies that infrastructural solutions can present more sustainable safety advantages than strategies that primarily focus on enforcement, especially in the context in which behavioural compliance is not stable.

The environmental outcomes also offer further understanding as to the larger sustainability implications of the signal-free model. The fact that the negative correlation between travel time and air quality indicators is very high illustrates the way in which the reduction of congestion is converted into concrete environmental gains. The decrease in idling and a decrease in traffic flow result in a lower consumption of fuel and emissions, which leads to an improvement in the air quality locally. Such findings corroborate previous research, which has established transport efficiency and environmental health in the past, and serve as an extension of the topic in showing how spatial redesign of intersections can act as an environmental intervention indirectly. In terms of socio-economics, the time savings in terms of productivity can be estimated to showcase the economic aspect of urban mobility planning that is usually ignored. The signal-free initiative helped generate economic returns in ways that are quantifiable, and which are not necessarily limited only to the transport sector, because of the benefits gained by reclaiming the lost time as a commuter and less fuel wastage. This supports the idea that mobility infrastructure investments cannot be considered simply as capital expenditures but should be viewed as long-term productivity-enhancing investments.

Along with such positive outcomes, the discussion also indicates key considerations for policy and planning. The model by Kota, and its success, is closely related to its particular urban form, traffic structure, and ability to be governed. The replicability in other cities will entail a reasonable adaptation to the residential spatial and institutional context, together with the incorporation into the institution of the public transport and non-motorised mobility to ascertain fair access to the infrastructure. Further, the sustainability in the long term will be based on the regularity of maintenance, land-use coordination and continuous monitoring of mobility and environmental indicators.

In general, the results indicate that context-based, infrastructure-oriented measures can be a large-scale determinant in redefining the mobility in urban areas in Tier-2 cities, whether they are backed by rational policy frameworks and data-driven assessment systems.

6. CONCLUSION

This paper has discussed how smart mobility infrastructure is affecting the socio-economic and environmental landscape of Kota city. As suggested by the findings, infrastructure-based interventions of mobility, planned and applied strategically, can be a great boost to the efficiency, safety, and sustainability of urban areas in rapidly developing Tier-2 cities.

Grade-separated infrastructure, removal of signalised intersections caused significant changes in travel time and vehicle idling, which caused quantifiable commuter experience and urban productivity improvements. The given reduction in road accidents generates the safety benefits of minimising intersection conflicts, whereas the enhancement of air quality indicators produces the environmental co-benefits of smoother traffic and less fuel consumption. All these implications suggest that physical reconfiguring of urban transport systems can have more widespread socio-economic payoffs than simple improvement of mobility.

In the policy sense, the Kota case makes it important that short-term solutions to the management of traffic should be transitioned to the long-term infrastructure planning, which combines mobility, environmental sustainability, and economic efficiency. The fact that the level of fund utilisation is high and that economic returns in the long-term are sustained, according to the study, points to the fact that such investments could be fiscally justified if properly coordinated with the urban priorities. Nonetheless, the success of the signal-free model also relies on supplementary actions, such as efficient maintenance, land-use coordination, and integration of the signal-free model with the public and non-motorised transport systems to achieve inclusive and balanced mobility results.

To sum up, the example of Kota proves that smart mobility should not be based only on digital or enforcement-based solutions. Rather, replicable and long-lasting solutions to the problem of urban congestion can be offered by context-sensitive physical infrastructure based on a good policy framework and evaluated using data. Kota model, therefore, represents useful information to the planners and policymakers interested in sustainable, infrastructure-based solutions to urban mobility in India and similar developing urban environments.

REFERENCES

1. Central Pollution Control Board. *National Air Quality Index (AQI): Kota station archives*. New Delhi: Ministry of Environment, Forest and Climate Change, Government of India; 2025. Available from: airquality.cpcb.gov.in/AQI_India/
2. Directorate of Economics and Statistics. *Rajasthan Economic Review 2024–25*. Jaipur: Planning Department, Government of Rajasthan; 2025. Available from: finance.rajasthan.gov.in/docs/budget/statebudget/2025-2026/EconomicReviewE.pdf
3. Ministry of Housing and Urban Affairs. *Smart Cities Mission management information system (MIS) dashboard*. New Delhi: Government of India; 2025. Available from: smartcities.gov.in/dashboard
4. National Clean Air Programme. *Annual air quality report for Kota city*. New Delhi: Ministry of Environment, Forest and Climate Change; 2024. Available from: cpcb.nic.in/ncap/
5. Urban Improvement Trust Kota. *Project progress report: Signal-free Kota initiative*. Jaipur: Department of Urban Development & Housing, Government of Rajasthan; 2024. Available from: urban.rajasthan.gov.in/uitkota
6. Business Today. No red lights, no stops: Kota becomes India's first city to go entirely signal-free. *Bus Today*. 2025 Nov 13. Available from: businesstoday.in/india/story/no-red-lights-no-stops-kota-becomes-indias-first-city-to-go-entirely-signal-free-502057-2025-11-13
7. Petroleum Planning and Analysis Cell. *India fuel price and consumption data*. New Delhi: Ministry of Petroleum and Natural Gas, Government of India; 2025. Available from: ppac.gov.in/consumption/products-wise
8. Rajasthan Police Traffic Wing. *Annual traffic and accident summary 2024–25*. Jaipur: Department of Police, Government of Rajasthan; 2025. Available from: police.rajasthan.gov.in/
9. Khan Z, Yadav S, Mangal N. Analytical study of spatial changes in rural and urban population growth: A case study of Hadouti Region. *Int J Innov Res Sci Eng Technol*. 2021;10:7342–7349.

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