

Geospatial Urban Planning: Analyzing Road Density and Transportation Across Different Cities

Sakilam Saishiva

Introduction

Cities are more than just clusters of buildings, they are dynamic entities with networks of roads, highways, and public transport systems that determine how efficiently people move. Some cities boast well-planned road networks and robust public transport, while others deal with traffic congestion, poor road infrastructure, and limited mobility options. But what sets a well-connected city apart from one that is challenging to navigate?

To answer this question, I analyzed over 500 cities across 25 countries across Asia delving into their road networks, public transport accessibility, and road density. The goal was to uncover how road density and transportation impact urban mobility and connectivity.

Data Collection and Description

This analysis is based on a dataset covering road density and transportation infrastructure across 500+ cities. It includes key metrics such as total road length, city area, road density, number of highways, metro lines, bus stops, and airports. The data provides insights into how different cities develop their transport networks and how road infrastructure interacts with public transit availability..

The city and country data were collected using web scraping techniques with BeautifulSoup, extracting structured information from Wikipedia. This method ensured that the dataset included comprehensive city details

For transportation analysis, OpenStreetMap (OSM) data was utilized through the OSMNx library, which allowed for the extraction of road networks, classifications, and lengths.

transportation features, such as the number of highways, metro lines, bus stops, and airports, were extracted from OSM using spatial queries. This enabled a detailed comparison of how different cities balance road infrastructure with public transport.

To visualize the dataset, road networks and transport features were mapped using GeoPandas, and base maps were added using Contextily. This approach allowed for a geospatial representation of urban infrastructure, helping to classify cities into developed, developing, and undeveloped categories.

Understanding Road Density and Its Impact

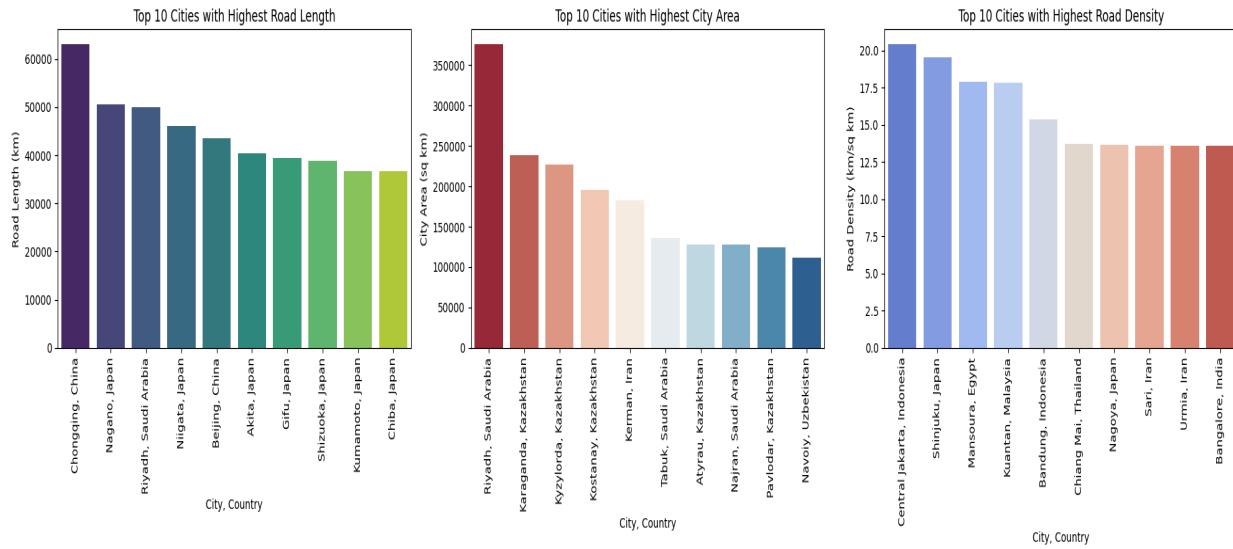
What is Road Density?

Road density is a crucial metric that measures how well -connected a cities road network is. It is calculated as

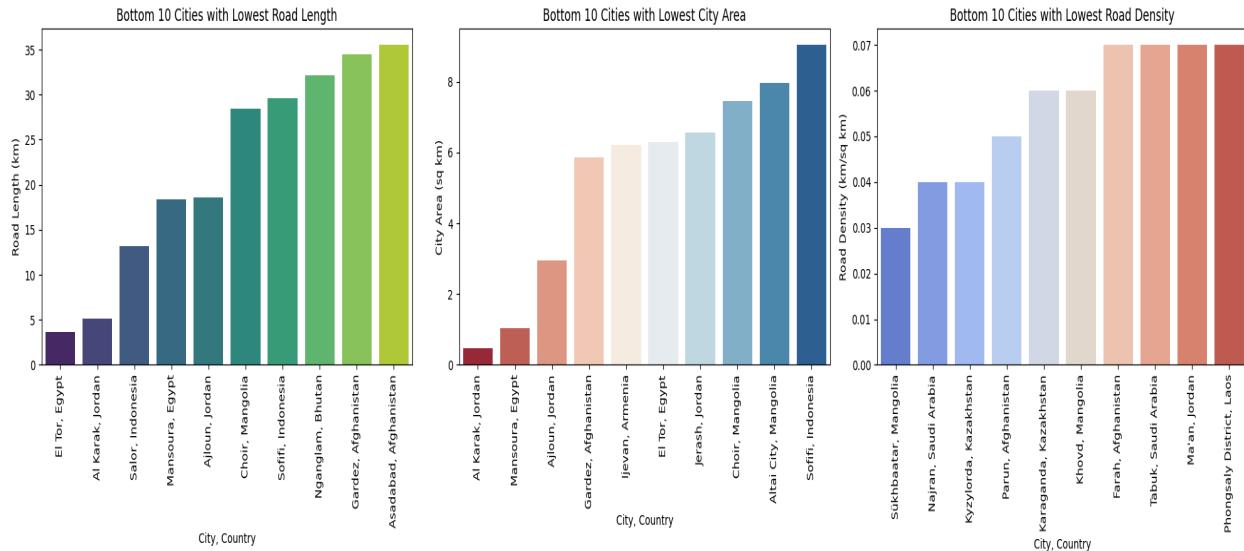
- **Total Road Length** – The sum of all roads in a city (in kilometers).
- **City Area** – The total land covered by the city (in square kilometers).
- **Road Density** = Total Road Length ÷ City Area (km per sq. km).

Road density is a critical metric in urban planning as it reflects the extent of a city's road infrastructure. Cities with high road density generally have well-developed road networks that support efficient mobility. However, an excessive concentration of roads in limited spaces can also lead to congestion. On the other hand, low road density is often seen in underdeveloped cities or regions with vast open spaces, where connectivity is limited and travel times are longer. While a well-connected road network is essential, cities must also integrate other transportation systems, such as public transit and air travel, to ensure balanced urban mobility.

Cities with highest Road Length,City Area,Road Density

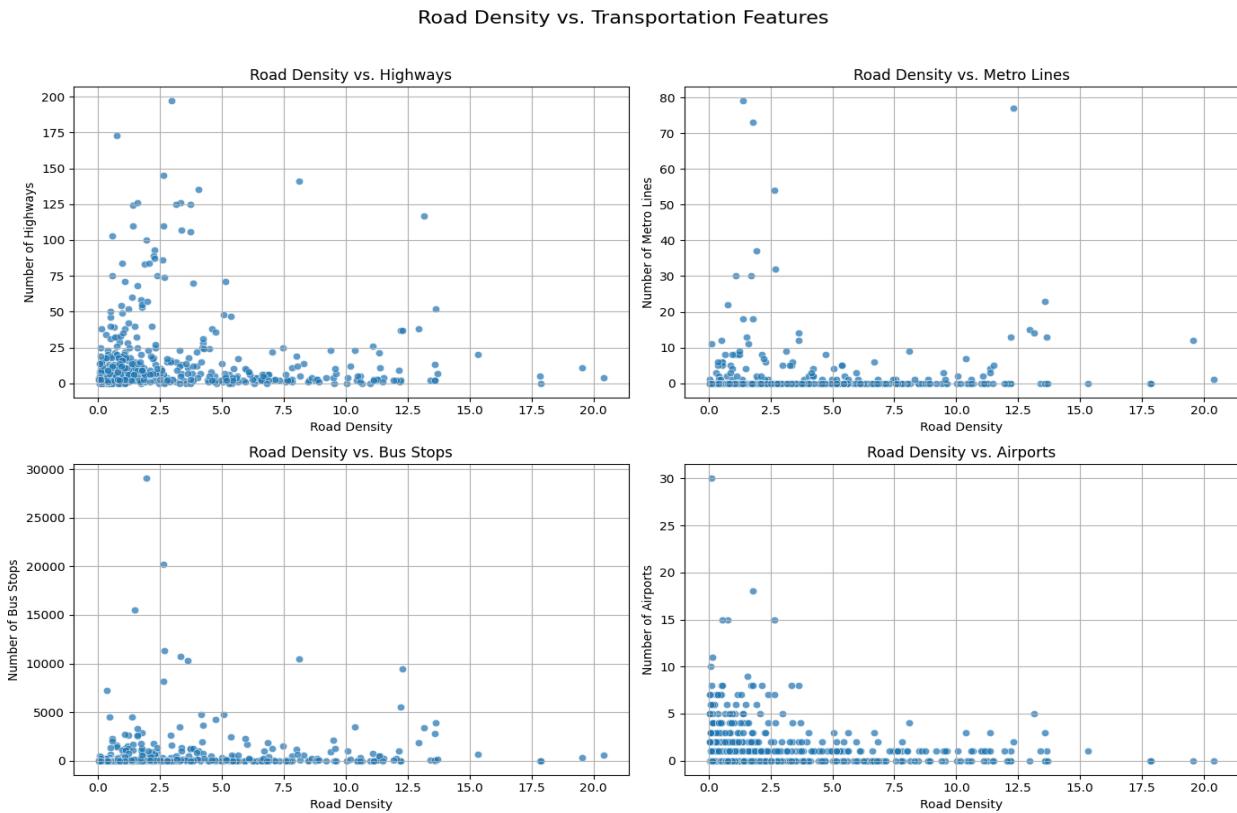


Cities with Lowest Road Length,City Area,Road Density



The Relationship Between Road Density and Transport Features

Understanding the relationship between road density and transportation infrastructure is crucial for urban planning. By analyzing the distribution of highways, metro lines, bus stops, and airports in cities with varying road densities, we can gain valuable insights into how different transport systems evolve based on urban development.



Key Observations:

- Cities with low road density tend to have a higher concentration of highways. This suggests that in sprawling cities with more land area and fewer internal roads, highways play a significant role in connectivity.
- Cities with high road density often have fewer highways, likely due to limited space and a focus on alternative transport modes.
- Metro lines show a clear trend where they are more common in cities with higher road density. This is expected, as densely populated cities require efficient public transportation to reduce congestion.
- Bus stops display a widespread distribution across both high and low-density areas. This suggests that buses serve as a flexible mode of transport, catering to different city structures. However, cities with extremely high bus stop counts often have moderate road density, indicating a well-planned public transit network with extensive road access.
- Airports do not show a strong correlation with road density. Since airports require large land areas and serve both domestic and international travel needs, their locations are influenced more by regional connectivity than by internal city road networks. Airports exist in both dense and sparse cities, emphasizing their role in long-distance transport rather than local commuting.

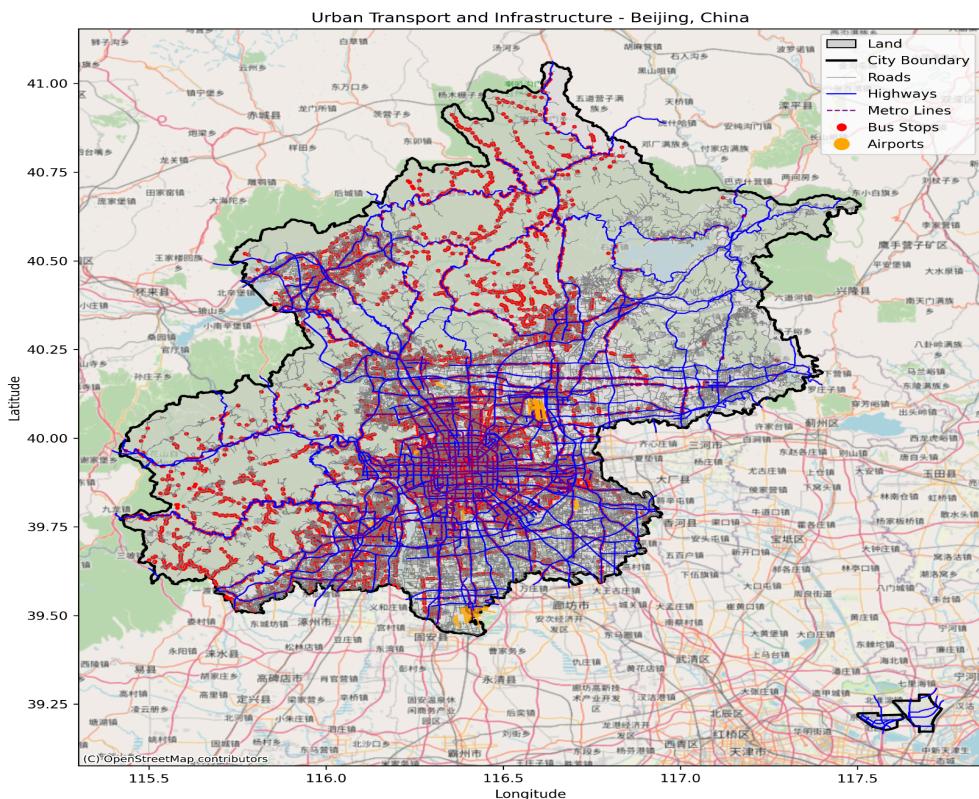
Examples of Key Observations:

- A city with low road density but a high number of highways suggests reliance on major roads for transport rather than an intricate network of smaller streets.
- A densely populated city with a well-developed metro system indicates a shift toward efficient, space-saving public transport.
- A city with moderate road density and an extensive bus network highlights a strong focus on local public transit accessibility.
- The presence of airports in cities with varying road densities confirms that air travel operates independently of urban road infrastructure.

Developed vs. Developing vs. Undeveloped Cities

Cities worldwide vary significantly in transportation efficiency and infrastructure quality. By analyzing road networks, metro systems, and connectivity, we can classify cities into three broad categories: developed, developing, and undeveloped.

Developed Cities

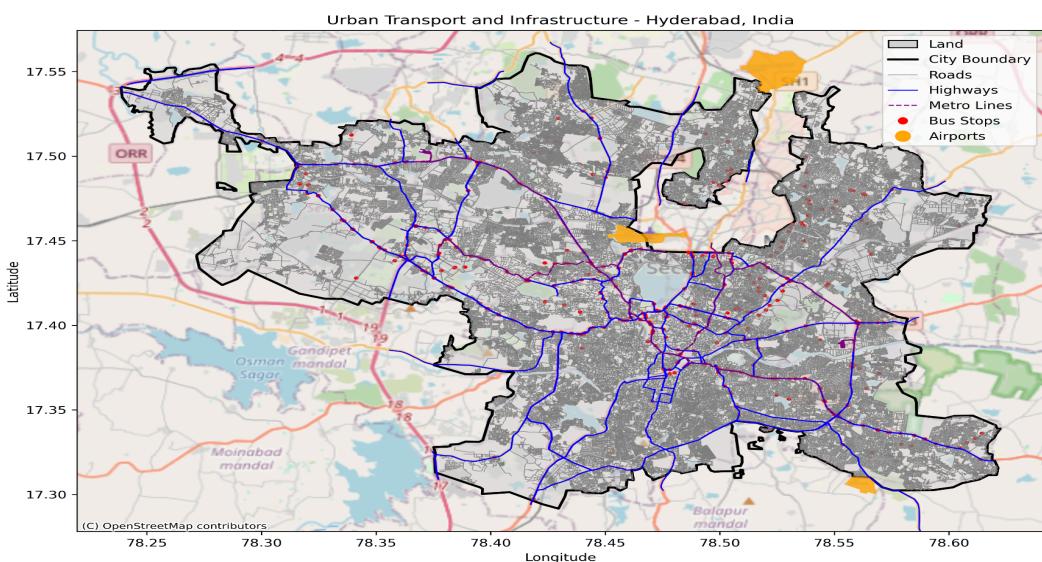


Developed cities are characterized by highly efficient and well-planned transportation networks that ensure smooth mobility and minimal congestion. These cities have high road density, with structured highways that allow for the seamless flow of traffic. Public transport systems, such as metro networks and bus routes, are well-integrated into the city's infrastructure, reducing dependence on private vehicles and improving accessibility for residents. Airports in developed cities are strategically located, enhancing both domestic and international connectivity, further strengthening their role as economic and commercial hubs.

Example: Beijing, China

Beijing is a prime example of a developed city with a sophisticated transport system. The city has a dense and well-maintained road network, allowing for efficient vehicular movement. Its metro system, one of the largest in the world, connects major districts through multiple lines, ensuring quick and reliable transportation for millions of commuters. Additionally, Beijing's airports are strategically positioned to accommodate both regional and global travel demands. The city's transportation system is a result of meticulous urban planning, where roads, highways, metro systems, and airports work together to create a highly efficient and accessible urban environment.

Developing Cities

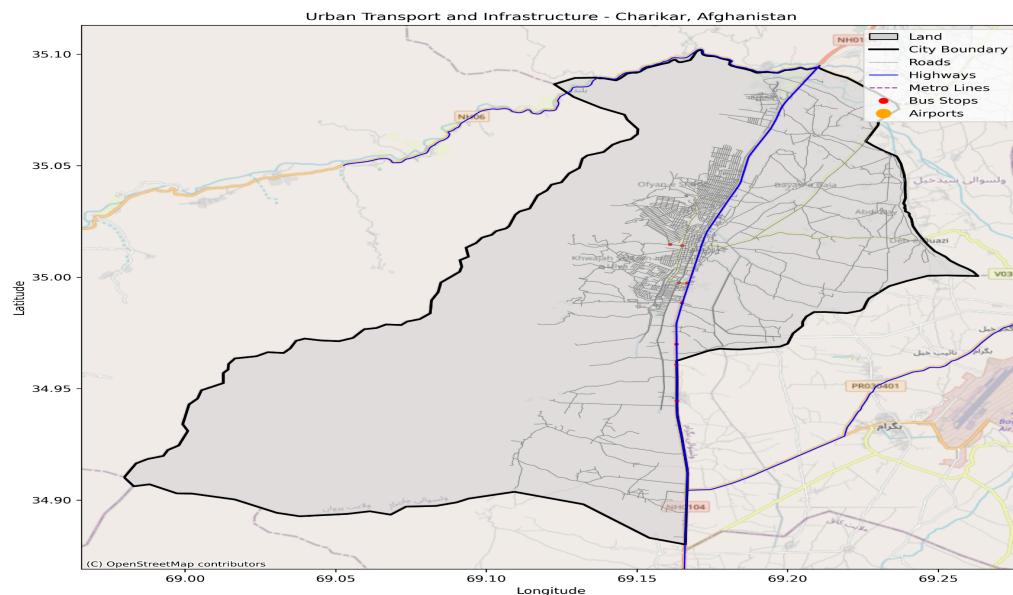


Developing cities are in a phase of rapid expansion, where urban growth is outpacing transportation infrastructure. These cities are actively working on expanding their road networks, improving public transit, and reducing congestion. However, despite ongoing development, they continue to face major challenges such as traffic congestion, incomplete transit systems, and an overreliance on road-based transportation.

Example: Hyderabad, India

Hyderabad is an example of a developing city where metro expansion is underway, and the number of bus stops and transport hubs is increasing. However, the reach of public transit is still limited, and many areas remain highly dependent on road networks, leading to persistent congestion. While infrastructure projects are helping to improve mobility, the lack of integration between different transport modes continues to pose challenges.

Undeveloped Cities



Undeveloped cities, on the other hand, have limited transportation infrastructure and poor connectivity between districts. These cities often lack paved roads, structured public transit, and essential transportation facilities, making travel inefficient and unreliable. The absence of metro systems and organized bus networks forces residents to rely on informal transport methods, leading to longer commute times and restricted access to economic and social opportunities.

Example: Kabul, Afghanistan

Kabul faces significant challenges due to inadequate road networks and the absence of public transport options. Limited infrastructure severely impacts mobility and economic growth, forcing residents to rely on unstructured transit systems. Investment in infrastructure development is critical for improving accessibility and connectivity.

The distinction between developed, developing, and undeveloped cities highlights the importance of strategic urban planning and transportation investments. Developed cities benefit from high road density, integrated metro networks, and well-planned public transport, ensuring smooth and efficient mobility. Developing cities are expanding their infrastructure but still struggle with congestion and incomplete transit systems. Undeveloped cities face fundamental challenges due to a lack of structured transport infrastructure, which hinders economic progress and accessibility.

Understanding these classifications can help urban planners and policymakers prioritize infrastructure improvements to create more efficient and sustainable cities.

Conclusion

A great city is not defined by its skyscrapers or commercial centers but by the efficiency of its transportation network and how easily people can navigate within it. The ability to move seamlessly across a city impacts economic growth, social development, and overall quality of life. Through analyzing road density and transportation infrastructure, valuable insights can be gained into how cities function and what improvements are needed to enhance mobility. A well-planned urban transport system ensures that roads, highways, metro networks, and bus services are integrated to reduce congestion and provide reliable connectivity. The key to building better cities lies in developing well-structured roads, strengthening public transport, and adopting sustainable urban planning strategies. By prioritizing these elements, cities can become more accessible, less congested, and better prepared to support future growth and development.