An analytical insight into the factors affecting road conditions in Bangalore

Abstract

This study examines how the road conditions in Bangalore have been affected from 2000 to 2024. Using multiple primary and secondary sources, the number of vehicles, the number of buildings, the number of construction projects, and weather conditions were analyzed in this study to see their effects on the Bangalore roads. Using frequency analysis and data regression, the key contributors to the road deterioration were found. It was found that the number of vehicles had the strongest relationship with the road deterioration. It was also found that weather conditions were an accelerant of the damage caused by other factors, rather than solely affecting the roads. The study focuses on the need for proper planning by the government and the use of better, more durable materials for the roads.

Introduction

Infrastructure has been and still is considered the central part to ensure a city grows. Various studies, including one done on several major Chinese cities from 2009 to 2019, have confirmed that transportation and infrastructure directly increased urban productivity, which has been seen mainly in ‘mega-cities’ (Zeng et al.). These cities include Beijing, Shanghai, Guangzhou, and Tianjin (P. Groff and Rau). In another study done by GI Hub in 2020, it was found that the amount of public investment in infrastructure increased by 150% within 2-5 years. Especially, in today’s world, in which there is rapid growth of cities, the infrastructure needs to keep up; otherwise, there would be a lot of mishaps in the cities. The most important infrastructure that is needed for cities to grow is roads, as they allow people to transport things and ease for the growth of other infrastructure.

There are different parts of the roads that are targeted in this paper to show what would need to be strengthened to help improve this infrastructure. This includes improving asphalt, the material used to make roads, and street lighting, which would be used to improve the visibility for drivers at night. The target research location would be the most rapidly growing city in the world, and in this current era, it is Bangalore, India. Bangalore has grown 3% every year for the last couple of years. It is because Bangalore is the Silicon Valley of India and is the newest IT hub for both India and the world.

Literature Review

There have been a lot of studies conducted in this area of study, and the 10 studies below present the most important and relevant information for this area of study. There have been several gaps in their research, though.

The study conducted by Chang, Chang, Fang, and Yu (2023) has determined that there is a climate-based asphalt mix that is used in southern Chinese cities. The various kinds of this asphalt mix were made according to the specific region and its meteorological data. This data was collected from 1960 to 2020, which allowed for the making of the proper asphalt mix. The authors of the study found that there were five different climate zones across these cities. Due to this, they also found the specific asphalt binding mixes to be used in these regions. The authors had done this with the help of two different data collection techniques, spatial interpolation and clustering. The SHRP method, otherwise known as the Strategic Highway Research Program method, was used to convert the various air temperatures into their pavement surface equivalents. There were specific performance grades given to the asphalts of each zone based on the temperature and precipitation trends in the paper. However, the paper lacked any consideration for the traffic load and road construction, limiting the full practical scope.

The study conducted by Dizon and Pranggono (2021) is focused on Sheffield, UK. This paper evaluated how energy-efficient smart street lighting is while it uses IoT-based control systems. Dizon and Pranggono used simulated and real data analysis to reveal that there was significant energy savings across multiple lighting schemes. It is particularly seen with the adaptive Talisman model. There were case studies from Doncaster and Edinburgh that further validated the scalability for using the adaptive Talisman model. While results showed about a 50% to about a 180% increase in energy savings, the amount of energy saving really depends on the local traffic data and infrastructure conditions. The main limitation in this study is that there were a lot of generalizations and not area-specific data.

The study conducted by Hamidi and Moazzeni (2022) examines the influence of urban design on walking behavior in Dallas, Texas. They had done field surveys of over 400 various blocks. Then the information from the surveys was used along with regression models to conclude that transparency, like visible storefronts, and picturing had significantly improved pedestrian activity. Surprisingly, traditional metrics for walking like the human scale or complexity had a limited impact statistically. This study provides emphasis on how policies are shifting towards a visual engagement in street designing. However, this study is limited because the data is specific to a specific time period and there could have been a potential subjectivity in the observations.

The study conducted by Liu, Yang, Guan, Chen, Keith, You, and Menendez (2023) had included their proposed framework for integrating physical and virtual infrastructure for connected and autonomous vehicles (CAVs). Using Oxford's road network system, there was a demonstration of what the model, proposed in the study, could do. There were nine key

principles related to the design of the model in the study. These include embedded sensors, standardized markings, and edge computing systems. The model proposed was both balanced and future ready because it allows for infrastructure to be built in accordance to newer goals. However, the study lacked observational data and any sort of cost analysis. On top of that the framework required updates since CAV technologies evolved rapidly.

The study conducted by Marshall(2021) advocated for the redesigning of curbs and lanes to make them more cost efficient for building them. When building curbs there should be curb extensions and in the case of building lanes there should be narrower lanes. The study pushed for these redesigns to reduce the pedestrian death toll. This toll has been a major issue for a while and has been greatly rising as shown in the study. It is shown in the study that there was a sudden, sharp rise of the pedestrian death toll especially between 2009-2016. In addition to this, for proving that technology could not solve traffic related issues and accidents, Marshall had used several national statistics and case examples such as Tempe's Uber crisis. The articles proved to be informative and credible since it used information from trustworthy sources such as IIHS and Vision Zero. However, there was a lack of data modeling and analysis which could lead to the questioning of the paper's academic rigor.

The study conducted by Chandra and Barai (2019) presented a model for urban road planning in which various environmental, traffic, and socio-economic variables had been weighed out to find a balance. In addition to this there was data used from the Chinese city, Shanghai, to show a projection through the model. In this prediction it was shown that there were various sustainable scenarios for the roads in Shanghai up to 2029. For the predictions to occur, moderate investments were needed so Chandra and Barai could pinpoint a balance between the amount of emissions and time taken for traveling. Even though the study had presented a large and complex range of concepts, the writers simplified some topics, such as human travel behavior, while omitting others, such broader lifecycle impacts. However, this is also a limitation as it reduced the study's applicability across various urban settings.

The study conducted by Tafida, Alaloul, Zawawi, Musarat, and Abubakar (2024) compiled recent innovations for building eco-friendly roads globally. The innovations included using recycled materials, the integration of renewable energy, and ITS. The study identified the high potential for having sustainability integrated with the building of roads. However, it flagged key issues such as high costs and weak support from the government and its policies. The authors of the study organized their findings into nine core areas which allowed for the making of a strategic roadmap which presents the potential development of sustainable roads. Some limitations of the study and its solutions included biases towards some countries and the use of obsolete technologies and screening techniques. These limitations affected comprehensiveness and effectiveness of the roadmap and the solutions mentioned in the study.

The study conducted by Shaheen and Bouzekri (2024) defined a well thought of framework for improving the overall walkability. Shaheen and Bouzekri had done this by using improved smart technologies and urban designs in their framework. For research, there was a gathering of information from global case studies, such as Singapore and Barcelona. Due to

this, the study emphasized real-time data to show that smart crosswalks and the 15-minute city concept were important for improving walkability. The review is conceptually strong however it lacked important quantitative data such as those from field surveys and cost metrics. Along with this there was nothing mentioned for any adaptation of the framework in lower-income or high-density cities.

The study conducted by Toh, Sanguesa, Cano, and Martinez (2020) had included data from the survey on ten cutting-edge smart road technologies. These technologies range from solar pavements to weigh-in-motion systems and they were considered as the pillars for future smart cities. With the help of numerous case references from across the US, China, and major European countries, the study showcased how transportation, energy, and ICT can be integrated into modern road networks. The article did cover a large amount of important information however this information is largely qualitative. Additionally, the article lacked deployment and cost data, which in turn weakened its application in the engineering and policy aspects.

The study conducted by Grabar (2024) focused on how the U.S. state-managed highways, expressways, and other major routes, accounted for a major part of pedestrian deaths in urban regions. After looking through various case studies and data related to vehicular accidents, Grabar criticized the priorities of the United States's Department of Transportation as it focused on speed over safety. Due to these issues there was a call for the redesign of the infrastructure of major cities but numerous state bodies had opposed it. The combination of the highway related fatality rates along with the policy failures from state governments added a strong real-world context to the paper. A limitation to this study is that its insights may be limited when outside the U.S.

Objectives

To address some of these gaps there were four main objectives that were created:

1) To investigate the key factors influencing the deterioration of Bangalore's road quality between 2000 and 2024.

2) To analyze how changes in vehicle numbers influence road conditions

3) To investigate building density and construction activity influence road conditions

4) To understand how weather conditions influence road conditions

Methodology

This study focuses on finding the best way in which the roads of Bangalore can be improved. To do this there was an analysis done on the relationships between the number of vehicles that travel on the roads, the quantity of buildings surrounding the roads, the amount of construction projects, and local weather, with the condition of the roads. This topic was selected because road quality is something that affects millions of people every day. The effects of this is especially in fast-growing cities such as Bangalore, which is now considered as the city with the fastest growth. Making sure road qualities in Bangalore meet the required levels while not needing the constant fixing of roads and the saving of time, money, and resources is what this study hopes to achieve. To do this the study covers various designs for better roads as well as an understanding of what's causing the road damage in the first place.

Bangalore is the perfect place to study as well as find jobs in India as the world's biggest tech companies have major offices here (TNN, 2026). This means more and more people, companies, and vehicles are entering the city each year. Due to this it earned the name the "Silicon Valley of India" and became one of the fastest-growing cities in India and the world. However, it also is now becoming one of the most populous cities. "He said more than 500 top global companies were currently op" (TNN, 2026). '"We are preparing for the next 25 years," Shivakumar said. "Today, the world's IT capital of California has 13 lakh engineers but Bengaluru has 25 lakh. This demonstrates Bengaluru's strength. World leaders and industrialists are attracted to the city. We are working on improving infrastructure with a focus on transport"' (TNN, 2026). Due to this the roads in the city are used constantly and get worn out much faster than roads in smaller towns. This is bad since the roads are the pillars of the cities and their growth. The national and state governments tried to rebuild the roads again as they understood this, however the roads have always worn out faster than they could be built. On top of this it just causes traffic, delays, and wastes government resources. So the goal is to build smarter roads that last longer, especially in busy or sensitive parts of the city.

The research done for this study has included various primary and secondary sources. The primary sources included interviews of individuals and surveys of groups. These individuals have either been a part of the government at the city level or have been a major part of the Bangalore community in another way. One interviewee was a respected older gentleman who lived in Bangalore for over 25 years and has worked in many service projects in the area. Another interviewee was a man who worked in the local city-level government, called a Panchayat. The third interviewee was a woman who has been in Bangalore for about 25 years and has worked in many parts of the city and seen it grow. She has also been a large part of the community. There was also a small survey conducted with some more people and these people had similar backgrounds to the interviewees. The secondary sources are various research articles or papers which have done research on similar issues on road conditions. These sources have found possible solutions to these issues. A deep analysis of the data on how each variable affected the road conditions was conducted. After careful interpretations a couple of conclusions were made which included what independent variables had the most impact on the road conditions.

Data Analysis

Table 1: Sources Mentioning Variables

Independent Variable	Number of Sources Mentioning the Variable	Percentage of Total Sources (%)
Number of Vehicles	8	57.1%
Number of Buildings	7	50.0%
Number of Construction Projects	8	57.1%
Weather Conditions	6	42.9%

Source: Compiled by the author using various websites(2000-2026), interviews, and primary surveys (2025) - MDPI (2025), Springer Natural Link (2021), Springer Natural Link (2023), Wired (2018), IJRSI (2024), MDPI (2024), The Royal Society Publishing (2020), Sage Journals (2020), Science Direct (2024), VOX (2024)

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The rapid increase in the number of vehicles on Bangalore's roads has had a direct impact on the roads' conditions. Table 2 shows that heavy vehicles such as trucks and buses contributed significantly to potholes and faster road deterioration. One of the interviewees has noted that many roads have been widened since 2009 but congestion has still worsened. This suggests that road expansion is not a permanent solution for this as it cannot keep up with the number of vehicles that come to the city. Another interviewee has said that the population has boomed exponentially in the past 20-25 years and thus the number of vehicles dramatically increased.

Table 2: Number of Vehicles Analysis

Source Type	Source / Evidence	Effect on Road Conditions
Primary	Panchayat interview	The heavier the vehicles the more surface damage is caused and thus more potholes due to higher axle loads. So, buses and trucks cause faster surface damage and potholes compared to cars and motorcycles.

Primary	Retired community member	Even though the roads widened, congestion and road wear still increased, especially after 2017. This shows that the vehicle growth in Bangalore exceeded the city's road capacity.
Primary	Survey responses	The creation of potholes and uneven road surfaces was considered to be caused by heavy vehicles because of their weight and motorcycles because of the large amount of them.

Source: Compiled by the author using various interviews and primary surveys (2025)

The rise in the number of buildings in Bangalore is one of the biggest factors for the quality of the roads. With more gated communities, apartments, IT parks, and offices being built there is an increase in the population and traffic. In the panchayat interview, it was mentioned that there is inadequate road planning even though there is a large amount of land conversions for building expansion. This led and still leads to narrower, overloaded streets which was seen in places such as East Bangalore which had a 7-8 fold growth in buildings. Another interviewee has also said that there was a growth in the amount of companies, like Texas Instruments, coming to Bangalore which led to the increase in buildings, whether non-residential or residential. This growth in buildings indirectly worsens road conditions by bringing in more people and vehicles into areas making it more concentrated without having the required infrastructure improvement.

Table 3: Number of Buildings Analysis

Source Type	Source / Evidence	Effect on Road Conditions
Primary	Panchayat interview	There was a rapid increase in apartments which were built without the proper proportional road expansion, which led to the local roads being overloaded.

Primary	Retired community member	East Bangalore experienced a huge and sudden development and this caused a tremendous increase in buildings. This led to an exponential growth in sustained pressure on the roads in that area.
Primary	Survey responses	Dense residential areas are considered as something which has caused the chronic congestion and horribly damaged roads in Bangalore.

Source: Compiled by the author using various interviews and primary surveys (2025)

There are various construction projects which have a major effect on Bangalore's roads such as the building of a metro, utility digging, and the road widening. One interviewee specifically said that intersections, like Nagawara and Tin Factory, have metro constructions which led to traffic congestion and road breakdown. In addition to this, in a different interview it was revealed that there is a lot of uncoordinated digging for different utility projects, such as the ones for water, sewage, and cabling, which reduce the lifespan and quality of roads. Secondary research shares similar results.

Table 4: Construction Projects

Source Type	Source / Evidence	Effect on Road Conditions
Primary	Panchayat interview	So that utility and metro projects could be completed, the Bangalore roads were often broken open which led to early road failure.
Primary	Retired community member	Due to the large amounts of construction for metros at major intersections there were lots of road degradation and traffic jams. These intersections include the one at Hebal, Nagawara, and Tin Factory.

Primary	Survey responses	The poor quality of Bangalore roads were caused by either unfinished or repeated construction.

Source: Compiled by the author using various interviews and primary surveys (2025)

Weather plays a major role in the deterioration of Bangalore's roads, especially when it's the rainy season. This can be seen in the surveys and interviews that were conducted. They consistently identified that this time of the year is when the road quality declines the most. It is even explained by the panchayat official in detail that there are various reasons as to why this is. This includes poor drainage and water seepage which allows water to penetrate concrete and bitumen layers.

Table 5: Weather Conditions

Source Type	Source / Evidence	Effect on Road Conditions
Primary	Panchayat interview	Due to the poor drainage systems in Bangalore, during the monsoon season, there are water seepages in roads even through the ones made of concrete and bitumen which leads to the worsening of the roads.
Primary	Retired community member	Due to the water stagnation as well as weakened surfaces, roads consistently worsened during rainy months more significantly compared to other months.
Primary	Survey responses	The rainy season caused the Bangalore roads to have the highest number of potholes as well as the worst traffic was.

Source: Compiled by the author using various interviews and primary surveys (2025)

The increase in vehicles directly results in the increase of more potholes, quicker surface wear, higher accident risk, and congestion of highways. This independent variable has the strongest time-based correlation with the dependent variable. Buildings means more residents, more vehicles, more construction, and narrower roads. This contributes indirectly but powerfully to road deterioration. Construction weakens roads through various manners. Roads are directly weakened by construction because of repeated digging, the temporary surfacing of the roads, and immense pressure because of heavy machinery loads. Roads are inadvertently weakened because of the uncalled for amount of traffic rerouted on the road from the routes which have construction. Weather does not directly cause the roads to become worse but rather adds onto the other variables and speeds up the process of road deterioration. Weather is more of an accelerator while the other independent variables are more of root causes of the issue.

Conclusion and Discussion

As the city of Bangalore grows so do its roads. The roads however were subpar and this was seen in the data collected through various primary and secondary sources. However, there were solutions that were also found due to this issue of roads being subpar for the city standards in various other cities and research being done in those cities. So combining the different data and information the holes in previous research was covered and thus the final combined interpretation was shown. This was done through covering the four main objectives which focused on investigating the road quality in Bangalore and how its affected by weather, the number of vehicles, building density and construction activity. Investigating the road quality had led to the conclusion that the Bangalore roads were of poor quality. After that, there was a thorough analysis on how the number of vehicles affected the road conditions. Through this analysis it was found that there was a strong negative correlation between the number of vehicles and the road quality, as the vehicle number increased the road quality decreased. Secondary data also supports this as seen in two different sources. Chang et al. (2024) emphasizes that the asphalt mixes used must be adjusted for the traffic load on the specific routes and Vox (2022) shows that the large volumes of vehicles, vehicular crashes, and other damages on highways and expressways must be taken into account when building the roads. All of these sources help show that the growth in vehicles on the roads is the biggest cause of road deterioration.

There was an investigation done on how the number of buildings and construction projects affected the road quality and it had similar effects on road quality with the number of vehicles. This means that the number of buildings and construction projects also have a negative correlation with the road quality. Secondary sources, such as Hamidi and Moazzeni (2016), also argue that poor urban designs are linked to the building density. These sources also say that these poor designs also reduce street quality and walkability. Liu et al. (2023) urges that if urban construction is not planned then the road construction will fail especially if there will be autonomous and connected vehicles. Chandra & Barai (2019) also say that poorly

phased projects create hard trade-offs between traffic flow and sustainability. As a result, construction activity, even though it is meant to help infrastructure improve, often contributes to the road conditions worsening.

After a thorough in depth analysis was done on how weather affected the road quality it was found that it was more of an accelerator of the process rather than anything else. The weather, like rain, could only worsen the roads in the long term if there was some damage done to it beforehand. Otherwise the weather would not worsen the roads if there was no previous damage to the roads. The effect of the population growth was mentioned in studies and the study did not include how the amount of people affected the road conditions. This can either create or worsen cracks and potholes in the roads. This is supported by the secondary sources as well. Chang et al. (2024) showed that extreme precipitation and temperature both have a direct effect on the durability of the pavement. Tafida et al. (2024) emphasized the need for using eco-friendly materials in roads so that there is better weather resistance. All these findings show that while human activity like traffic and construction accelerates damage due to stressing it, weather conditions are the natural force which exposes the weaknesses of Bangalore's roads and enhances the issues.

The government and the local panchayats should come together and make a coordinated, well-made plan for making the roads. The national and state government needs to take more responsibilities for the planning. Along with this there could be better coordination with the construction projects so that the traffic and the number of road repairs are reduced. The current plans always lead to the roads having to be rebuilt every month or every other month, which should not be the case. Better, more durable materials, such as modified bitumen, recycled aggregates, and moisture-resistant mixes, should be used for the roads so they would last longer. There should be research done to understand what type of mixture should be used as well as what the plan should be used for specific routes. This can be done through understanding the amount of traffic and the loads that go through each road. The roads should be able to last for at least a couple of years. This is how the Bangalore roads can be fixed so that it supports the growth of the city.

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