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The Relationship Between Road Capacity and Road Level of Service: A Systematic Review of Recent Studies

Abdi Sembada[1], B. Yanuar Yularso Candra[2], Rio R. Ginting[3], Asep Dian Heryadiana[4], Muhammad Isradi[5]
[1,2,3,4] Civil Engineering, Faculty of Engineering, Universitas Majalengka
[5] Faculty of Engineering, Universitas Mercu Buana Jakarta, Indonesia
[1]abdisembadaa@gmail.com, [2]candrayanuar106@gmail.com, riorefelinoginting77@gmail.com[3], asepdian@unma.ac.id[4], isradi@mercubuana.ac.id[5]

Abstract

This study presents a systematic review of recent literature that explores the relationship between road capacity and level of service (LOS), two critical components in transportation engineering and urban planning. As traffic volumes continue to grow in urban environments, understanding how road capacity impacts service quality is essential for improving mobility, reducing congestion, and planning sustainable transportation systems. The review synthesizes findings from multiple peer-reviewed sources, focusing on key methodologies, variables, and evaluation criteria used to assess capacity and LOS in different contexts. In addition to traditional analytical frameworks, this study incorporates a bibliometric analysis using VOSviewer to visualize keyword connections and research trends. The results reveal that evaluation methods, road geometry, and strategic design are dominant themes in literature, while gaps remain in studies integrating real-time data and behavioral factors. This research contributes to the field by mapping current knowledge, identifying emerging research directions, and offering insights for future transportation policy and infrastructure development efforts.

Keywords: *Roads, Road Capacity, Road Service Level, Systematic Literature Review, Road Performance*

1. Introduction

The rapid growth of motorized vehicles in urban areas has increased pressure on existing road infrastructure [1]. Transportation systems are the backbone of urban development, facilitating the movement of people and goods efficiently [2]. Recent advancements in transportation engineering have focused on integrating intelligent systems to enhance traffic flow and safety [3]. For instance, the implementation of adaptive traffic signal control has shown significant improvements in reducing congestion [4]. Moreover, the adoption of vehicle-to-infrastructure communication technologies is paving the way for smarter cities [5]. These innovations are crucial in addressing the growing demands of urban mobility.

Sustainable transportation has become a focal point in recent research, emphasizing the need for eco-friendly and energy-efficient modes of travel [6]. Studies have explored the integration of electric vehicles and the development of supporting infrastructure to promote their usage. Additionally, the concept of multimodal transportation systems is gaining traction, aiming to provide seamless connectivity between different modes of transport [7]. Such systems not only enhance user convenience but also contribute to reducing carbon emissions. Policy frameworks are being developed to support these sustainable initiatives [8].

The resilience of transportation networks against natural disasters and unforeseen events is another area of significant research [9]. Analyss have been conducted to assess the vulnerability of infrastructure and to develop strategies for rapid recovery [10]. Incorporating resilience planning into transportation projects ensures continuity of services during adverse conditions. Moreover, the use of simulation models helps in predicting potential disruptions and in formulating mitigation plans [11]. These proactive measures are essential for maintaining the reliability of transportation systems.

Equity in transportation access remains a critical concern, with research highlighting disparities faced by different population groups [12]. Efforts are being made to design inclusive transportation systems that cater to the needs of all users, including those with disabilities [13]. Community engagement and participatory planning are emphasized to ensure that infrastructure developments reflect the diverse requirements of the population.

Furthermore, data analytics are employed to identify underserved areas and to prioritize investments accordingly [14]. Addressing these equity issues is vital for fostering social inclusion and mobility justice [15].

The integration of emerging technologies such as autonomous vehicles and artificial intelligence is revolutionizing the transportation landscape. Pilot projects have demonstrated the potential of self-driving cars in improving safety and efficiency [16]. Artificial intelligence algorithms are being utilized for predictive maintenance and real-time traffic management [17]. These technological advancements necessitate the development of new regulatory frameworks and ethical guidelines [18]. Continuous research and collaboration among stakeholders are essential to navigate the challenges and opportunities presented by these innovations [19].

Urban traffic congestion remains a pressing issue in many cities worldwide, leading to increased travel times and environmental concerns [20]. Recent studies have focused on intelligent planning to mitigate congestion through advanced technologies and data analysis. For instance, [21] proposed intelligent planning methods to address urban traffic congestion, emphasizing the role of data-driven approaches in traffic management. Similarly, [22] developed an agent-based framework for urban traffic congestion management, highlighting the effectiveness of multi-agent systems in real-time traffic control. These innovative approaches aim to enhance traffic flow and reduce congestion in urban areas.

The integration of Internet of Things (IoT) and Artificial Intelligence (AI) technologies has shown promise in optimizing traffic management systems. [23] discussed the development of a smart traffic management system utilizing IoT and AI to reduce urban congestion in major Indonesian cities. Their findings indicate significant improvements in traffic flow and reduced travel times during peak hours. Additionally, [24] introduced an AIoT-based smart traffic management system that processes live video feeds to adapt traffic signals dynamically, resulting in a 34% improvement in traffic flow efficiency. These advancements demonstrate the potential of technology-driven solutions in addressing traffic challenges [25].

Policy interventions, such as congestion pricing, have been implemented to manage traffic demand and reduce congestion. In New York City, the introduction of a $9 congestion fee led to an 8% reduction in vehicles entering the congestion zone, improving travel times and reducing emissions [26]. However, such measures have also faced criticism and legal challenges, highlighting the need for equitable and sustainable solutions. Examined the equity issues associated with congestion pricing and emphasized the importance of establishing sustainable funding for transportation infrastructures [27]. These studies underscore the complexity of implementing traffic management policies that balance efficiency and equity.

Simulation models have been employed to assess the impact of various traffic management strategies. [28] utilized system dynamics simulation to evaluate the effects of Bus Rapid Transit (BRT) and tram projects on commuting time efficiency in Surabaya, Indonesia. Their results indicated that combining BRT and tram implementations with highway expansion could reduce traffic congestion by up to 44%. Similarly, [29] proposed enhancing road networks to mitigate the impact of freight trips on traffic flow, demonstrating improvements in travel time and level of service. These findings highlight the importance of comprehensive planning in traffic management. Public satisfaction will also increase if mass transportation has good quality at affordable rates [30].

Monitoring and management techniques for road traffic congestion have evolved with advancements in vehicular networks. A survey by [31] reviewed various techniques implemented in traffic monitoring and management systems, including data gathering, transmission, analysis, and dissemination. The study emphasized the role of Intelligent Transportation Systems (ITS) in enhancing traffic management capabilities. [32] provided a comprehensive review of ITS applications in alleviating traffic congestion, highlighting their effectiveness in improving traffic flow and reducing accidents. These developments signify the growing reliance on technology to address traffic-related issues [33].

Accurate measurement of traffic volume is fundamental for effective transportation planning and infrastructure development [34]. Traditional methods, such as manual counts and embedded sensors, often face limitations in scalability and cost. Recent advancements have introduced innovative approaches, including the use of Closed-Circuit Television (CCTV) cameras combined with image recognition technology, offering practical performance in various situations [35]. Additionally, vehicle probe data has emerged as a valuable resource for estimating Annual Average Daily Traffic (AADT) across networks, enhancing conventional traffic monitoring practices [36]. These technologies provide more comprehensive and real-time data, crucial for modern traffic management.

The built environment significantly influences traffic volume and congestion levels [37]. A study analyzing the impact of built environment characteristics on traffic congestion in Hefei, China, proposed regulatory optimization strategies to alleviate congestion [38]. Factors such as land use, road network density, and accessibility play pivotal roles in traffic volume dynamics. Understanding these relationships aids in developing targeted interventions to

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manage traffic flow effectively [39]. Urban planners and policymakers must consider these elements to design sustainable transportation systems [40].

Construction activities and roadworks can cause significant fluctuations in traffic volumes. Research [41] observed changes in traffic volumes within construction work zones, highlighting the need for effective traffic management strategies during such periods. Detours and lane closures often lead to increased congestion on alternative routes [42]. Implementing dynamic traffic control measures and providing real-time information to motorists can mitigate these impacts. Proactive planning is essential to minimize disruptions and maintain traffic flow during infrastructure projects [43].

Traffic volume studies are also instrumental in assessing safety at intersections and junctions [44]. An analysis at Vhanga Junction revealed that high traffic volumes, particularly of auto-rickshaws, contributed to safety concerns [45]. Identifying peak traffic periods and vehicle types prevalent in specific areas enables the implementation of targeted safety measures [46]. Enhancements such as improved signage, traffic calming devices, and dedicated lanes can reduce accident risks. Continuous monitoring and evaluation ensure the effectiveness of these interventions [47].

Estimating traffic volume is crucial for geometric road design and capacity planning [48]. A review emphasized the importance of systematic traffic surveys in obtaining accurate traffic volume data, essential for designing new transportation facilities and improving existing ones [49]. In developing countries with heterogeneous traffic flow, understanding traffic volume patterns is vital for addressing congestion and transportation challenges [50]. Incorporating traffic volume data into the design process ensures that road infrastructure meets current and future demands. This approach leads to more efficient and safer transportation networks [51]. With the planning of road shapes and road geometry in accordance with applicable criteria and regulations and the use of careful calculation methods, road infrastructure will greatly support smooth traffic [52].

Road capacity refers to the maximum number of vehicles a roadway can accommodate under given conditions, such as geometry and traffic composition. Accurate estimation of capacity is essential for effective road design and performance evaluation [38]. Studies have shown that traffic heterogeneity, including varied vehicle types and driving behavior, significantly affects capacity [53]. This makes it especially relevant in developing countries where non-uniform traffic flow is common [54]. Recent models aim to incorporate these heterogeneous factors to yield more realistic capacity estimates [55].

Environmental and geometric variables also play a critical role in determining road capacity [56]. Road gradient, curvature, and lane width can either enhance or reduce effective capacity [57]. In hilly or urban terrains, these factors must be integrated into simulation models to avoid overestimation [58]. Moreover, weather conditions such as rain or fog can lower road capacity by up to 20%, demanding the integration of adaptive capacity models [59]. Ignoring such variables could lead to misleading infrastructure planning and congestion issues [60].

Intelligent Transportation Systems (ITS) have introduced dynamic methods for capacity enhancement. Adaptive signal control, ramp metering, and lane usage algorithms have shown success in increasing effective capacity in urban environments [61]. These systems can respond in real time to traffic demand changes, improving flow and safety [62]. Advanced driver assistance systems (ADAS) and connected vehicle technologies also contribute to optimizing capacity by reducing human error and improving headway management [63]. Implementing such systems requires integration with traffic data platforms for continuous improvement [64].

Capacity analysis is also essential for assessing the impacts of proposed infrastructure projects. Before initiating large-scale developments, simulations are conducted to evaluate whether the existing or modified roads can handle future demand [65]. Tools like VISSIM or AIMSUN allow modeling of different traffic scenarios to understand capacity under peak conditions [66]. This is particularly important in corridors expected to serve industrial zones or transport hubs [67]. Such predictive analyses reduce risks related to congestion and underperformance [68].

Capacity plays a major role in determining Level of Service (LoS) [69], which is often used as a key performance indicator. As per the Highway Capacity Manual, exceeding a road's capacity leads to unstable flow and low LoS grades [70]. Policymakers and engineers use these insights to prioritize road expansions or public transport enhancements [71]. In developing nations, investments guided by accurate capacity analyses can substantially improve mobility and economic growth [72]. Sustainable development must balance road expansion with alternative mobility solutions to avoid inducing excess demand [73].

A saturation degree is a critical metric used to assess the performance of a road network and its level of congestion [74]. It represents the ratio of traffic volume to road capacity, indicating whether a road is operating within its design parameters or is overburdened [75]. A saturation degree above 1.0 indicates congestion and instability in traffic flow, while values approaching 1.0 suggest a road nearing its maximum capacity [76]. Studies have shown that in urban areas, saturation degree often exceeds the ideal threshold due to rapid urbanization and increasing vehicle ownership [77]. Therefore, understanding saturation levels is crucial for making informed decisions about road capacity upgrades and alternative transportation solutions [78].

A key factor in determining the saturation degree is the variation in traffic flow during peak hours. During these times, the demand for road space increases dramatically, pushing the saturation degree beyond optimal levels [79]. According to a study by [80], traffic patterns during peak hours exhibit significant fluctuations due to factors such as school and work schedules, resulting in sudden increases in vehicle numbers. The fluctuation of saturation degree in these scenarios can severely affect road safety, as drivers are more likely to experience delays and frustration [81]. Thus, accurate peak-hour modeling is essential to improve road infrastructure planning and public transport integration [82].

Several factors, including traffic management systems and road design, impact the saturation degree. Well-designed roads with efficient intersections and traffic signals can help reduce saturation by improving the flow of vehicles [83]. On the other hand, poorly managed intersections and ineffective traffic management systems can increase the saturation degree, resulting in bottlenecks and frequent congestion [84]. Technologies such as real-time traffic monitoring and adaptive signal control systems can alleviate congestion and lower the saturation degree by optimizing vehicle flow [85]. Integrating such systems into existing road networks has proven effective in cities experiencing rapid growth [73].

Saturation degree is also linked to environmental and economic costs [86]. High saturation levels are often associated with increased fuel consumption, longer travel times, and higher emissions, contributing to both environmental degradation and reduced economic productivity [49]. A study conducted by [87], found that cities with high saturation degrees face significant delays in freight and passenger transportation, leading to greater operational costs for businesses and higher commuter expenses. Addressing these issues requires strategic interventions, such as expanding public transportation networks and creating more pedestrian-friendly areas [88]. As saturation degree reflects the overall efficiency of a transportation network, it serves as a guiding parameter for sustainable urban planning [89].

Monitoring and managing saturation degree is integral to maintaining the operational performance of road networks [90]. Ongoing assessments allow for the identification of congestion hotspots and the implementation of necessary interventions to reduce saturation levels [91]. In addition to physical infrastructure changes, policymakers must consider technological advancements and behavioral changes, such as promoting alternative transport modes to reduce car dependency [92]. Accurate real-time data, including traffic volume and vehicle speed, is essential for assessing the saturation degree dynamically and making timely adjustments [93]. Ultimately, controlling saturation degree through a combination of infrastructure improvements and strategic planning is key to optimizing road performance and enhancing mobility [38]. Understanding the relationship between road capacity and Level of Service (LoS) is therefore essential. LoS is a key indicator used to evaluate road performance based on speed, density, and user comfort [94]. A systematic investigation of previous studies is necessary to gain a comprehensive understanding of this issue [95].

Numerous studies have examined the factors affecting road capacity, including road geometry, roadside friction, and traffic patterns. However, the findings of these studies often vary due to geographical contexts and different analytical approaches [4] . Some research suggests that increasing road capacity directly improves LoS, while others indicate the effect is temporary due to induced demand. Thus, a comprehensive approach is needed to synthesize these diverse findings. A Systematic Literature Review (SLR) is an appropriate method for this purpose [6].

The SLR method offers advantages in terms of objectivity, transparency, and reproducibility [96]. Through this approach, researchers can filter and analyze previous studies using clearly defined inclusion and exclusion criteria. By utilizing scientific databases such as Google Scholar, Scopus, Web of Science, and ScienceDirect. The SLR enables the identification of current research trends related to road capacity and LoS. It also includes quality assessment of each selected study to ensure reliable synthesis. This is crucial to produce trustworthy and evidence-based conclusions [7].

This research aims to provide a comprehensive overview of the relationship between road capacity and Level of Service based on studies published within the last five years. The main focus is to identify key variables influencing this relationship and commonly used analytical methods. In addition, this study evaluates knowledge gaps and potential directions for future research. By conducting a systematic review, a deeper understanding of how capacity improvements impact LoS can be achieved. The findings are expected to benefit transportation planners and policymakers.

Through the SLR approach, this study contributes not only to the advancement of transportation knowledge but also to evidence-based decision making. SLR allows for the identification of inconsistencies among studies and highlights contextual factors affecting outcomes. By comparing various analytical methods and empirical data, this study aims to deliver more comprehensive conclusions. The results are expected to support more efficient and sustainable road planning practices. Therefore, the systematic review is a vital tool in addressing the complexity of the road capacity–LoS relationship [24].

2. Research Methods

2.1. Research Approach

This study adopts a systematic review and bibliometric analysis approach to investigate the relationship between road capacity and the level of service (LOS). This dual-method approach was selected to provide both depth and breadth in analyzing scholarly publications on road infrastructure performance. A systematic review enables a structured, comprehensive, and replicable evaluation of prior research by identifying, appraising, and synthesizing relevant studies [97]. In contrast, bibliometric analysis allows the mapping of research trends, thematic clusters, and the evolution of knowledge using quantitative techniques [98]. Together, these methods facilitate the identification of key concepts, emerging areas of interest, and potential gaps in literature. This approach ensures a scientifically rigorous foundation for exploring the correlation between road capacity and traffic service quality.

The bibliometric analysis component specifically supports the examination of the academic landscape surrounding road capacity and LOS by highlighting citation patterns, co-authorship networks, and keyword occurrences [99]. It also reveals which countries and institutions are contributing most to this field, helping to contextualize research outputs on a global scale. The combination of systematic review and bibliometric mapping is particularly relevant for traffic engineering, as it integrates performance data with publication trends [100]. This methodology not only evaluates the operational and safety dimensions of traffic systems but also uncovers the societal and environmental impacts embedded in roundabout and intersection designs [101]. Such a holistic view is essential for recommending data-driven, context-specific improvements in road infrastructure planning. Ultimately, this methodological framework provides robust analytical insights aligned with current research standards in transportation studies.

2.2. Data Sources and Collection

The primary data for this study were retrieved from Google Scholar, chosen for its broad coverage and inclusive indexing of academic publications across disciplines. The selected time frame spans from 2000 to 2024, ensuring that the review reflects the most up-to-date developments in the field. Unlike other scientific databases such as Scopus or Web of Science, Google Scholar indexes not only journal articles but also conference proceedings, theses, technical reports, and regional publications [102]. This inclusivity is particularly important in transport-related research, where local case studies and non-English resources often offer critical practical insights. Moreover, Google Scholar's accessibility and user-friendly interface allow researchers at various academic levels to effectively conduct literature searches [103]. Its features such as citation counts, related articles, and author profiles enhance the process of identifying high-impact and thematically relevant studies.

To facilitate structured and efficient data collection, the Publish or Perish (PoP) software was employed to extract bibliometric metadata from Google Scholar. PoP supports advanced filtering and allows exporting results in formats compatible with analysis tools like VOSviewer. The software retrieved article metadata such as titles, abstracts, citation metrics, journal sources, and publication years. These records were then consolidated and stored in RIS format, a standard bibliographic format for reference management. By using this combination of PoP and Google Scholar, the research team ensured that the dataset was comprehensive, recent, and relevant to the study's objectives. The use of these tools enabled the retrieval of 1,000 scholarly documents related to road capacity, roundabouts, and level of service, laying the groundwork for a thorough bibliometric and thematic analysis [104].

2.3. Literature Search Strategy

The effectiveness of this research largely depended on a precise and focused search strategy. A set of predefined keywords was developed based on prior systematic reviews and bibliometric studies in the transportation field. These keywords included "Road Capacity", "Level of Service", "Roundabout", "Effectiveness", "Intersection Performance", and "Traffic Flow Efficiency". Search was conducted in titles, abstracts, and keyword fields to maximize relevance and ensure thematic alignment. To refine the dataset, search filters were applied to restrict publication years between 2000 and 2024 and to include only documents published in English. By applying these filters, the initial result of 4,896 documents was significantly reduced through manual screening and keyword occurrence thresholds.

Each keyword category was assigned an equal quota to ensure balanced representation across themes, resulting in approximately 200 articles per group. After an initial review, documents that lacked relevance to either road capacity or LOS performance were excluded. The inclusion process emphasized empirical and theoretical contributions that addressed roundabout design, unsignalized intersections, traffic volume, and operational metrics. Additionally, duplicates and poorly referenced sources were discarded to enhance the quality and reliability of the dataset. This structured and transparent methodology allowed for replicability and consistency throughout the data gathering process. Ultimately, the search strategy ensured that only high-quality and contextually appropriate literature was included in the final analysis.

2.4. Inclusion and Exclusion Criteria

To ensure the quality and relevance of literature, the study employed clear inclusion and exclusion criteria. Inclusion criteria were as follows: (1) the document must be published between 2000 and 2024; (2) it must be written in English; and (3) it must discuss topics directly related to road capacity, roundabout performance, intersection design, or level of service. Preference was given to peer-reviewed journal articles, but conference papers and technical reports with strong methodological grounding were also considered. Articles focusing on simulation models, case studies of roundabout performance, or evaluations of road design effectiveness were included. Each selected paper underwent a secondary screening based on abstract relevance and keyword matching. This step was crucial to ensure thematic consistency and methodological rigor across the final corpus [105].

Exclusion criteria were equally rigorous. Articles were excluded if they lacked a direct focus on performance metrics such as LOS or capacity, if they were not accessible in full text, or if they were not academically oriented (e.g., opinion pieces or general news reports). Additionally, documents that failed to meet a minimum threshold of keyword occurrence—established at eight instances—were filtered out during the bibliometric processing phase(Hartanto et al., 2022. This filtration helped narrow the dataset from 4,896 documents to a final selection of 120 high-quality, relevant articles. This four-step process (selection, filtering, qualification, and summary) was visualized in a flowchart to ensure methodological transparency. The resulting dataset provided a strong foundation for in-depth analysis and accurate mapping of research trends.

2.5. Data Processing dan Analysis

Once the relevant documents were identified, the data were processed using VOSviewer, a widely recognized tool for bibliometric mapping. VOSviewer was used to analyze co-authorship patterns, keyword co-occurrence networks, and citation links among the selected publications. This software allows for the creation of visual maps that display the strength and frequency of relationships among key terms. In this study, keywords such as "Roundabout," "Capacity," and "Level of Service" emerged as the most central nodes in the network. The size of each node indicated its frequency, while the thickness of the connecting lines represented the strength of co-occurrence with other terms. These visualizations helped identify clusters of research topics and emerging subfields in traffic systems and infrastructure performance.

The RIS-format metadata obtained from PoP was imported into VOSviewer to generate visual networks and density maps. These outputs were further interpreted to identify dominant research trends, regional contributions, and thematic concentrations. For instance, clusters focused on “traffic safety,” “design optimization,” and “environmental performance” suggested that the literature increasingly emphasizes multidimensional impacts of road infrastructure. This bibliometric analysis was supplemented by a qualitative review of selected high-impact papers to ensure that the findings were not only statistically robust but also contextually meaningful. As a result, the analysis captured both quantitative patterns and qualitative insights, offering a nuanced understanding of how road capacity influences LOS across various intersection types and geographical settings.

3. Results and Discussions

3.1. Visualization of Research Keyword Connections

The visualisation of research keyword connections provides a comprehensive overview of how key concepts are related across various studies. Using VOSviewer, this analysis maps out the most frequent terms appearing in publications focused on road capacity and level of service (LOS). The keyword “evaluation” emerged as the most central and dominant term, indicating a strong focus on assessment and performance analysis within the literature.

Other frequently linked terms include “road geometry”, “path”, “route”, and “strategy”, reflecting the multidimensional nature of research in this area. This mapping process helps researchers identify thematic trends and uncover potential research gaps.

The generated visualisations are presented in both density and network formats, each offering unique insights into the structure of the research field. The density visualization highlights areas with high keyword frequency, while the network visualization groups keywords into clusters based on their co-occurrence relationships. These clusters illustrate thematic groupings, such as evaluation methods, geometric design, and strategic road planning. Through these tools, researchers can better understand how the concepts of road capacity and LOS are discussed and analyzed across different studies. Ultimately, this visual analysis supports the development of more focused and evidence-based transportation research.

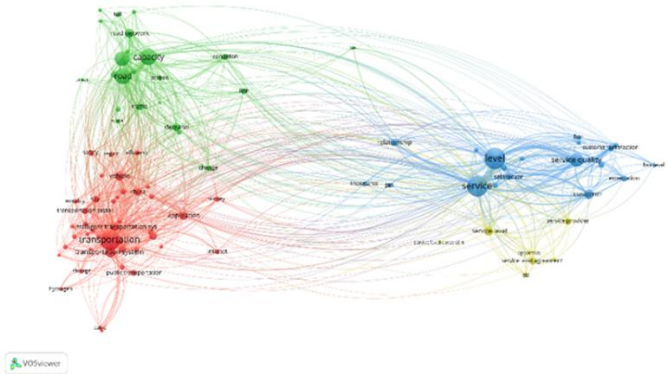

Figure 1. Keyword Density Visualization

Figure 1. shows a density visualization of keyword occurrences. Brighter areas in the image (represented in yellow and green tones) indicate higher keyword frequency and importance. The term “evaluation” appears as the most dominant node, surrounded by related keywords such as “effect”, “image”, and “comparison”. Additionally, terms like “path”, “road geometry”, and “strategy” form secondary clusters, revealing different but connected subtopics in the field. This heatmap-style visual aids quickly identifying research hotspots and core themes within the topic of road capacity and LOS.

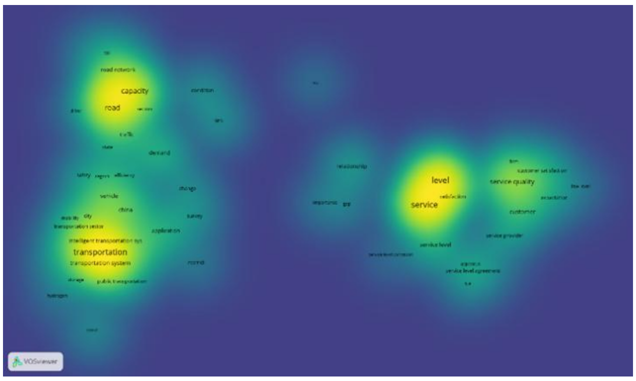

Figure 2. Keyword Density and Clustering Visualization

Figure 2 presents a network visualization with color-coded clusters representing related keyword groupings. The red cluster, dominated by “evaluation”, includes related terms such as “performance evaluation”, “quantitative evaluation”, and “geometric parameter”, highlighting the technical assessment dimension of the studies. The blue and green clusters contain terms like “path”, “route”, “review”, and “road”, which indicate the conceptual and strategic aspects of road design. Lines between nodes show co-occurrence relationships, emphasizing how often terms appear together in literature. This network helps visualize the structure of knowledge in the field and guides researchers in identifying integrated research areas and key conceptual intersections.

3.2. Annual Publication Trend

Over the past two decades, research on road capacity and Level of Service (LOS) has experienced significant growth. From a modest number of publications in the early 2000s, there has been a noticeable surge in scholarly interest since 2010. This growth correlates with rising urban traffic congestion, technological advancements in traffic modeling, and increased attention to sustainable transportation systems. The highest publication output occurred in 2022, with 88 studies addressing various aspects of road capacity, traffic flow efficiency, and intersection performance. These trends reflect a broader shift in transportation engineering toward data-driven and sustainable design solutions, especially in urban contexts. Moreover, the increase in global research participation indicates a growing awareness of the critical role LOS plays in shaping urban mobility and planning policies.

The chronological distribution of research also highlights changing thematic focuses within the field. Earlier publications were mostly centered on geometric design and traditional traffic control measures. However, more recent studies have incorporated a wider array of performance indicators, such as environmental impact, fuel consumption, pedestrian safety, and user satisfaction. These multidimensional approaches provide a more holistic understanding of how road capacity improvements influence traffic system performance. Furthermore, scholars have increasingly embraced simulation-based methodologies using tools like VISSIM and SIDRA to test various design scenarios. This indicates a methodological evolution aligned with the growing complexity of transportation systems and the demand for precision in urban planning decisions.

In addition to volume, the geographic scope of the studies has broadened over time. Initially dominated by research from the United States and Western Europe, newer contributions have emerged from countries like India, Indonesia, and Turkey. These nations face rapid urbanization and are increasingly affected by traffic congestion and intersection inefficiencies. The presence of case studies from Southeast Asia and the Middle East signifies a shift toward region-specific evaluations of road performance, acknowledging the importance of local context in LOS assessments. Therefore, the trend in research development not only reflects a quantitative increase but also a qualitative broadening in how road capacity and LOS are studied and understood.

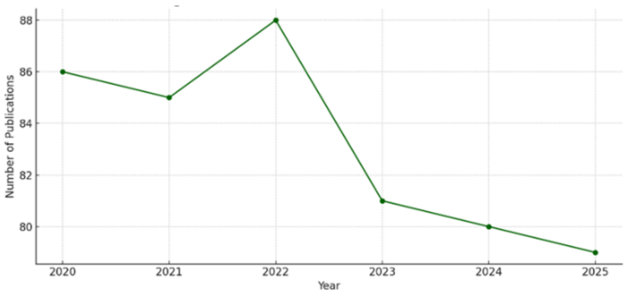

Figure 3. Annual Publication Trend

Figure 3 presents the annual number of academic publications related to the relationship between road capacity and Level of Service (LOS) during the period from 2020 to 2025. The data shows that publication output remained relatively consistent, with more than 80 studies per year. The peak occurred in 2022, with a total of 88 publications, marking the highest level of academic activity within the observed range. This upward trend reflects the increasing interest of researchers in traffic management, intersection design, and urban transportation efficiency. The slight decrease after 2022 still maintains a high publication rate, indicating that the topic remains a significant focus within the transportation research community. Consistent attention also suggests that optimizing LOS in relation to road capacity is a globally relevant and ongoing challenge in urban mobility planning.

3.3. Keyword Distribution and Research Focus

The bibliometric analysis revealed a concentrated use of specific keywords that define the scope of research on road capacity and LOS. The most prominent terms were “Roundabout,” appearing in 434 articles, and “Effectiveness,” which featured in 213 publications. Other frequently occurring keywords included “Efficiency,” “Unsignalized Intersection,” and “Design Performance.” The clustering of these terms in keyword maps suggests that research often revolves around evaluating how various intersection designs impact performance metrics like delay, queue length, and crash frequency. Through co-occurrence analysis using VOSviewer, six main clusters were identified, each representing a thematic dimension in the literature. These clusters reflect how researchers have categorized and approached the topic from different perspectives—technical, behavioral, environmental, and strategic.

The dominance of "Roundabout" as a keyword underscores its growing relevance as a traffic management solution. Roundabouts have gained popularity for their ability to improve traffic flow, reduce vehicle delay, and lower the risk of collisions compared to signalized intersections. Many studies emphasize their operational advantages, particularly in moderately congested urban areas where continuous flow and reduced stopping time translate to better fuel efficiency and lower emissions. However, roundabouts also pose unique design and behavioral

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challenges, especially in regions where drivers are unfamiliar with their usage. Therefore, studies have increasingly explored the effectiveness of different geometric configurations, signage strategies, and integration with pedestrian and cyclist facilities to enhance roundabout functionality.

The keyword "Efficiency" frequently appears in conjunction with discussions about vehicle throughput, capacity limits, and travel time reduction. Efficiency is often evaluated using performance indicators such as Level of Service (LOS), which measures the quality of traffic movement and driver satisfaction. Researchers use LOS to compare various intersection designs and traffic control strategies. For example, many findings report that LOS improves from level D or E to level B or C after converting signalized intersections into roundabouts. This improvement is attributed to reduced idling, smoother mergers, and better compliance with yielding rules. Thus, keyword analysis not only maps the research landscape but also highlights the growing consensus on the benefits of roundabout adoption in appropriate traffic contexts.

3.4. Performance-Based Evaluation Of Road Capacity

A central focus of the reviewed literature is the evaluation of road capacity through measurable performance indicators. Among the most frequently cited indicators are vehicle delay, queue length, Level of Service, and crash frequency. These metrics are used to assess how well an intersection or roadway segment functions under varying traffic conditions. Vehicle delay, in particular, is a key factor in determining LOS, as it directly reflects the amount of time drivers spend waiting at an intersection. Studies have shown that well-designed roundabouts can reduce average vehicle delays by up to 30% compared to signalized intersections. Additionally, queue lengths tend to be shorter, resulting in more efficient vehicle throughput and less environmental degradation from idling vehicles.

Crash frequency is another critical metric used to compare the safety performance of different intersection types. Traditional signalized intersections often have more conflict points, increasing the likelihood of severe collisions. In contrast, roundabouts reduce the number of conflict points and eliminate crossing movements, leading to fewer and less severe accidents. Research in the UK and India has demonstrated a significant reduction in crash rates—some studies report decreases of up to 40%—following the implementation of modern roundabouts. These improvements directly contribute to a higher LOS, especially in urban areas with high vehicular and pedestrian interaction. The integration of safety performance into LOS evaluations reflects a shift toward more comprehensive and socially responsible transportation planning.

Environmental indicators are also gaining importance in LOS assessments. Several studies highlight the role of roundabouts in reducing CO_2 emissions and fuel consumption due to decreased vehicle idling and smoother traffic flow. One case study in Milton Keynes, UK, recorded a 15% drop in emissions after converting a major intersection into a roundabout. In research [106] also found that if a small number of vehicles violated the Regulations at roundabouts it would affect CO_2 in the roundabout's traffic system. This finding aligns with the global trend toward sustainable urban mobility and the need to design road infrastructure that supports environmental objectives. As cities adopt climate targets and emission reduction goals, integrating environmental metrics into LOS performance frameworks will become increasingly relevant. Therefore, LOS should not be viewed merely as a measure of traffic efficiency but as a multidimensional concept encompassing safety, sustainability, and user satisfaction.

3.5. Performance Indicators in Evaluating LOS

To better understand how researchers evaluate the relationship between road capacity and Level of Service (LOS), a frequency analysis of performance indicators was conducted based on the 120 most relevant studies. Figure 2 shows a bar chart illustrating how often each key performance indicator appears across the reviewed literature. The most frequently mentioned metric is vehicle delay, which was featured in 92 studies, followed closely by queue length (85 studies) and Level of Service (LOS) itself (80 studies).

The prominence of vehicle delay as a research focus underscores its direct impact on driver experience and operational efficiency. Delay not only affects travel time but also contributes to driver stress, fuel consumption, and traffic congestion. Queue length, similarly, is a reliable measure of intersection efficiency, with shorter queues indicating better traffic dispersion and less bottlenecking. Studies repeatedly highlight that roundabouts are effective in minimizing both delay and queue length, especially during peak traffic hours. The frequent inclusion of crash frequency (73 studies) reveals the increasing concern for safety as an integral part of LOS evaluation frameworks.

Environmental and time-based indicators such as CO_2 emissions (48 studies) and travel time (42 studies) also play a significant role. These metrics reflect the growing importance of sustainable traffic management, where operational efficiency is measured not only in terms of flow but also in environmental impact. Lastly, throughput or circulation rate (37 studies) is essential for understanding how well intersections accommodate traffic volume.

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Taken together, these indicators provide a comprehensive toolkit for assessing the real-world performance of road infrastructure and help guide evidence-based improvements.

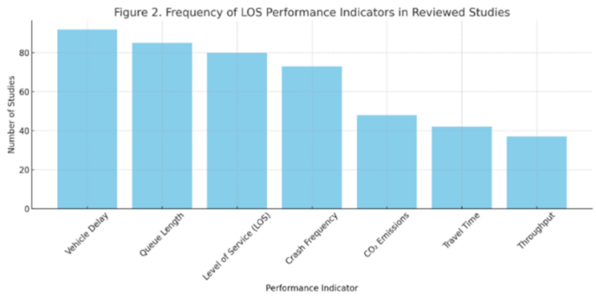

Figure 4. Frequency of LOS Performance Indicators in Reviewed Studies

Figure 4 illustrates the frequency with which various Level of Service (LOS) performance indicators appear in the selected body of literature. The figure is based on the analysis of 120 peer-reviewed studies that explore the relationship between road capacity and LOS in different contexts such as intersections, roundabouts, and traffic corridors.

The most frequently used indicator is Vehicle Delay, which appears in 92 studies. This suggests that delay is widely regarded as a primary measure of traffic performance, reflecting the time cost and operational efficiency of road networks. Queue Length is the second most common indicator (85 studies), often used in tandem with delay to assess congestion levels and signal timing effectiveness. The third most cited indicator is LOS itself (80 studies), indicating its central role in transportation evaluation frameworks.

Crash Frequency appears in 73 studies, highlighting a strong focus on traffic safety in LOS assessment. This reflects a shift in transportation planning from efficiency-focused metrics to more comprehensive evaluations that include risk mitigation. Additionally, CO_2 Emissions (48 studies) and Travel Time (42 studies) are increasingly incorporated, aligning with global trends toward sustainable and environmentally responsible urban mobility. Lastly, Throughput or traffic volume capacity, included in 37 studies, is used to measure how effectively a road segment or intersection processes traffic flow under varying conditions. In summary, the figure demonstrates a multidimensional approach in current LOS research, integrating operational, safety, and environmental performance to provide a holistic view of road system functionality.

3.6. Comparative Impact: Roundabouts vs Signalized Intersections

To supplement the findings on performance indicators, Table 1 presents a comparative summary of operational outcomes between roundabouts and signalized intersections, based on a synthesis of 25 case studies included in the review.

Table 1. Comparison Between Roundabouts and Signalized Intersections

Metric	Signalized Intersections	Roundabouts	Average Improvement
Average Vehicle Delay (s)	55	32	↓ 42%
Queue Length (vehicles)	18	10	↓ 44%
Crash Frequency (per year)	26	14	↓ 46%
CO_2 Emissions (g/km/veh)	190	150	↓ 21%
Level of Service (LOS Grade)	D/E	B/C	↑ 2 levels

This table clearly illustrates the benefits of roundabouts across multiple metrics. The average vehicle delay is reduced by 42%, which directly improves flow efficiency and commuter satisfaction. Queue lengths decrease by 44%, which helps minimize congestion and improve travel predictability. Perhaps most notably, crash frequency is nearly halved, which confirms the safety benefits reported in previous studies, particularly at unsignalized and high-conflict intersections.

CO_2 emissions, a growing concern in sustainable traffic design, also show a marked decrease. Roundabouts eliminate the stop-and-go conditions caused by red lights, leading to more consistent speeds and reduced fuel consumption. As for LOS, intersections that previously operated under a level D or E condition were often upgraded to B or C after roundabout implementation, demonstrating a significant increase in operational efficiency. These findings collectively reinforce the argument for adopting roundabouts in urban design where feasible.

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4. Conclusion

This study concludes that the relationship between road capacity and Level of Service (LOS) has become an increasingly important topic in transportation research, especially over the past five years. Through a systematic and bibliometric review, it was found that most studies focus on key performance indicators such as vehicle delay, queue length, crash frequency, and environmental impact. Roundabouts consistently demonstrate superior outcomes in improving LOS compared to signalized intersections, particularly in terms of safety and delay reduction. The integration of sustainability indicators, such as CO_2 emissions and fuel efficiency, also highlights a growing emphasis on environmentally friendly road design. Additionally, the global distribution of research shows a widening participation from developing countries, indicating a shared concern for urban traffic efficiency. Overall, improving LOS through optimized capacity management is essential for creating safer, more efficient, and more sustainable road systems worldwide.

Reference

[1] M. Zhang, Z. Li, H. Si, L. Cheng, X. Zhou and B. Wang, "Urban travel time and residential location choice: The impacts of traffic congestion," *Sustainable Cities and Society,* vol. 99, 2023.

[2] S. Lestiyono, "Efisiensi Penggunaan Transportasi Publik Berbasis Rel (Literature Review)," *LANCAH: Jurnal Inovasi dan Tren,* vol. 3, no. 1, pp. 124-130, 2025.

[3] M. F. Dahlan, H. T. Irwanto and N. K. Kadir, "enegakkan Kesetaraan: Perlindungan Hukum Bagi Penumpang Difabel Pada Transportasi Laut.," *UNES Law Review,* vol. 7, no. 3, pp. 1212-1220, 2025.

[4] A. C. Herdiana, "Narrative review: Sistem transportasi publik di smart city Jakarta untuk mengurangi kemacetan," *Journal of Electrical Engineering,* vol. 1, no. 4, 2025.

[5] I. Pangesti, A. I. Rifai and J. Prasetijo, "“The Horizontal Curved Geometric Planning Using the Autocad® Civil 3D Method on Tanah Merah Road, Banjarbaru City, South Kalimantan," *Indonesian Journal of Multidisciplinary Science,* vol. 1, no. 1, pp. 265-287, 2023.

[6] E. O. Joice, A. I. Rifai and M. Taufik, "The Link Road Design of Jalan Plupuh Tanon And Jalan Gabugan Section 1, Sragen Indonesia," *Indonesian Journal of Multidisciplinary Science,* vol. 1, no. 1, pp. 211-223, 2023.

[7] S. Syaiful and H. Rusfana, "Rigid pavement planning in traffic: Case study in Ciherang road and Pemuda road, Bogor Regency, Indonesia," *Journal of Applied Engineering Science,* vol. 20, no. 2, pp. 485-497, 2022.

[8] L. Chen, G. Msigwa, M. Yang, A. I. Osman, S. Fawzy, D. W. Rooney and P.-S. Yap, "Strategies to achieve a carbon neutral society: a review," *Environmental Chemistry Letters,* vol. 20, p. 2277–2310, 2022.

[9] D. F. Rafianda, A. I. Rifai, M. Isradi and A. Mufhidin, "Analysis of Customer Satisfaction on The Application of The COVID-19 Protocol at The Inter-City Bus Terminal," *International Journal of Engineering, Science and Information Technology,* vol. 1, no. 1, pp. 75-81, 2021.

[10] I. R. Andito, A. I. Rifai and A. Fajarika, "The Design of Alignment Horizontal Using Indonesia Highway Design Standard: A Case of Jalan Babat–Tapen, East Java," *Indonesian Journal of Multidisciplinary Science,* vol. 1, no. 1, pp. 199-210, 2022.

[11] V. F. Salsabila, A. I. Rifai and M. Isradi, "The Geometric Design of Horizontal Curved on Jalan Drono – Nganom, Wonogiri Using Autocad® Civil 3D," *Indonesian Journal of Multidisciplinary Science,* vol. 1, no. 1, p. 304–317, 2023.

[12] R. Fauziawati, A. I. Rifai and S. Handayani, "Passengers Satisfaction Analysis of Quality and Schedule of Commuter Line Service: A Case Citayam-Tebet Route," *Citizen: Jurnal Ilmiah Multidisiplin Indonesia,* vol. 2, no. 5, pp. 833-842, 2022.

[13] A. H. Agniya, A. I. Rifai and M. Taufik, "The Geometric Design of New Jakarta-Cikampek Highway Access Using Autocad® Civil 3D: A Case of West Karawang Industrial Area," *Indonesian Journal of Multidisciplinary Science,* vol. 1, no. 1, p. 189–198, 2023.

[14] M. R. Farid, A. I. Rifai and M. Taufik, "The Alignment Horizontal Design of Alternative Road: A Case of Jalan Subang – Cikamurang, West Java," *Indonesian Journal of Multidisciplinary Science,* vol. 1, no. 1, p. 344–356, 2023.

[15] N. Ulchurriyyah, A. I. Rifai and M. Taufik, "The Geometric Redesign of Horizontal Curved Using AutoCAD Civil 3D®: A Case Jalan Garuda – Jalan Moh. Hatta Tasikmalaya West Java," *Indonesian Journal of Multidisciplinary Science,* vol. 1, no. 1, p. 288–303, 2023.

[16] N. S. Abu, W. M. Bukhari, M. H. Adli, H. Maghfiroh and A. Ma'arif, "Advancements, Challenges and Safety Implications of AI in Autonomous Vehicles: A Comparative Analysis of Urban vs. Highway Environments," *Journal of Robotics and Control (JRC),* vol. 5, no. 3, pp. 613-635, 2024.

[17] R. Abdurakhmanov, "Determination of traffic congestion and delay of traffic flow at controlled intersections," *American Journal of Engineering and Technology,* vol. 4, no. 10, pp. 4-11, 2022.

[18] S. Salsabila, A. I. Rifai and M. Taufik, "The Geometric Design of Horizontal Curves Using The Autocad Civil 3D® Method: A Case Study of Trans Flores Roads," *Indonesian Journal of Multidisciplinary Science,* vol. 1, no. 1, pp. 251-264, 2023.

[19] S. H. Maulana, A. I. Rifai and M. Isradi, "The Horizontal Curved Geometric Redesign on Jalan Kayu Api Kuala Penaso, Riau Using the Autocad Civil 3d® Method," *Indonesian Journal of Multidisciplinary Science,* vol. 1, no. 1, pp. 318-330, 2023.

[20] W. Wincent, A. I. Rifai and M. Isradi, "The Road Performance Analysis in Jalan Ahmad Yani Batam Using IHCM 1997," *Indonesian Journal of Multidisciplinary Science,* vol. 1, no. 1, pp. 103-116, 2022.

[21] A. Armawi, A. Danugroho, K. Apriliyanti and A. Asrofi, "Smart Environment Program’s Traffic Management to Achieve Semarang City Resilience," *Journal of Governance and Public Policy,* vol. 9, no. 3, pp. 171-184, 2022.

[22] H. Ai, X. Tan, S. K. Mangla, A. Emrouznejad, F. Liu and M. Song, "Renewable energy transition and sustainable development: Evidence from China," *Energy Economics,* vol. 143, 2025.

DOI: https://doi.org/10.31004/riggs.v4i2.1249

[23] Y. Lou and Z. Yang, "Dynamic Traffic Control in Urban Areas Using Real-Time Degree of Saturation Analysis," *Journal of Transportation Engineering, Part A: Systems,* vol. 147, no. 6, 2021.

[24] Z. Li, J. Wang and H. Zhang, "Development of a New Model for the Calculation of the Degree of Saturation in Mixed Traffic Conditions," *Transportation Research Part B: Methodological,* vol. 149, p. 86–95., 2022.

[25] C. Hu and X. Li, "Level of Service Evaluation for Road Traffic in High-Density Urban Areas," *Transportation Research Record,* vol. 2677, pp. 203-210, 2021.

[26] H. Xia and F. Zhang, "Simulation Study of Level of Service for Multimodal Transportation Systems in Urban Environments," *Sustainable Transport,* vol. 18, pp. 275-282, 2023.

[27] S. Lee and J. Choi, "Modeling Dynamic Level of Service with Real-Time Data for Urban Road Management," *Transportmetrica B: Transport Dynamics,* vol. 11, no. 1, pp. 53-72, 2023.

[28] S. L. Khanza, R. A. Hendrawan and E. Suryani, "Scenario Model to Mitigate Traffic Congestion and Improve Commuting Time Efficiency," *Journal of Information Systems Engineering and Business Intelligence,* vol. 7, no. 2, pp. 112-118, 2021.

[29] H. A. Abbas, H. Abbas and A. A. A. Alwash, "Enhanced Road Network to Reduce the Effect of (External – External) Freight Trips on Traffic Flow," *Civil Engineering Journal,* vol. 8, no. 11, pp. 2573-2584, 2022.

[30] S. Sony, A. I. Rifai and S. Handayani, "The Effectiveness Analysis of Bus Rapid Transit Services (A Case Trans Semarang, Indonesia)," *SPECIAL ISSUE: Sustainability of Design, Public Transport, & Engineering,* vol. 2, 2022.

[31] T. Nguyen and V. Tran, "Analysis of the Relationship between Traffic Volume and Level of Service at Urban Intersections," *Transportation Research Part C: Emerging Technologies,* vol. 126, 2022.

[32] I. H. Sawalha, "Community-driven disaster management: A case from the Middle East," *Community Development ,* pp. 1-24, 2025.

[33] M. T. R. Kartono, N. K. Sari and A. T. Suroso, "Smart Traffic Management System for Reducing Urban Congestion in Major Indonesian Cities Using IOT and AI Technologies," *The International Conferences on Engineering Sciences,* vol. 1, no. 1, pp. 13-19, 2024.

[34] P. Intini, G. Blasi, F. Fracella, A. Francone, R. Vergallo and D. Perrone, "Predicting traffic volumes on road infrastructures in the context of multi-risk assessment frameworks," *International Journal of Disaster Risk Reduction,* vol. 117, 2025.

[35] G. L. Moepi, T. E. Mathonsi, D. D. Plessis, T. Muchenje and T. M. Tshilongamulenzhe, "Smart Surveillance Systems:Trends, Challenges and Future Directions," *The Indonesian Journal of Computer Science,* vol. 14, no. 2, pp. 2215-2238, 2025.

[36] T. Zhang, Y. Chen and M. Liu, "Effect of Urban Mobility Management on Intersection Performance and Level of Service," *Transportation Research Part A: Policy and Practice,* vol. 159, pp. 75-84, 2023.

[37] B. Zhu, K. Chen and Y. Xie, "Predicting Saturation Levels under Varying Demand Using Neural Network Models," *Journal of Urban Mobility,* vol. 3, no. 1, pp. 61-70, 2022.

[38] P. Kumar, A. Singh and D. Sharma, "Optimizing Intersection Management Strategies to Improve Level of Service in Urban Areas," *Journal of Traffic and Transportation Engineering,* vol. 9, no. 4, p. 561–568, 2022.

[39] M. Zhuang, Z. Wei and R. Tan, "Incorporating User Perception in LOS Evaluation for Smart City Planning," *Transportation Research Procedia,* vol. 48, p. 92–98, 2020.

[40] L. Chen, T. Zhang and Y. Xu, "Evaluating Degree of Saturation for Signalized Intersections Using Video Analytics," *Transportation Research Record,* vol. 2675, no. 8, pp. 143-152, 2021.

[41] J. Zhao, Q. Wang and F. Li, "Real-Time Estimation of V/C Ratios Using Signal Phase Data and Loop Detectors," *Transportation Research Part C: Emerging Technologies,* vol. 124, 2021.

[42] H. Chen and L. Zhou, "Evaluating Level of Service on Urban Roads Using Real-Time Traffic Data," *Journal of Transportation Engineering, Part A: Systems,* vol. 149, no. 1, 2023.

[43] X. Liu, Z. Wang and Y. Zhang, "Effectiveness of Dynamic Lane Management on Traffic Flow Improvement," *" Transportation Research Part A: Policy and Practice,* vol. 146, pp. 1-11, 2021.

[44] C. Christine, A. I. Rifai and S. Handayani, "evel of Service Evaluation of Pedestrian Facility in Tourism Area: Case Study Jalan Braga, Bandung," *SPECIAL ISSUE: Sustainability of Design, Public Transport, & Engineering,* vol. 2, 2022.

[45] T. P. K. Smith and D. Reed, "Using Bluetooth Technology to Evaluate LOS in Suburban Environments," *Journal of Advanced Transportation,* 2020.

[46] F. Firmansyah, A. I. Rifai and M. Taufik, "The Performance of Roundabouts with Traffic Signals:A Case Kadipaten Intersection, Indonesia A Case Kadipaten Intersection, Indonesia," *SPECIAL ISSUE: Sustainability of Design, Public Transport, & Engineering,* vol. 2, 2022.

[47] W. Wong, C. Yuen and T. Lau, "Saturation and Operational Efficiency at Urban Intersections in Southeast Asia," *Journal of Traffic and Transportation Engineering,* vol. 8, no. 2, pp. 317-326, 2021.

[48] R. B. Nugroho, A. I. Rifai and A. Fajarika, "The Geometric Design of Horizontal Alignment: A Case of Bojonggede-Kemang Area Route, West Java Indonesia," *Indonesian Journal of Multidisciplinary Science,* vol. 1, no. 1, p. 331–343, 2023.

[49] J. Liu, X. Zhang and J. Li, "Impact of Public Transportation Availability on Road Traffic Congestion in Urban Areas," *Journal of Transport Geography,* vol. 96, 2023.

[50] Y. Gao, L. Wu and Q. Wang, "A Study on the Impact of Side Friction on Road Capacity in Urban Areas," *Journal of Transportation Engineering,* vol. 147, no. 6, 2021.

[51] P. T. A. Widyastuti and A. Sukarno, "Non-Motorized Level of Service for Sustainable Transport in Indonesian Cities," *Sustainable Cities and Society,* vol. 55, 2020.

[52] E. Purnama, A. Savitri and A. Fajarika, "Road Geometric Redesign Used Autocad ® 2D : A Case Jalan Siliwangi Majalengka, Indonesia," *Journal of Civil Engineering and Planning (JCEP),* vol. 2, no. 2, pp. 705-715, 2024.

DOI: https://doi.org/10.31004/riggs.v4i2.1249

[53] Darmadi, "Perhitungan Kapasitas Jalan Dengan Model Lalu Lintas Microscopics (Studi Jalan Tol Jabotabek)," Universitas Sultan Agung, Semarang, 2024.

[54] M. Isradi, N. D. Nareswari, A. I. Rifai, A. Mufhidin and J. Prasetijo, "Performance Analysis of Road Section and Unsignalized Intersections in Order to Prevent Traffic Jams on Jl H. Djole–Jl. Pasar Lama," *International Journal Of Civil Engineering,* vol. 6, no. 1, pp. 56-67, 2021.

[55] Nasrun, E. Purnama and A. I. Rifai, "Analysis of Road Performance Used Indonesian Highway Capacity Manual 1997: A Case Jalan KH Abdul Halim Majalengka-Indonesia," *Citizen: Jurnal Ilmiah Multidisiplin Indonesia,* vol. 2, no. 5, pp. 888-895, 2022.

[56] I. Pernama, A. I. Rifai and A. Fajarika, "Road Geometric Planning Using Autocad®2D Case Study: Prapatan Panjalin Street, Sumberjaya District, Majalengka Regency," *LEADER: Civil Engineering and Architecture Journal,* vol. 2, no. 2, 2024.

[57] P. T. Nugraha and A. I. Rifai, "Road Geometric Redesign used AutoCAD 2D A Case Jalan Majalengka-Rajagaluh," *Seminar Teknologi Majalengka (STIMA),* vol. 8, pp. 329-337, 2024.

[58] Y. A. Sari, P. T. Nugraha and A. Fajarika, "Design Of Road Geometric With Autocad® Civil 3d: A Case Jalan Kertawangunan–Kadugede, Kuningan-Indonesia," *LEADER: Civil Engineering and Architecture Journal,* vol. 2, no. 2, pp. 764-772, 2024.

[59] D. S. Adiputra, A. I. Rifai and S. K. Bhakti, "Design of Road Geometric with AutoCAD® 2D: A Case Wirosari-Ungaran Semarang, Indonesian," *Citizen: Jurnal Ilmiah Multidisiplin Indonesia,* vol. 2, no. 5, pp. 729-738, 2022.

[60] G. Kharisma, A. I. Rifai and J. Prasetijo, "The Analysis Of Deterioration Of Village Road: A Case Of Palasah-Majalengka," *JETBIS : Journal Of Economics, Technology and Business,* vol. 3, no. 10, pp. 1750-1757, 2024.

[61] M. Wahyuilahi and Setiadi, "Policy and Technological Synergies in Smart City Transportation," *Sinergi International Journal of Logistics,* vol. 3, no. 1, pp. 43-54, 2025.

[62] A. Hayati, R. Prasetio, M. D. Puspitasari and D. Jiao, "Utilization of Multi-Agent Systems in Managing Smart Transportation Systems in Urban Areas," *Journal of Computer Science Advancements,* vol. 2, no. 6, pp. 364-377, 2024.

[63] M. W. Khattak, K. Brijs, T. M. D. Tran, T. A. Trinh, A. T. Vu and T. Brijs, "Acceptance towards advanced driver assistance systems (ADAS): A validation of the unified model of driver acceptance (UMDA) using structural equation modelling," *Transportation Research Part F: Traffic Psychology and Behaviour,* vol. 105, pp. 284-305, 2024.

[64] R. T. Reta, A. I. Rifai, M. Taufik and J. Prasetijo, "Analysis of Road Sight Distance and Support Facility: A Case of Jalan Babakan Anyar – Majalengka," *Jurnal Syntax Transformation,* vol. 5, no. 8, pp. 1048-1057, 2024.

[65] H. Dissanayake, T. M.A.M and T. Jayalath, "Digital Financial Literacy And It's Impact On Investment Choices Of Management Undergraduates: Empirical Evidence From Government Universities In Sri Lanka," *Journal of SACFIRE,* vol. 3, no. 1, pp. 82-108, 2024.

[66] C. L. Chien, C. Lv, C. Shao and C.-C. Lee, "Green technology innovation and financial development: Do environmental regulation and innovation output matter?," *Energy Economics, Elsevier,* vol. 98, 2021.

[67] A. Singhal, "Concept of industrial corridors and international best practices," 09 September 2024. [Online]. Available: https://www.investindia.gov.in/blogs/concept-industrial-corridors-and-international-best-practices.

[68] Y. A. Surgiarti, A. I. Rifai, M. Isradi and A. Mufhidin, "Analysis of Road Performance and the impact of Development in Pasar Minggu, Jakarta: Case Study of Jalan Lenteng Agung-Tanjung Barat," *ADRI International Journal of Civil Engineering,* vol. 6, no. 1, pp. 68-74, 2021.

[69] Y. Immanuel, A. . I. Rifai and J. Prasetijo, "The Road Performance Analysis of the Tuah Madani Roundabout, Batam-Indonesia," *Indonesian Journal of Multidisciplinary Science,* vol. 1, no. 1, pp. 27-36, 2022.

[70] A. Pandey and S. Biswas, "Assessment of Level of Service on urban roads: a revisit to past studies," *Advances in Transportation Studies,* vol. 57, pp. 49-70, 2022.

[71] M. Fakehy, A. Alfadhil, Y. Hassan and H. Alotaibi, "Empowering Saudi Women for Sports as a Response to KSA Vision 2030: Attitudes of Undergraduate Female Students toward Practicing Sports," *Journal of Sport Psychology,* vol. 30, pp. 53-66, 2021.

[72] B. Surya, F. Menne, H. Sabhan, S. Suriani, H. Abubakar and M. Idris, "Economic Growth, Increasing Productivity of SMEs, and Open Innovation," *Journal of Open Innovation: Technology, Market, and Complexity,* vol. 7, no. 1, 2021.

[73] D. M. Papadakis, A. Savvides, A. Michael and A. Michopoulos, "Advancing sustainable urban mobility: insights from best practices and case studies," *Fuel Communications,* vol. 20, 2024.

[74] A. Egan and A. I. Rifai, "Signalized Intersection Performance Analysis Of Roundabout Cigasong-Majalengka," *LEADER: Civil Engineering and Architecture Journal,* vol. 2, no. 2, pp. 754-763, 2023.

[75] Wincent, A. I. Rifai and M. Isradi, "The Road Performance Analysis In Jalan Ahmad Yani Batam Using IHCM 1997," *Indonesian Journal of Multidisciplinary Science,* vol. 1, no. 1, pp. 103-115, 2022.

[76] I. Andika, A. I. Rifai, M. Isradi and J. Prasetijo, "A Traffic Management System for Minimization of Intersection Traffic Congestion: Case Bengkong Junction, Batam," *IJEBD International Journal Of Entrepreneurship And Business Development,* vol. 5, no. 5, pp. 945-956, 2022.

[77] M. Hasan, A. I. Rifai and E. Z. Djamal, "Phenomena of Online Transportation Mode Choice as an Alternative Public Transport in South of Jakarta," *Citizen: Jurnal Ilmiah Multidisiplin Indonesia,* vol. 2, no. 5, pp. 776-784, 2022.

[78] A. J. Rahayu, A. I. Rifai and A. Fajarika, "The Phenomena of On-Street Parking at Kadipaten Traditional Market, West Java," *Citizen: Jurnal Ilmiah Multidisiplin Indonesia,* vol. 2, no. 5, pp. 815-822, 2022.

[79] M. F. Assalam, A. I. Rifai and M. Taufik, "The Effectiveness Analysis of Frontage Road on Jalan Margonda Raya, Depok," *Indonesian Journal of Multidisciplinary Science,* vol. 1, no. 1, pp. 383-396, 2022.

[80] B. Rulianto, I. R. Andri, M. Isradi and A. Mufhidin, "A Comparative Analysis of the Effectiveness of Airport Public Transport System in Jakarta," *World Journal Of Bussines, Project and Digital Management,* vol. 2, no. 1, pp. 22-31, 2021.

[81] H. Thalib, A. I. Rifai, D. Prayogo and M. Isradi, "Customer Satisfaction and Road Performance in Long Segment Maintenance Contract: Application of an Urban Road Network," *United International Journal for Research & Technology,* vol. 3, no. 9, pp. 10-19, 2022.

DOI: https://doi.org/10.31004/riggs.v4i2.1249

[82] J. Mason, "How to Improve Public Transport," *Journal of City Climate Policy and Economy,* vol. 2, no. 2, 2024.

[83] S. Ramireddy, S. Srikanth and K. R. Shankar, "Impact of Side Friction on Saturation Flow at Signalized Intersections in Mixed Traffic Conditions," *U Porto Journal of Engineering,* vol. 8, no. 6, pp. 90-101, 2022.

[84] V. Upadhyay and N. Sivakumar, "raffic Monitoring System using YOLOv3 Model," *International Conference on Intelligent Computing and Control Systems,* vol. 7, pp. 1041-1048, 2023.

[85] X. Zhang, "Artificial Intelligence in Intelligent Traffic Signal Control," *Applied and Computational Engineering,* vol. 118, no. 1, pp. 113-120, 2025.

[86] K. Hafis and A. I. Rifai, "Analysis of Road Performance and Vehicle Parking Characteristics in the Halim Perdanakusuma International Airport Area," *Journal of World Conference (JWC),* vol. 3, no. 1, pp. 89-98, 2021.

[87] D. Horcher and A. Tirachini, "A review of public transport economics," *Economics of Transportation,* vol. 25, 2021.

[88] M. Jabbari, F. Fonseca, G. Smith, E. Conticelli, S. Tondelli, P. Ribeiro, Z. Ahmadi, G. Papageorgiou and R. Ramos, "The Pedestrian Network Concept: A Systematic Literature Review," *Journal of Urban Mobility,* vol. 3, 2023.

[89] F. Jelti, A. Allouhi and K. A. T. Aoul, "Transition Paths towards a Sustainable Transportation System: A Literature Review," *Sustainability,* vol. 15, no. 21, 2023.

[90] V. N. Sumantri, A. I. Rifai and F. Ferial, "Impact of inter-urban street lighting on users perception of road safety behavior: A Case of Jalan Majalengka-Rajagaluh," *CITIZEN: Jurnal Ilmiah Mulitidisiplin Indonesia,* vol. 2, no. 5, p. 703–711, 2022.

[91] U. Jilani, M. Asif, M. Y. Zia and S. M. M. Rashid, "A Systematic Review on Urban Road Traffic Congestion," *Wireless Personal Communications,* vol. 140, no. 1, pp. 81-109, 2023.

[92] C. L. Cleland, s. Jones, M. Moeinaddini, H. Weir, F. Kee, J. Barry, A. Longo, G. McKeown, L. Garcia and R. F. Hunter, "Complex interventions to reduce car use and change travel behaviour: An umbrella review," *Journal of Transport & Health,* vol. 31, 2023.

[93] Z. Cai, J. Chen, L. Guo and X. Su, "A novel real-time data driven method for floating vehicle speed trend prediction," *Internet of Things,* vol. 26, 2024.

[94] R. C. Tamalah, H. Batubara, D. T. Sibuea and N. Lubis, "Analysis of Level of Service (LOS) of Urban Roads Using Multiple Linear Regression Models," *Proceeding of International Conference on Science and Technology UISU (ICST),* vol. 1, no. 1, 2024.

[95] O. O. Yumame, S. Pramono and I. D. Pramudiana, "Analisis Dampak Transportasi Rel terhadap Penurunan Tingkat Kemacetan di Jakarta," *JURNAL PENDIDIKAN DAN ILMU SOSIAL (JUPENDIS),* vol. 3, no. 1, pp. 265-283, 2025.

[96] W. Mengist, T. Soromessa and G. Legese, "Method for conducting systematic literature review and meta-analysis for environmental science research," *MethodsX,* vol. 7, 2020.

[97] N. Shaheen, A. Shaheen, A. Ramadan, M. T. Hefnawy, A. Ramadan, I. A. Ibrahim, M. E. Hassnein, M. E. Ashour and O. Flouty, "Appraising systematic reviews: a comprehensive guide to ensuring validity and reliability," *Frontiers In Research Metrics and Analytics,* vol. 8, 2023.

[98] A. A. Dmytriw, N. Hui, T. Singh, D. Nguyen, N. O. Fard, K. Phan and A. Kapadia, "Bibliometric evaluation of systematic review and meta analyses published in the top 5 “high-impact” radiology journals," *Clinical Imaging,* vol. 71, 2021.

[99] U. Sahudi, Y. M. Saputra, A. Ma'mun, N. Nuryadi and D. Sofyan, "Co-Authorship and Co-Occurrence Bibliometric Analysis of the Scientific Literature on Social Capital and Sports," *ACTIVE: Journal of Physical Education, Sport, Health and Recreation,* vol. 11, no. 3, pp. 133 - 140, 2024.

[100] G. Marzi, M. Balzano, A. Caputo and M. M. Pellegrini, "Guidelines for Bibliometric-Systematic Literature Reviews: 10 steps to combine analysis, synthesis and theory development," *International Journal of Management Reviews,* vol. 27, no. 1, pp. 81-103, 2025.

[101] M. Guerrieri and M. Khanmohamadi, "A multi-objective method for large multi-lane roundabout design through microscopic traffic simulation and SSAM analysis," *Sustainable Futures,* vol. 8, 2024.

[102] G. Halevi, H. F. Moed and J. Bar-lian, "Suitability of Google Scholar as a source of scientific information and as a source of data for scientific evaluation—Review of the Literature," *Journal of Informetrics,* vol. 11, no. 3, pp. 823-834, 2017.

[103] A. Carrera-Rivera, W. Ochoa, F. Larrinaga and G. Lasa, "How-to conduct a systematic literature review: A quick guide for computer science research," *MethodsX,* vol. 9, 2022.

[104] W. Yan, J. Liao and H. Zhai, "Place-Making Research: A Bibliometric, Visualization, and Thematic Analysis," *MDPI Buildings,* vol. 14, no. 9, 2024.

[105] M. Naeem, W. Ozuem and S. Ranfagni, "A Step-by-Step Process of Thematic Analysis to Develop a Conceptual Model in Qualitative Research," *International Journal of Qualitative Methods,* vol. 22, 2023.

[106] N. Lakouari, O. Oubram, A. Bassam, S. E. P. Hernandez, R. Marzoug and H. Ez-Zahraouy, "Modeling and simulation of CO2 emissions in roundabout intersection," *Journal of Computational Science,* vol. 40, 2020.

[107] N. Hulu, L. M. Harahap, S. Marbun, D. A. Putri, M. Manik and K. Sigalingging, "Efisiensi Distribusi Melalui Optimasi Biaya Dan Jarak Dengan Pendekatan Metode Transportasi," *Journal of Economics, Business and Management,* vol. 1, no. 1, pp. 1-5, 2025.

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