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Original Research

EVALUATION OF THE LEVEL OF SERVICE PROVIDED AT SOME BUS ROUTES IN BAGHDAD CITY

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Abstract: The public transportation system is critical in meeting the demands of the rapidly growing population and increased mobility. Thus, providing and improving public services has become an urgent need in recent years. This study aims to evaluate the level of Baghdad's public transport system using a variety of criteria, including public transport availability, and comfort level. Service level is a method used to develop transport infrastructure labels based on a specific analysis. The importance of evaluating road operational performance services to improve bus service delivery is based on the concept of service level. The relatively high performance of bus service delivery can affect the level of satisfaction of its users. The availability of public transportation is analyzed in terms of frequency, service coverage, and hours. This study assesses the level of service for five specific major bus routes in Baghdad (4, 12, 45, 61, and 113). Survey processes were used to collect data. The results indicate that all lines according to service hours were at the level of service "E". While the service frequency is within the service levels "A", "B", and "C", and transit-auto travel time is within the service levels Class "B", and "C". This study contributes to being a useful guide for developing a comprehensive plan for the level of service and improving the quality of bus service.

Keywords: *Baghdad City; Level of service; Public transport; Quality of bus service*

1. Introduction

Due to urbanization's ongoing nature, both the economy and the population have grown rapidly in recent years. While this is happening, the need for regular commutes is growing [1]. The rapid development is mostly attributable to rising living standards, which in turn has increased the volume of traffic on the roads [2]. Due to the enormous volume of vehicles moving through urban and suburban areas, congestion is expected to worsen as metropolitan populations continue to soar [3-5]. When traveling from one location to another, individuals in developing countries rely heavily on their automobiles [6-8]. Consequently, the planning of a substantial transit system and the optimization of bus schedules are essential to reduce the use of automobiles [9-11]. Also, in recent years, there has been a rise in the number of complaints lodged by passengers and users of bus services; which include tardiness, improper conduct by drivers, and inadequate service coverage [1] On the other side, passengers desire an increase in the number of service frequencies to reduce the amount of waiting time [12]. The level of service should be evaluated by operators because should also be implemented by operators because it serves as a standard measurement to establish what constitutes an acceptable level of service for each attribute [13]. Some researchers have

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criticized certain transport policies on a local scale for not addressing the current issues faced by bus operators. They have identified the insufficient implementation of public transport connections between interstate and local bus services as a problem [14]. This point was brought up by several different researchers. Government and authorities need to better coordinate bus services, fix the way bus services are organized, upgrade terminal facilities [15, 16], and set clear standards for the quality of bus service [14]. In addition, evaluations of bus services need to take into account logistical concerns, as well as riders' and drivers' perspectives and needs [17]. Every day, passengers and users in this country have to deal with issues including insufficient service hours, a narrow service area, and a high volume of people using public transportation during peak times of the week, especially in urban areas [18]. If the service provided lives up to the minimally acceptable standard, then the consumer will have a positive impression [19, 20]. It has been also justified that overall satisfaction and behavioral intentions are important factors in the analyses of the level of service of bus services on qualitative aspects [21]. Comfort, connivance, safety, and security are the attributes that have a great influence on passenger satisfaction [22-24]. Quantitative measurement such as hours of service, service frequency, passenger load factors, and on-time performance should be measured as they are important variables to evaluate the performance of bus services [25]. The efficiency of bus service is measured based on delay and number of stops. To increase the speed of the bus, specific bus stops should be defined. Scheduling is important to ensure that buses operate according to the demand during off-peak periods and use minimum resources [26].

2. Aim of the Study

This study aims to analyze the level of service of the public transportation system in Baghdad city from different points of view, including availability and comfort for users. This paper is complementary to previous studies of analyzing the public transport network with different analysis criteria, and the continuous development of the network.

To achieve this goal, public transportation accessibility was first assessed in terms of frequency of operation, operating hours, and service coverage. The comfort and convenience are evaluated as the second aspect. Overall automobile congestion levels, commitment to advancement, and travel time between transit vehicles are taken into consideration. Transit-auto travel time refers to the difference between door-to-door travel times for automobiles and transit. This time includes walking, waiting, and transferring between modes. The majority of these evaluations were carried out by the protocols established in Report 165 of the Transit Cooperative Research Program (TCRP), the primary goal of this study was the analysis and evaluation of given by public transportation in terms of Service Hours and service frequency.

3. Study Area

Baghdad City is the capital of Iraq. According to the UTM (Universal Transverse Mercator) geographic coordinate system, is located inside the (38N) zone with area (5065.163 sq. km) accounting for 1.04 percent of Iraq's total area [27]. With 9 million residents in 2018, Baghdad is the most populous [28]. Although there have been numerous suggestions to upgrade the city's infrastructure over the past 30 years, no substantial transportation-related developments have been implemented [29]. Since then, this has become a big issue on the city's busiest

thoroughfares [30,31], notably those leading toward the downtown area. Therefore, it has been becoming more urgent that the city's traffic and transportation difficulties should be resolved. Therefore, our research has produced a method to fix Baghdad's transportation issues.

4. Performance of the Public Transportation System

Public transit networks are now essential to urban mobility plans for a variety of reasons, including the proliferation of cities and the increasing number of car owners. Bus systems are the backbone of the public transportation network. Successful urban bus transit systems will increase the demand for public transportation, and enhance city life by reducing the number of people who drive alone. Many urban dwellers attribute traffic jams and pollution, to the frequency with which people utilize their personal cars to get to town [32]. On public transportation networks, it is possible to accommodate high levels of demand for time- and distance-based travel. To some extent, modern societies could benefit from an improved standard of living thanks to lower overall costs, which could be made possible by better transportation infrastructure [33, 34].

The success of a bus system usually depends on how well it serves the public and how efficiently it operates [35]. The ease with which people can navigate the bus system is what is meant by the phrase "accessibility". The proximity of bus stations to potential riders is important because most riders will choose the nearest stop. As the number of bus stations increases, users will have to walk less to reach them, making the system more convenient. The efficiency of a bus system has traditionally been measured by the number of stops it makes in a given amount of time [36].

Since the vast majority of riders would rather take the speedier transit, the bus system is more used. Accessibility and efficacy, however, are mutually exclusive goals. To make the bus system more user-friendly, more stops need to be introduced, which will increase travel time but slow down vehicle speeds. To strike a balance between passengers' needs for ease of access and the needs of the bus company's bottom line, it may be required to expand transportation [37-38]. This will maintain a wide pool of potential bus riders while improving the system's efficiency.

5. Data Collection Methodology

Many factors must be taken into account to develop an appropriate study approach to the subject [39]. These include:

1. The first of these factors is the availability of equipment to collect data, including time, people, and equipment for data collection, and analysis.
2. The size and routing of the bus network.
3. Accuracy, completeness, and details of the currently available data. Fig.1 shows the data-collection strategy for this investigation.

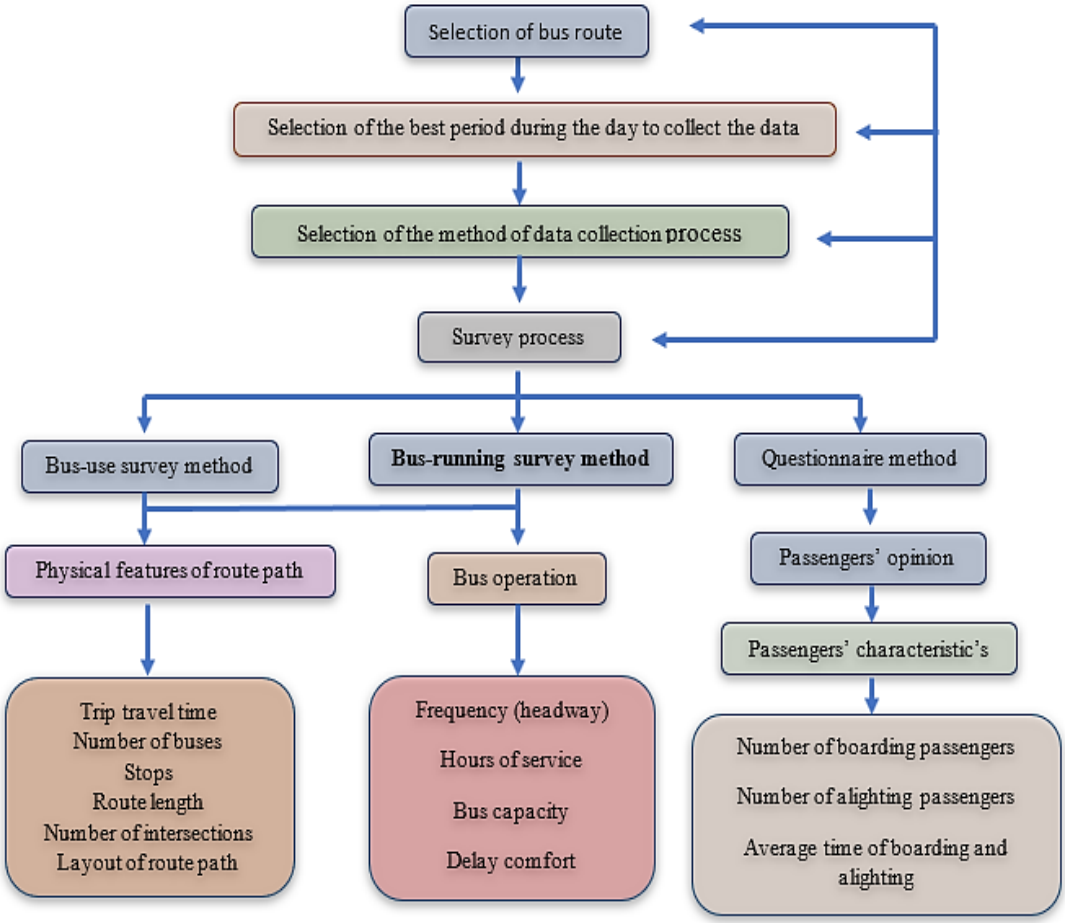

Figure 1. Methodology of Data Collection Process

6. Public Transport Modes in Baghdad City

Baghdad City sits on the banks of the Tigris River and serves as the country's commercial and economic hub. In 1870, when the first population count was taken, there were estimated to be 66,000 males living in Baghdad and the surrounding areas. The land area of Baghdad is about 734 square kilometers. From a low of 2.04 million in 1970, Baghdad's population climbed steadily to 3.189 million by 1977, 3.841 million by 1987, and 5.423 million by 1997. Baghdad City's roads and intersections have grown rapidly since the late '70s.

In the central business district and urban regions, main roads account for 23.2% and 25.6% of the entire network, respectively. Public transportation in Baghdad is managed by the General Company for Passenger Transport (GCPT). It's part of the Ministry of Transport and Communications' State Organization for Road Transport. It is the primary government agency in charge of transportation in Baghdad [40].

A total of four public benefits were made available by the Committee. Passenger transportation between Baghdad and other major centers in Iraqi provinces, as well as high-speed buses for private routes and restricted stopover services, are all part of these offerings. About 120 bus routes have been operated in Baghdad. With a total passenger capacity of between 44 and 50, GCPT operates 178 large buses going to and

from Baghdad and 25 large buses going within Amanat Baghdad [41]. Bab Al-Moadam, AL-Maidan Square, Al-Askary, Al-Tahrir Square, and Al-Nasr Square are only a few of the central business district (CBD) stops served by GCPT. These locations are commonly referred to as "major bus terminals." Buses also stop at secondary locations including Quraish Square, Baghdad Aljadida, Al-Bayia, and Al-Dora. Taking money from travelers, checking IDs, and sizing up the load. Thus, the bus will move even more slowly and experience more delays. From what was found in the field, certain bus lines do not have enough buses to accommodate the predicted number of passengers, while other lines have more buses than necessary.

7. Public Transportation Options in Baghdad

According to Al-Maaini [38], Baghdad City has five kinds of public transportation. These include:

- General Company of Passengers Transportation (GCPT).
- General Company of Administrating Private Transportation (GCAPT).
- Baghdad Company of Passenger Transportation (BCPT).
- Railway Transportation.
- Service to waterways: Due to BCPT's smaller fleet size compared to GCPT and GCAPT, only GCPT and GCAPT will be covered in detail in the following sections. Additionally. Fig. 2 below shows Baghdad's planned public transportation network.

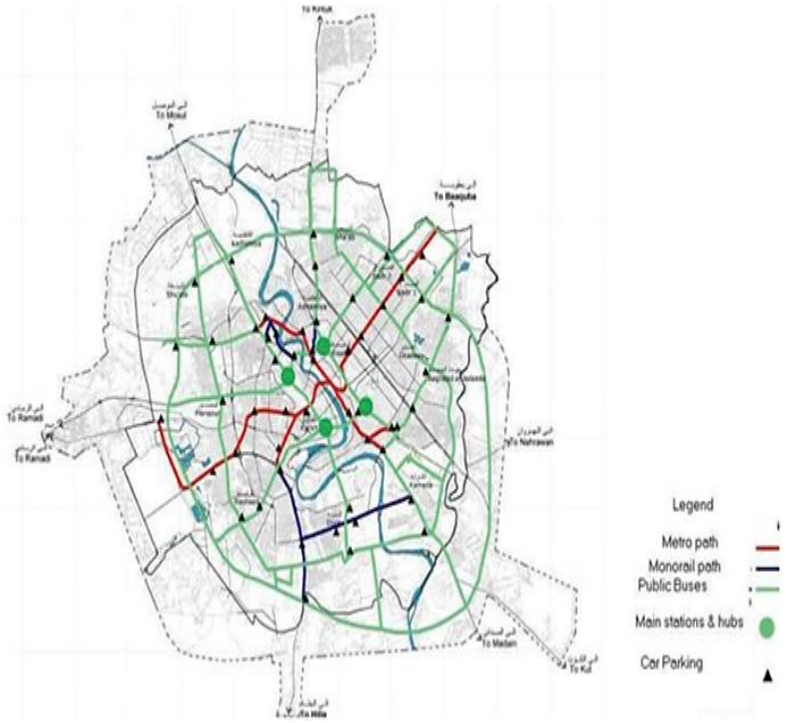

Figure 2. The planned public transportation network in Baghdad.

According to Amanat Baghdad information, Table 1 shows the five different bus routes, and Table 2 indicates the periods for each. This table shows the total number of passengers carried by these lines monthly. The information in this table can be used to calculate the number of passengers transported by each of the 19 lines during a particular month and shows that there are lines that carry much more passengers than the other lines listed here. The general condition of these bus lines is shown in Fig. 3.

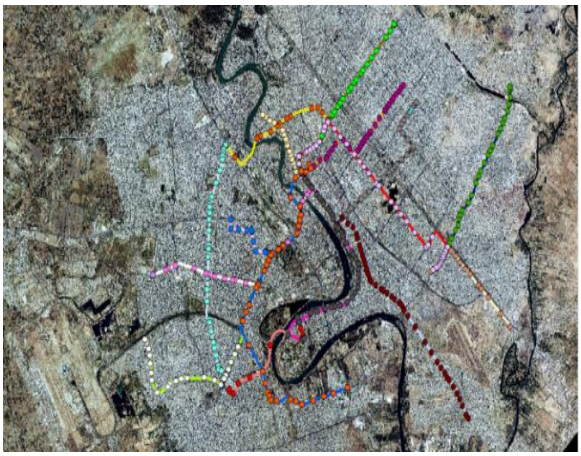

Figure 3. Public Bus Routes in Baghdad City

Table 1. The characteristics of the route

Line	Origin	Destination
4	Bab Al-Moadam	Al-Nasr square
12	Bab Al-Moadam	Baghdad University
13	Al-Nasr square	Al-Bayia
20	Bab Al-Moadam	Aljihad Neighborhood
23	Bab Al-Moadam	Al-Laka Square
31	Bab Al-Moadam	almusfaa aldawra
32	Bab Al-Moadam	Sanaa Square
33	Al-Nasr square	Al-Zaafaranya
41	Baghdad aljadida	Al Rustumiya
45	Bab Al-Moadam	Al-Bayia
46	Al-Nasr square	Aldakhal
61	Bab Al-Moadam	Al-Amriya
62	Al-Nasr square	Al Adamiyah
63	Bab Al-Moadam	Alhi Bazaar
68	Baghdad aljadida	Al-Obaidi
79	Bab Al-Moadam	Baghdad aljadida
90	Sanea' square	Al-Bayia
108	Bab Al- Moadam	Al Casra
113	Bab Al-Moadam	Al-Nessor Intersection

Table 2. The time spans, the line lengths, and the total number of people transported on each of the bus routes every month (source: Amanat Baghdad)

Line	Length (km)		Period (minutes)		The Number of Passengers Carried per Month
	go	back	go	back	
4	4.9	4.9	37.6	37.0	12.0
12	14.2	12.7	75.7	72.4	2.4
13	15.6	16.4	65.5	67.9	3.6
20	19.9	20.9	78.5	82.2	1.5
23	9.9	11.0	52.8	59.5	2.2
31	18.9	19.6	70.9	70.6	7.4
32	12.1	8.7	51.4	44.3	7.2
33	13.4	13.7	72.2	73.7	6.6
41	7.0	7.3	38.4	38.7	4.6
45	13.1	14.0	66.0	63.0	10.7
46	9.4	9.6	55.6	55.8	5.3
61	14.5	15.5	63.3	68.1	9.5
62	7.6	7.9	53.2	53.8	5.5
63	8.1	9.2	52.4	56.2	7.7
68	10.2	9.7	53.0	53.6	5.8
79	15.8	14.2	72.6	74.6	4.1
90	11.0	11.0	45.7	45.8	7.3
108	10.3	10.4	58.5	62.5	1.5
113	8.1	8.8	43.2	45.9	10.2

8. Evaluation of the Efficiency of Urban Public Transport in Baghdad

As previously indicated, numerous factors including the availability of transportation, comfort, and well-being, was used to evaluate the quality of the public transportation service in the city of Baghdad. To do this, the issue of transit accessibility was initially researched in terms of service hours, frequency of operation, and service coverage. Second, the public transportation system in Baghdad was examined concerning its comfort and convenience. Due to this, factors such as general vehicle congestion, dedication to development, and journey times between transit vehicles were taken into account. The methods outlined in the 165th report of the Transit Collaborative Research Programme (TCRP, 2013) were used to carry out the majority of these investigations [42].

8.1. Assessment of Transit Availability in Baghdad

When assessing the Baghdad transport system, operating hours, and service covering for the entire city were taken into account. To achieve this, the service level of service periods was first established for all lines per the process outlined in TCRP Report 165 according to Table 3. The last run's departure time was removed from the first run's departure time, and one hour was added to this subtraction to determine the hours of service. The last hour that service is rendered is made up of this extra hour. When service was not offered continuously throughout the day, the amount of time for each period of the day when service was offered was computed, and the sum was then used to assess the level of service [43]. With regards to the outcomes of this analysis, they are shown in Table 4. All lines provide Class "E" hours of service.

Table 3. Fixed-Route Hours of Service LOS

LOS	Service Hours	Comments
A	19-24	Night service provided
B	17-18	Late evening service provided
C	14-16	Early evening service provided
D	12-13	daytime service provided
E	4-11	Only peak hours service or limited mid-day service
F	0-3	Very limited or no service

Second, service frequency attributes were supposed to decide how frequently each route ran each day. For a full day, the service frequency for all routes leaving from Baghdad was recorded for this study. Bus schedules at bus terminals were used to determine the frequency count as well. First, a schedule for each route for an entire day was obtained as part of the operation to gather the essential data. Second, the time between each route's departures was measured. The average departure time between each route was then calculated. Last but not least, the average departure times for each route would be used to classify the level of services. The study's average departure time mirrored the frequency of services. Table 5 illustrates how the level of service frequencies would be categorized depending on the average departure interval. For the duration of a single full day, Table 6 summarizes the outcomes of this analysis as well shows that Lines No. 45, 61, and 113 offers LOS "B" in comparison to Line No. 4 offers LOS "A" for service frequency. Line No. 12 on the other hand, has a "C" for its LOS service frequency.

Table 4. Fixed-Route Hours of Service LOS of 5 bus lines in Baghdad

Line	Hours of Service of Line	LOS in Terms of Hours of Service
4	10	E
12	10	E
45	10	E
61	10	E
113	10	E

Table 5. Fixed-Route Service Frequency LOS

LOS	Average Headway	Comments
A	< 10	Passengers do not need to schedule
B	10 - 14	frequent service, passenger consult schedule
C	15 - 20	Maximum desirable time to wait if bus/train missed
D	21 - 30	service unattractive to choose riders
E	31 - 60	service available during the hour
F	> 60	service unattractive to all riders

Table 6. Fixed-Route Service Frequency LOS of 5 bus lines in Baghdad

Line	Average Headway of Line (minutes)	LOS in Terms of Average Headway
4	5	A
12	15	C
45	13	B
61	13	B
113	14	B

8.2. Evaluation of the Level of Convenience and Ease of Use in Baghdad

One of the most important criteria to select transit as a frequent mode for road user is the trip distance and its differences from the distance of car trips. For this, transit-auto journey time door-to-door difference between trip times by car and by transit, including walking, waiting, and transfer times (if applicable) are measured. Transit-auto journey time can be assessed during peak hours and off-peak hours, just like many other service metrics. The LOS thresholds for transit-auto journey time are shown in Table 7.

Table 7. Fixed-Route Transit-Auto Travel Time LOS

LOS	Travel Time Difference (min)	Comments
A	≤ 0	Faster by transit than by automobile
B	1 - 15	About as fast by transit as by automobile
C	16 - 30	Tolerable for choice riders
D	31 - 45	Round-trip at least an hour longer by transit
E	46 - 60	Tedious for all riders; may be best possible in small cities
F	> 60	Unacceptable to most riders

Table 8 illustrates the constrained range of transit-auto journey time level of service that was experienced on lines. Regarding transit-auto journey time, the majority of lines offer LOS "D", while for Lines No. 4, 113 is "C".

Table 8. Fixed-Route Transit-Auto Travel Time LOS of 5 bus lines in Baghdad

Line	Time Difference (min)	LOS in Terms of Transit-Auto Travel Time
4	21.9	C
12	38.0	D
45	30.7	D
61	30.8	D
113	22.9	C

9. Conclusions

The purpose of this study is to evaluate Baghdad's public transportation system. So, the accessibility of public transportation was examined in terms of service frequency, service hours, and service coverage. Different levels of

service were attained for each line of public transportation. The information offered by these service levels could be used to increase the effectiveness of the public transportation system. Traveling in Baghdad by public transit can take two to three times longer than traveling by car, despite adequate service coverage offered by many bus routes.

According to the findings, all lines were at service level “E" during all service hours. Service levels "A", "B", and "C" are within service frequency. Service levels "D” and "C" are within transit-auto travel time. This study makes it easier to create a thorough service level plan by serving as a valuable manual. Increasing the frequency of public transportation and making it more comfortable for passengers will encourage drivers to switch to public transportation instead of their cars. To achieve this, it is necessary to start by shortening the lengths of the lines. In addition, the city's transportation lines must run continuously throughout the day in uncrowded lanes. To increase the attractiveness of public transportation, coordination of routes between different bus lines must be provided.

Conflict of interest

The authors confirm that the publication of this article causes no conflict of interest.

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Author Contribution Statement

Sara R. Nasser and Gofran J. Qasim: proposed the research problem.

Sara R. Nasser: developed the theory and performed the computations, verified the analytical methods.

Gofran J. Qasim supervised the findings of this work.

Both authors discussed the results and contributed to the final manuscript.

References

1. Calvo, F., Eboli, L., Forciniti, C., and Mazzulla, G., (2019). *Factors influencing trip generation on metro system in Madrid* (Spain). Transportation Research Part D: Transport and Environment, 67 p. 156-172. https://doi.org/10.1016/j.trd.2018.11.021 .

2. Chow, M.F. and M.F.A. Bakar.(2017) *Environmental benefits of green roof to the sustainable urban development*: A review. In GCEC 2017: Proceedings of the 1st Global Civil Engineering Conference 1. 2019. Springer. https://doi.org/10.1017/S1742170522000138

3. Aziz A,. and J. Mohamad., (2013) .*Urban public transport in Penang: Some policy considerations.* In Proceedings of the Eastern Asia Society for Transportation Studies. 9, p. 1-19.

4. Aboud, G. M., Khaled, T. T., Ezzat, E. N., Jashami, H., & Shukri, Z. A. (2024). *Assessment of signalized intersection: a case study in Baghdad city by using sidra software*. Journal of Engineering and Sustainable Development, 28(02), 178-189. https://doi.org/10.31272/jeasd.28.2.3

5. Qasim, G. J., Jameel, A. K., Abdulwahab, A. M., & Rajaa, A. S. (2020). Estimating a congested road *capacity–headway relationship of a multi-lane highway in an*

urban area based on lane position. Periodicals of Engineering and Natural Sciences, 8(3), 1263-1279. https://doi.org/10.21533/pen.v8i3.1449.g611

6. Khudhair, H. A., Alsadik, S. M., & Jameel, A. K. (2021). *Estimation of transportation service quality for selected groups of users using customer satisfaction index*. Periodicals of Engineering and Natural Sciences, *9*(2), 325-332. https://dx.doi.org/10.21533/pen

7. Abdullah, M. M., & Asmael, N. M. (2023). *Analytic hierarchy process for evaluation of transportation alternatives on the Karkh side of Baghdad*. Journal of Engineering and Sustainable Development, 27(6), 771-782. https://doi.org/10.31272/jeasd.27.6.8

8 Lytvynenko, T., Tkachenko, I., and Gasenko, L., (2017). *Principles of the road beautification elements placin*g. Periodica Polytechnica Transportation Engineering, 45(2): p.94-100. https://doi.org/10.3311/PPtr.9228

9. Wei, M., Liu, T., Sun, B., and Jing, B.,(2020). *Optimal integrated model for feeder transit route design and frequency-setting problem with stop selection*. Journal of Advanced Transportation, 2020: p. 1-12.

10. Wang, J. and Y.J. Cao,(2017). *Operating time division for a bus route based on the recovery of GPS data*. Journal of Sensors, 2017. https://doi.org/10.1155/2017/1321237

11. Asmael, N. M., & Hussein, A. A. (2021). *GIS-based analysis accessibility to destinations based on public transport*. Journal of Engineering and Sustainable Development (JEASD), 25(5). https://doi.org/10.31272/jeasd.25.5.2

12. Soh, K. L., Chong, C. L., Wong, W. P., and Hiew, Y. H. Soh, (2014). *The proclivity of university students to use public bus transport service.* Comprehensive Research Journal of Education and General Studies (CRJEGS). 2(2): p. 24-34.

13 Shukri, N. S. M., Ponrahono, Z., Sunoto, Y. N., and Ghazali, W. N. W. W.,(2020). *Evaluation of Level of Service (LOS) on routes of smart bus in Kajang, Selangor*. PLANNING MALAYSIA, 18.

https://doi.org/10.21837/pm.v18i13.789.

14. Minhans, A., A. Chatterjee, and S.J.H.G. Popli, (2020). *Public perceptions: an important determinant of transport users' travel behaviour*. Human Geographies. 14(2): p. 177-196. https://dx.doi.org/10.5719/hgeo.2020.142.1

15. Ensor, J.D. ,(2004). *Malaysia Transport Pricing Strategies, Measures, and Policies: Inception Report. Malaysia Transport Research Gro*up Massachusetts Institute of Technology. 2004.

16. Esmailpour, J., Aghabayk, K., Vajari, M. A., and De Gruyter, C.,(2020). *Importance–Performance Analysis (IPA) of bus service attributes: A case study in a developing country*. Transportation Research Part A: Policy and Practice, 142: p. 129-150. https://doi.org/10.1016/j.tra.2020.10.020.

17. Ponrahono, Z., Bachok, S., Osman, M. M., Ibrahim, M., and Abdullah, M. F., (2017). *Public Bus Level of Service Performance in Peninsular Malaysia: Correlation Analyses on Level of Service (LOS) and Passengers Satisfaction Level*. Planning Malaysia, 15. https://doi.org/10.21837/pm.v15i1.238.

18. Abdullah, A.A., R.M.J.I.J.o.A.R.i.B. Talip, (2013). *Rapidkl bus service in city center, Kuala Lumpur, Malaysia: an epitome of good service?*. International Journal of Academic Research in Business and Social Sciences, 3(4): p. 333.

19 Ngadiman, N.I., et al. (2020). *Survey on quality of services (QoS) at larkin central terminal (LCT), Johor Bahru*. International Journal of Advanced Trends in Computer Science and Engineering, 9(1.1 SI): p. 229-232. https://doi.org/10.30534/ijatcse/2020/4091.12020

20. Norhisham, S., Bakar, M. F. A., Tajri, A. A., Mohamed, D., Yatuka, S., Masjuki, S. A., and Zaini, N, (2019). S*tatistical overview on quality bus service in Klang Valley*. Int J Adv Sci Technol, 28(10): p. 370-380.

21. Aleksander, P., (2015). A s*tudy on evaluating urban bus service performance in developing countries: case studies of medium-sized cities in Indonesia*. Doctoral dissertation.

22. Eboli, L. and G.J. Mazzulla, (2021).*Customer satisfaction as a measure of service quality in public transport planning*. International Encyclopedia of Transportation, 6: p. 220-224. https://doi.org/10.1016/B978-0-08-102671-7.10643-8.

23. Rohani, M.M., D.C. Wijeyesekera, and A.T.A.J.P.E. Karim, (2013). *Bus operation, quality service, and the role of bus provider and driver*. Procedia Engineering, 53: p. 167-178. https://doi.org/10.1016/j.proeng.2013.02.022

24. Jameel, A., & Evdorides, H. T. (2023). *Review Of Modifying The Indicators Of Road Safety System*. Journal of Engineering and Sustainable Development, 27(2), 149-170. https://doi.org/10.31272/jeasd.27.2.1

25 Eboli, L., Forciniti, C., and Mazzulla, G., (2018). *Spatial variation of the perceived transit service quality at rail stations*. Transportation Research Part A: Policy and Practice, 114: p. 67-83.

26. Asmael, N.M. and M.Q.J.A.o. C.E. Waheed, (2020). *A data envelopment analysis based for evaluating efficiency of bus public routes*. Archives of Civil Engineering, 66(4): p. 303-323.

27. Wazer, Z. A., and Asmael, N. M. (2021). A*nalysis Travel Pattern of Freight Demand Using GIS Techniques*. In IOP Conference Series: Materials Science and Engineering,1090(1), p. 012091. IOP Publishing.

28. The General Company for land transport /Ministry of Transport and communication,2019.

29. Hammadi, I. A., Mesbah, S. A. L. E. H., and Mahar, K. H. A. L. E. D., (2008). *Transportation Network Design Using GIS–Based DSS: Baghdad Metro Case Study. in Recent Advances in Systems Engineering and Applied Mathematics*, Selected Papers from the WSEAS Conferences in Istanbul, Turkey.

30. Chaichan, M. T., Kazem, H. A., & Abed, T. A., (2018). *Traffic and outdoor air pollution levels near highways in Baghdad, Iraq*. Environment, development and sustainability, 20, p. 589-603. https://doi.org/10.1007/s10668-016-9900-x.

31. Al-Akkam, A.J., (2012). *Towards environmentally sustainable urban regeneration: A framework for Baghdad City*

Centre. Journal of sustainable development, 5(9): p. 58. https://doi.org/10.5539/jsd.v6n2p39

32. Aslan, H., and Kocaman, H.,(2018) *GIS Based Bus Stop Optimisation for Sakarya Public Transportation System*. Sakarya University Journal of Science,22(5): p. 1298-1308. https://doi.org/10.16984/saufenbilder.394911 .
33. Winston, C.J., (2013). *On the performance of the US transportation system*: *Caution ahead*. Journal of Economic Literature, 51(3): p.773-824. https://dx.doi.org/10.1257/ jel.51.3.773.
34. Mattson, J., Brooks, J., Godavarthy, R., Quadrifoglio, L., Jain, J., Simek, C., and Sener, I., (2021). *Transportation, community quality of life, and life satisfaction in metro and non-metro areas of the United States*. Wellbeing, Space and Society, 2: p. 100056. https://doi.org/10.1016/j.wss.2021.100056.
35. Delmelle, E. M., Li, S., and Murray, A. T., (2012). *Identifying bus stop redundancy: A GIS-based spatial optimization approach*. Environment and Urban Systems, 36(5): p. 445-455. https://doi.org/10.1016/j.compenvurbsys.2012.01.002.
36. Murray, A.T. and X.J.J.o.G.S. Wu, (2003). *Accessibility tradeoffs in public transit planning*. Journal of Geographical Systems, 5: p. 93-107. https://doi.org/10.1007/s.101090300105
37. Ibeas, Á., dell'Olio, L., Alonso, B., and Sainz, O., (2010). *Optimizing bus stop spacing in urban areas*. Transportation research part E: logistics and transportation review, 46(3): p. 446-458. https://doi.org/10.1016/j.tre.2009.11.001.
38. *Jameel*, A. K., Jassim, N. W., & Abdulwahab, A. M. (2022, January). Land *use variables affecting travel behaviour: a review*. In Proceedings of the Institution of Civil Engineers-Transport (pp. 1-11). Thomas Telford Ltd. https://doi.org/10.1680/jtran.21.00025
39. Yiqiu, T., Qin, L., Ismael, I., and Naser, A. F. , (2021). *Performance Measures and Level of Transit Service Assessment of Public Transport Bus Network in Baghdad City during 2002-2003*. Tikrit Journal of Engineering Sciences,28(3): p. 71-87.
40. Afaf, M., (1998). *Developing a public transportation system management and operation in Baghdad city*. Ph.D. Thesis, College of Engineering, Baghdad University, Iraq.,
41. Asmael, N.M., (2016). *Analysis Local Public Transportation Using GIS (Baghdad Case Study)*. International Research Journal of Engineering and Technology, 3(10): p. 1-5.
42. Al-Maaini, F. M. (2002). *Evaluation And Improvement of The Performance of a Selected Public Bus Network in Baghdad City*, M. SC. Thesis, College of Engineering, Al- Al-Mustansiriyah University.
43. Transportation Research Board Executive Committee (2003). *Transit Capacity and Quality of Service. 2nd Edition, TCRP Report 100*