Assessment of Intelligent Transportation Services in Greater Cairo: The Case of Green Bus

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Abstract

Intelligent transportation represents a contemporary global phenomenon in cities around the world that attempts to improve the quality of life for their residents. This study aimed to assess the efficiency of intelligent transportation services in Greater Cairo, focusing on the Green Bus lines. The assessment is based on a set of criteria, including accessibility, waiting time, travel time, cost, safety, and privacy. The study relied on a questionnaire for Green Bus passengers to determine the pros and cons of intelligent transportation in greater Cairo. It used various software programs for spatial and descriptive analysis of the study data, including ArcGIS 10.8.1, SPSS 27, and MS Excel.

The study concluded that passengers appreciate the convenience of intelligent transportation, such as payment options, interactive maps showing bus routes, their locations, and estimated arrival times and accommodations for the elderly and special needs. However, privacy and overcrowding were among the challenges. Thus, this study suggests expanding the use of intelligent transportation in Greater Cairo and various governorates, ensuring a smooth transition and proper practices. It also calls for the establishment of a set of regulations to protect passengers and prevent their misuse by the owning companies. The Public Transport Authority should standardize the successful experiences for other initiatives. Intelligent transportation is a comprehensive system that encompasses various components, including management, operation, maintenance, and more. It is a way of managing that is not limited to buses alone.

Keywords: Mass Transportation; Sustainable Transportation; Intelligent Bus; Greater Cairo; and Public Transportation.

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1. Introduction

City transportation is one of the most critical infrastructures in a big city, particularly in metropolitan areas where millions of people commute daily. It plays a paramount role, capable of either enhancing the lives of city residents or transforming it into a living nightmare. Consequently, numerous countries allocate significant investments towards constructing and maintaining efficient urban transportation networks. Notably, establishing such efficient networks facilitate the seamless movement of people and goods but they require significant financial investment, as well. Today, cities face a myriad of challenges, some of which stem from the transportation infrastructure, impeding the delivery of effective transportation solutions and hindering the assurance of a high standard of living. Specifically, attention must be directed towards addressing issues related to automobile-centric transportation (Zavitsas et al., 2010). The transportation challenges of a city are closely tied to its size, and it is often observed that cities of similar sizes around the world tend to face similar issues (Dyckman, 1965).

Cities worldwide are witnessing a rapid surge in population, exerting immense strain on their existing infrastructure and transportation networks. Among these bustling cities, Greater Cairo stands as one of the largest metropolitan areas, grappling with substantial challenges concerning mobility and public transportation. As the population continues to grow and its transportation demands escalate, the enhancement and modernization of the transportation system have become pressing imperatives. In this context, intelligent transportation emerges as a promising solution to elevate transportation services, alleviate traffic congestion, and enhance the overall passenger experience. Enhancing public transportation services in Greater Cairo necessitates the integration of cutting-edge technology and innovations within the realm of intelligent transportation, such as intelligent applications, sensors, and data analytics. Among the pivotal public transit options, the intelligent bus emerges as an innovative and sustainable solution, effectively catering to the transportation needs of citizens.

This paper is devoted to assessing the intelligent transportation services in Greater Cairo, focusing, in particular, on the application of intelligent bus technology. Through a comprehensive analysis, we aim to evaluate the performance, efficiency, and potential enhancements of the city's intelligent transportation system, while exploring ways to improve passenger experience and facilitate seamless movement between various areas. Accordingly, the available data will be reviewed, interviews will be conducted, and questionnaires will be applied to gather insights from citizens and users in order to understand their perspectives and transportation needs. The study also aspires to make significant contributions towards the advancement and evolution of intelligent transportation services in Greater Cairo. By providing actionable recommendations, this paper aims to enhance the convenience and efficiency of transportation, aligning with the citizens' aspirations for a more intelligent and resilient transportation system in this pivotal urban center.

2. Area of Study

The Greater Cairo region comprises the entire Cairo Governorate, along with all its districts, as well as selected areas from Giza Governorate, namely Imbaba, Agouza, Dokki, Giza, Boulaq El Dakrour, Al-Ahram, 6th of October City, Hawamdia, Giza district, Badrashin, Awsim, Al-Warraq, Al-Omraniya, Sheikh Zayed, and Kerdasa. Additionally, it extends into certain parts of Qalyubia Governorate, including Al-Khanka, Al-Qanater Al-Khairiya, Shebin Al-Qanater, the city of Shubra Al-Khaima and El Obour City. The city of 10th of Ramadan is located in Al-Sharqia Governorate, according to JICA (2008) fig. 1.

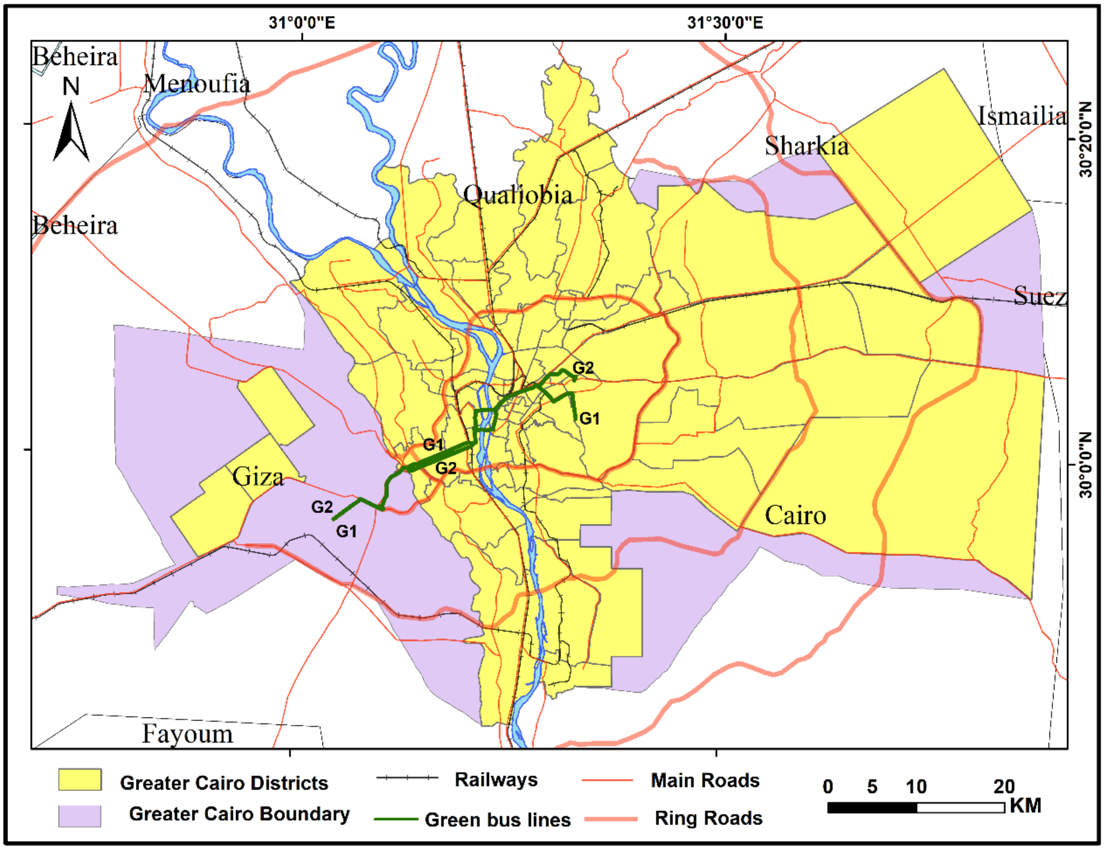


Fig. (1) Greater Cairo Region Boundary

The Greater Cairo Metropolitan Area stands as an unrivalled urban expanse in Egypt, Africa, and the Middle East, solidifying its position as one of the most populous and dynamic metropolises on a global scale. Remarkably, it claimed the 10th rank among big cities worldwide during the period from 2000 to 2015 (World Bank, 2013).

In 2017, the Greater Cairo region had a substantial population of approximately 20.2 million people, constituting around 22% of Egypt's total population (CAPMAS, 2007). Notably, the majority of this population resides in urban areas, with approximately 83.6%

living in cities. Cairo also contributes about 31% of the gross domestic product (JICA, 2008); there are about 50% of commercial, cultural, and service activities (UH-HABITAT, 1993).

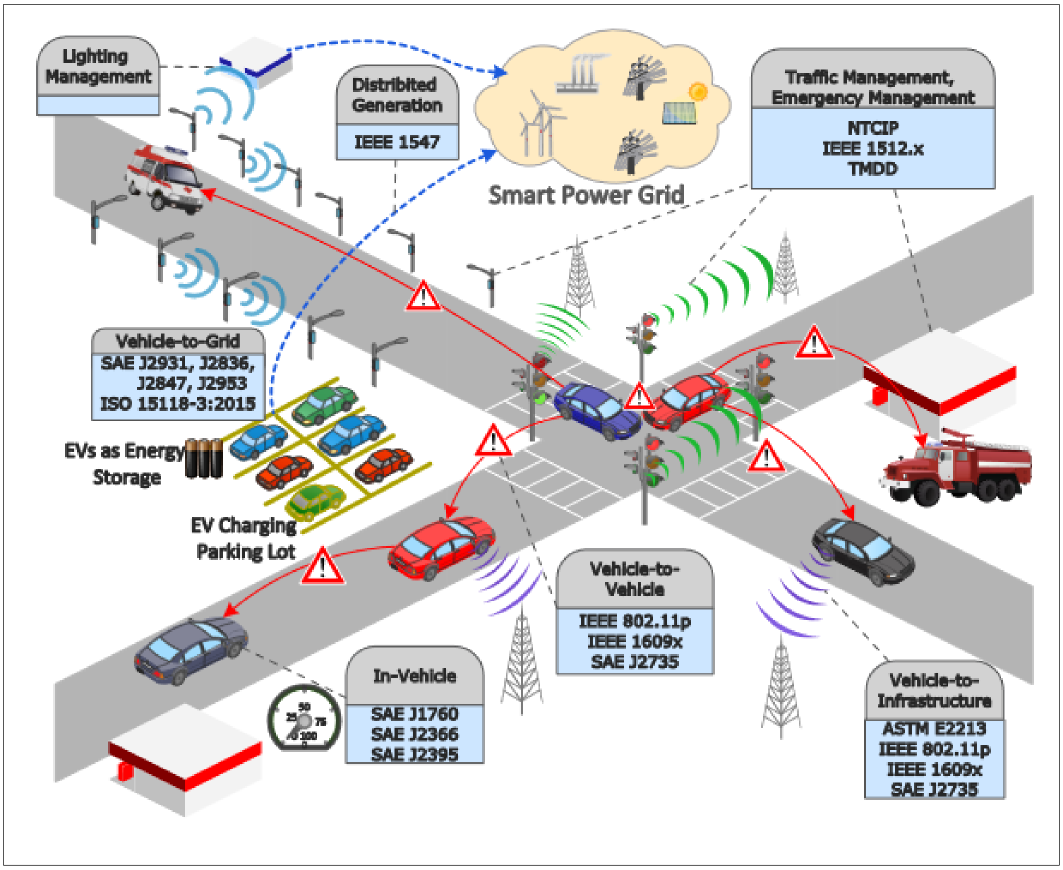
Greater Cairo is regarded as a prime city due to its significant population and the high concentration of economic activities, which encompass most of the nation's institutions. Clearly, it accommodates 55% of the country's university enrollments, 46% of hospital beds, 40% of pharmacies, 43% of public-sector employment, and 40% of private sector jobs (Smis, 2010).

3. The Concept of 'Intelligent Transportation' and its Applications

Intelligent Transportation System (ITS) is a set of advanced applications that use intelligent information and communication technologies to provide services for transportation and traffic management, and by combining various new technologies, ITS has become very efficient in solving transportation-related issues in smart cities (Zear et al., 2016). Plenty of different types of technology are employed in ITS. Car navigation and traffic signal control are two examples of management systems. They can also be more advanced apps that make better judgements by utilizing real-time data and feedback from a variety of sources. Moreover, ITS is one of the most effective ways to reduce or eliminate traffic congestion in a city. People are working on predictive algorithms to allow for effective modelling and comparisons with historical data in order to make better judgements (Tyagi & Sreenath, 2022a).

ITS uses advanced technology to provide drivers with convenient information, reducing traffic congestion and increasing available road capacity (Hou et al., 2016). It aims to improve safety, efficiency, and sustainability in transportation by integrating various ITS modules and entities, but they require effective communication and networking technologies to meet stringent requirements (Qu et al., 2010). The purpose of ITS is to learn about traffic. This data is then utilized to generate suggestions for traffic management, control, and study. It contains a wide range of technologies and functions. Technologies and processes include microwave, Bluetooth, and Internet connectivity. Also, Geographical Information Systems (GIS), data capture and sharing, camera systems, and artificial vision are all included. Detection and classification, in-vehicle systems, and digital mapping are further examples of these technologies and methodologies (Tyagi & Sreenath, 2022b).

Intelligent vehicles can provide various services, including sensing, data storage, cloud computing, data relaying, infotainment, and localization, in various situations, including emergency scenarios (Abdel Hamid et al., 2014). A major component of ITS is communication, and cellular and Wi-Fi technologies have been employed to provide Server-to-Server (S2S) and Vehicle-to-Grid (V2G) connection. Vehicle-to- Vehicle (V2V) and Vehicle-to–Infrastructure (V2I), as shown in figure (2). These technologies enable vehicles to exchange information with infrastructure and other vehicles in real-time, enhancing safety, and improving traffic flow. The integrated control platform in ITS improves transportation administration by integrating computer, electronic, and communication technologies (Qia, 2009).



Source: Turner & Uludag, 2016

Fig. (2) Wi-Fi technologies in intelligent transportations

4. Literature review

The literature reviewed highlights several key areas of interest in the realm of Intelligent Transportation Systems (ITS). Notable findings and contributions from previous studies are outlined as follows:

- **Benefits of Intelligent Transportation**: Numerous studies emphasize the manifold benefits of intelligent transportation, particularly in enhancing road safety and reducing traffic congestion. These advantages encompass improved traffic signal systems, enhanced traffic management, more efficient public transportation, and optimized vehicle routing strategies.
- **Predictive Models for Bus Speed**: Kopsacheilis et al. (2023) explore the development of predictive models for estimating commercial bus speed and identifying the factors influencing it between successive stops. Their study introduces three machine learning models (SVR, RFR, and ANN) tested on data from ten bus lines in Thessaloniki, Greece, with the ANN model yielding the most accurate results.
- **Risks in Bus Rapid Transit (BRT) Operations**: Alnsour (2023) investigates the risks associated with operating the Amman Bus Rapid Transit (BRT) system in Jordan. Through a survey of 115 respondents and expert interviews, 45 risk factors in five main groups were identified. The study underscores eight significant risks, including fuel price fluctuations, work-related stress, and the absence of supporting infrastructure.
- **Predictive Maintenance Systems for Bus Fleets**: Toni et al. (2023) aim to advance scientific knowledge and best practices for Predictive Maintenance Systems (PdM) for bus fleets in Europe, focusing on addressing key environmental challenges such as emissions control and water management.

- **Improving Road Safety**: Stepanov and Venger (2021) assert that ITS effectively addresses road safety issues by organizing traffic and ensuring safer road conditions.
- **Enhancing Transportation in Developing Countries**: Djalalov (2013) highlights the potential of ITS to reduce traffic accidents and congestion in developing countries by providing vital information on transportation systems and promoting sustainable communities. Omayer (2022) emphasizes the need for intelligent solutions in transportation systems to enhance urban sustainability and quality of life, using a case study of China's smart transportation.
- **Comprehensive Enhancements with ITS**: Fantechi et al., (2012) emphasize the multifaceted improvements that ITS brings, including transportation safety, productivity, travel reliability, informed choices, social equity, environmental performance, and network operation resilience.
- **IoT-Enabled ITS for Urban Traffic Control**: Zhu et al. (2020) present insights into how IoT-enabled intelligent transportation systems can enhance urban traffic control and management by integrating real-time and artificial intelligent systems. The result is more efficient, safe, and sustainable transportation.
- **Traffic Management Systems for Efficiency**: Buliali (2017) underscores the role of traffic management systems in improving traffic flow efficiency by providing real-time traffic information,

forecasting traffic conditions, and offering traffic recommendations to optimize the use of transportation networks.

- **Transportation's Vital Role in Society**: Transportation, as Wang et al. (2017) highlight, is an indispensable aspect of our daily lives, with deep connections to globalization, social and economic progress, and the ongoing evolution of transportation infrastructure.

These studies collectively underscore the multifaceted nature of ITS, its potential to address pressing transportation challenges, and its pivotal role in the contemporary transportation landscape.

5. Objectives of the Study

This study aimed to evaluate the quality of intelligent transportation services in Greater Cairo, focusing on green buses, using certain criteria, especially accessibility, waiting time, Travel time, Fare, comfort, safety, and privacy.

6. Data and Methods

The study was conducted following a well-structured approach that encompassed the following key steps:

6.1. Defining Goals and Criteria

The study's main objective was to evaluate the effectiveness of intelligent transportation services on the Green Bus lines in Greater Cairo. To achieve this, a set of essential criteria was established, including speed, accessibility, comfort, waiting time, safety, and privacy. These criteria served as the foundation for the evaluation process.

6.2. Data Collection

To gather relevant data, two distinct types were employed:

6.2.1 Spatial Data:

Spatial data comprised various layers such as information on Greater Cairo Streets, Green Bus lines, Green Bus stations, subway lines, subway stations, railway lines, and land use. This valuable data was sourced from reputable institutions such as the Central Agency for Public Mobilization and Statistics and the Urban and Regional Planning Authority. Additionally, maps from OpenStreetMap, Google Earth, and the Green Bus application were used to supplement the spatial data.

6.2.2 Attribute Data:

To obtain comprehensive insights, two sources contributed to the metadata:

- **Data on Green Bus**: Vital information regarding the number of Green Bus buses and passenger counts was acquired through personal interviews with the Green Bus management.
- **Passenger Data and Feedback**: To evaluate intelligent transportation services and passenger satisfaction on the Green Bus routes, a meticulously crafted questionnaire was designed and distributed to passengers during their rides. A total of 200 questionnaires were randomly distributed among Green Bus passengers, and the responses were meticulously collected and analyzed to yield accurate evaluation results.

6.3. Data analysis and Visualization

In this phase, the gathered data were processed, and visualized using several software tools, namely ArcGIS 10.8.1, SPSS 27, and Microsoft Excel. Network analysis was conducted within the ArcGIS environment to determine the accessibility zones of the green bus routes. Considering an average walking speed of 4 kilometers per hour, accessibility zones were defined within 500 meters, 1000 meters, and 2000 meters.

7. Results and Discussion

7.1. Intelligent transportation in greater Cairo

The transportation landscape in Greater Cairo (GC) has evolved significantly over the years. Daily travel increased from 5.6 million in 1971 to 21.6 million in 2001, with a notable rise in motorized journeys. The percentage of trips made on foot increased from 26% in 1971 to 36% in 1987 and 1998, but declined to 32% in 2001, likely due to the study's broader coverage area. Predictions for 2022 indicate a further increase in daily motorized journeys, reaching around 25 million. These changes reflect the region's high urban growth (JICA, 2002).

Big data analytics in ITS can enhance safety, efficiency, and profitability by analyzing traffic accidents, making flow predictions, and managing assets (Zhu, 2019). So, Egypt plans to implement intelligent transportation systems on its highways by installing devices on the sides of the road to monitor climate data, car movements, speeds, excessive loads, and non-compliant elevations.

These technologies will help reduce road accidents and improve the management of these roads. The roads that would be covered by the intelligent transportation system should include 20 roads in two phases. In the first phase, 6 roads will be included, which are: Cairo Ring Road, Shubra/Benha Expressway, Cairo/Ismailia Expressway, Cairo/Suez Expressway, Katameya/Al Ain Al Sokhna Expressway, and Cairo/Alexandria Expressway. In the second phase, the rest of the roads will be included.

Over the years, the Greater Cairo Transportation System has undergone significant growth and modifications to meet the increasing number of vehicle journeys. In 1971, there were only three modes of public transportation available, but by 2012, the system had expanded to include ten different options. Those included Cairo transport association CTA buses, minibuses, Greater Cairo Bus, Company buses, air-conditioned buses, river buses, light rail tramways (tram and Heliopolis metro), the metro, private concession lines minibuses, and unofficial modes like shared taxi microbuses and cooperatives' minibuses. This expansion has provided commuters with a wider range of travel choices to accommodate the rising demand for transportation in Greater Cairo (Huzayyin, 2004. Huzayyin & Salem, 2013).

Bus transportation policies impact urban air pollution directly through bus vehicle emissions and indirectly by influencing the use of smaller vehicles like three-wheelers, minibuses, and private automobiles, which contribute to traffic congestion. To combat air pollution effectively, policies should focus on maintaining clean buses and adhering to emissions standards while simultaneously making buses more attractive to passengers, encouraging them to choose high-occupancy transport options. This approach can lead to improved air quality, reduced traffic congestion, and a sustainable urban transportation system (Gwilliam., et al., 2004).

Many private companies have been allowed to operate intelligent transportation services in Egypt in general and in Greater Cairo in particular. This has enabled ride-sharing services like Uber, Careem, and Swvl. Additionally, it has allowed many private companies to provide intelligent transportation services in Greater Cairo through a network of bus lines, such as Mowasalat Misr, Green Bus, and others.

7.2. Intelligent Bus in Greater Cairo: Green Bus Case Study

The Green Bus initiative stands as a notable venture under the umbrella of the Greenz Mass Transportation Company in Greater Cairo. Its commencement dates back to 2015, marking its inception on two vital routes: Shubra Al-Khaima line extending to the Pyramids area in Giza; and the second line connecting Shubra El-Kheima to the Haram Hill. Each of these pivotal routes accommodates a fleet of 12 buses, encompassing conventional non-air-conditioned vehicles (Figure 3), each with a capacity to accommodate up to 48 passengers.

Source: https://www.facebook.com/GreenBusEgypt

Fig. (3). Greenz Company Buses: Shubra El-Kheima to Giza

In a pivotal stride forward, 2020 witnessed the acquisition of a concession from the Public Transport Authority, enabling the deployment of 24 intelligent buses across two meticulously charted courses:

The first route is named **G1**. It starts from the October Gardens Station, passes through the areas of Hadayek Al-Ahram, Remaya Square, Faisal Street, Giza Square, Cairo University, Tahrir Square, Ramses, Abbasid, Railway Club, Rabaa Square, altayaran Street, and ends in the Seventh District in Nasr City. Concurrently, the second route is named **G2**, originates from Hadayek October Station, traversing through significant locales including Hadayek Al-Ahram, Al-Remaya Square, Al-Haram Street, Giza, Dokki, Al-Tahrir, Ramses, Al-Abbasiya, Al-Khalifa Al-Mamoun Street, Al-

Merghani Street, culminating at the doorstep of the Girls' College in Heliopolis.

Distinguishing Features of the New Buses (Green Bus Fleet):

- Every bus is equipped with state-of-the-art air-conditioning systems.
- Seating capacity within each bus totals 42, complemented by standing room for a comparable number, effectively accommodating up to approximately 85 passengers per bus.
- Surveillance cameras, interactive display screens, and USB ports for device charging are thoughtfully integrated into each bus, enhancing the passenger experience.
- The bus is equipped with Wi-Fi service, which passengers can use for free.
- Multiple ticket options for bus fares are available; it can also accept cash payments; the convenient Green Bus mobile application; and Green Bus card. Those opting for the card or app enjoy a noteworthy 20% discount on their fare.
- Embracing inclusivity, the design extends its support to the elderly and individuals with special needs. Notably, one side of the bus is engineered to tilt, facilitating seamless boarding for these esteemed passengers.
- A designated button for passengers to press when disembarking from the bus.

Source: https://www.facebook.com/GreenBusEgypt

Fig. (4) Green Bus in Greater Cairo

- Green Bus Application: Green Bus has a mobile application contains an interactive map that people could use to find the nearest bus, its arrival time, and the locations of the following buses, as well as their arrival schedules. Additionally, through the application, you can learn about bus routes and their stations. The application can also be used for the electronic payment of bus tickets.

a) Green bus application nterface

b) fares paying by application

c) Route 1 interactive map

d) Route 2 interactive map

Fig. (5) Green Bus Application

7.2.1. Accessibility

Public transportation accessibility significantly impacts life satisfaction, environment, daily life, job opportunities, and social participation, highlighting the need for considering accessibility in planning (Saif et al., 2018). So, improving access and egress times on public transportation can significantly reduce trip time (Krygsman et al., 2004), and improves the quality of people's lives. This section of the study is devoted to assessing the accessibility of Greater Cairo's residents to the Green Bus paths. This was done by analyzing the transportation networks, and we were able to illustrate this in Figure 6.

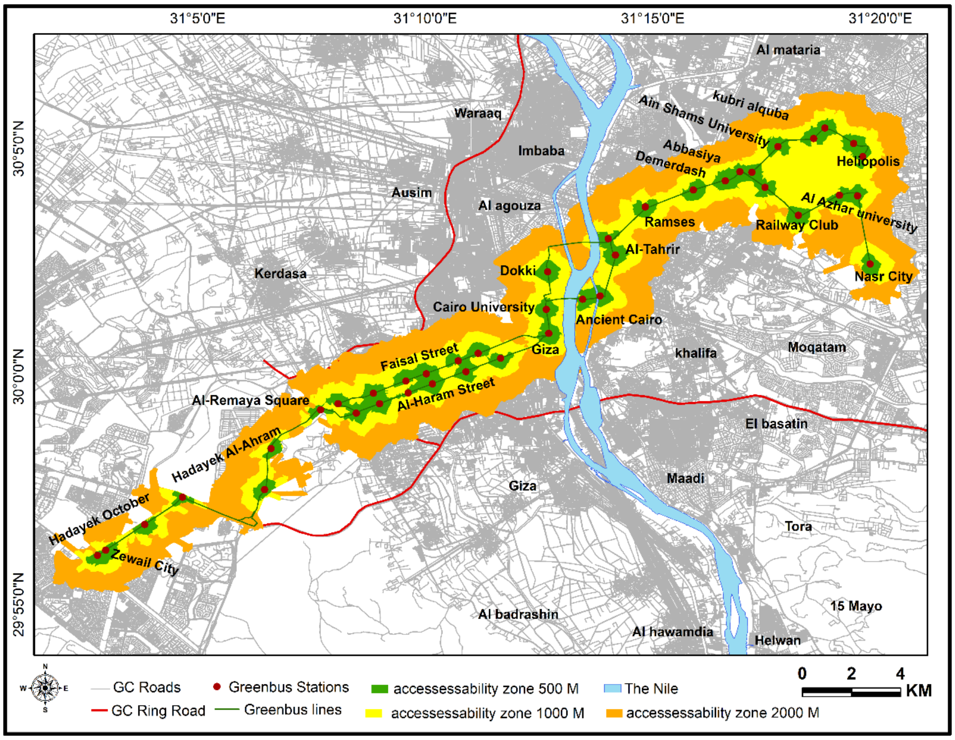


Fig. (6): Green Bus Accessibility Map

By analyzing the previous figure, we observe that approximately 17 km² of Greater Cairo's area allows its residents to access the Green Bus rapid transit system in less than 5 minutes. Furthermore, residents in an area of about 58 km² in Greater Cairo can reach Green Bus routes in under 15 minutes. Those living in an area of around 130 km² in Greater Cairo can access Green Bus routes in less than 30 minutes. In addition to the area served by the green bus routes, it passes through densely populated areas in the Pyramids, Faisal, Giza, Old Cairo, Downtown, Abbasia, Madinat Nasr, and Heliopolis. Its routes also serve several universities, including Al-Azhar University, Ain Shams University, Cairo University, and Zewail City for Science and Technology. Moreover, it connects Downtown with residential areas in the 6th of October City. What distinguishes the Green Bus route from other intelligent transportation companies is its transverse path across Greater Cairo from the west to the east, for 42 km.

7.2.2. Waiting Time

Another important item in any transportation mode is the waiting time; it saves time and attracts more passengers. The Green Bus lines, for example, operate an average of 6 buses in each direction. The operators of these buses work on a bus every 15 minutes. Figure (7) shows the result of different waiting times as an attest to the relativity between the number of users and the specific waiting time.

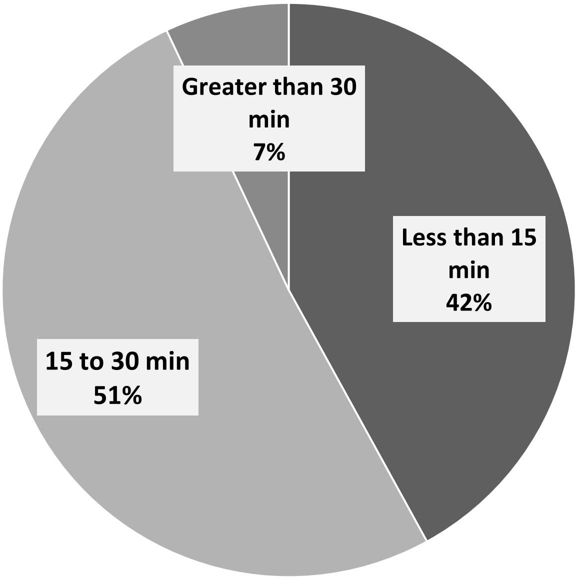


Fig. (7) The waiting time for travelers on a Green Bus

Based on this figure, it is evident that 42% of passengers perceive the bus to be punctual and wait for the bus for less than 15 minutes each time. Meanwhile, about half of the passengers wait for the bus for a period ranging between 15 and 30 minutes. Only 1% of passengers wait for the bus for more than 30 minutes. According to the questionnaire results, more than half of the passengers wait for the bus, in many cases, double the time announced by the operating company, with less than 10% noting irregularity in schedules. The frequent lateness of the bus is likely due to traffic congestion on the streets it passes through, especially in densely populated areas and streets with high traffic volume, such as Faisal Street, Al-Haram Street, Giza Square, downtown Al-Qasr Al-Aini, Ramses Square, Ramses Street, and Abbasiya Square.

The morning rush in Cairo is typically from 7-10 a.m., and the afternoon peak is from 3-6 p.m., corresponding to the departure and return times of employees and students. You can verify this through the Green Bus mobile application, which utilizes GPS to determine the bus’s location and estimate the time remaining for its arrival. Worth mentioning, this application initially provides a five-minute estimate for the bus’s arrival, followed by a 7- or 10-minute wait for the bus to arrive. When you look at the traffic map of the street it passes through, you realize that traffic congestion plays a significant role. This shows the difference between theory and practice in different cultural & economic regions.

7.2.3. Travel Time

Ridership on public transportation may be affected by several factors, including bus fares, service availability, and dependability. Additionally, modifications to bus travel times have a considerable impact on patronage. In particular, research by the Transit Cooperative Research Program (TCRP) found that a 0.4% drop in ridership is predicted for every 1% increase in overall journey time (Kopsacheilis et al., 2023). The influence of timeliness differs based on the type of vehicle utilized and the purpose of the journey (Kala, 2016). So, for individuals rushing to catch a flight or to receive emergency medical service, the importance of timely arrival differs for them compared to those who are going for a leisure outing. Given that intelligent transportation utilizes modern technological techniques such as remote sensing, artificial intelligence, and data analytics to enhance traffic flow and provide better services, it is expected to contribute to reducing travel time. To confirm this, passengers of one of the intelligent transportation modes in Greater

Cairo, the Green Bus, were asked about the travel time on the bus and compared it to other means of transportation. The survey results are clearly shown in figure (8).

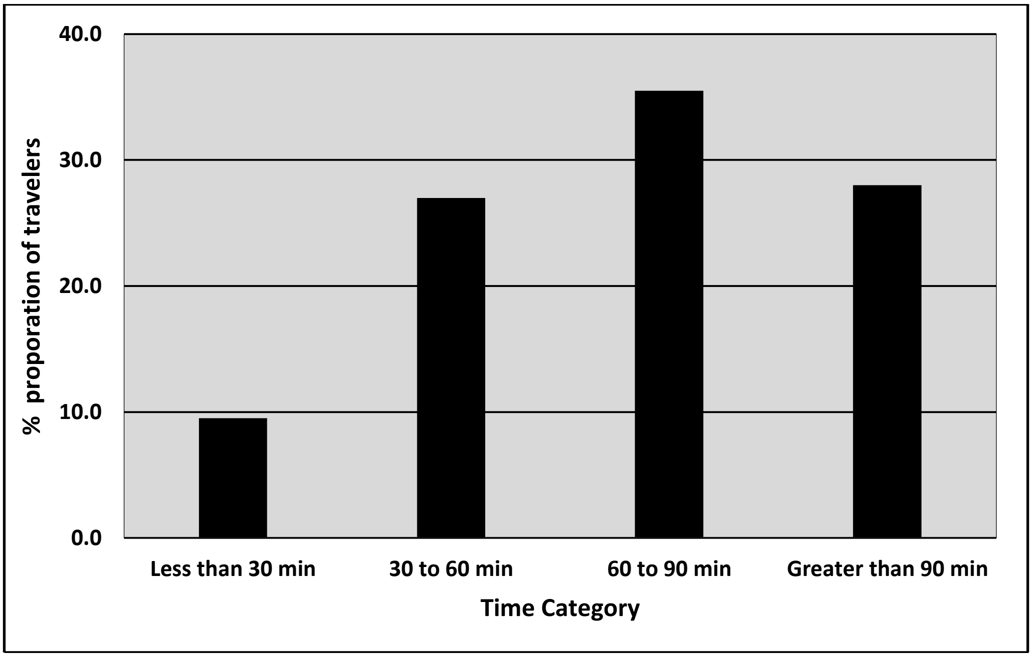


Fig (8) The travel time for travelers on a Green Bus

Through the previous figure, we notice that about two-thirds of Green Bus passengers spend more than an hour on the bus. Approximately 38% of the passengers spend more than an hour and a half on their bus journey. If the length of the bus route in any direction is about 43 kilometers, this means that the bus travels at an average speed of less than 30 kilometers per hour. This might explain passengers' opinions when asked to compare the travel time on the intelligent bus with other means of transportation. Sixty percent of the passengers indicated that the Green Bus is equal in travel time to other means, whether other surface transportation such as public buses, minibuses, microbuses, or underground transportation like subways. Meanwhile, about one-third of the passengers stated that the Green Bus takes more time than other means. What does this mean? Do traditional modes of transportation sometimes have a shorter travel time than the intelligent bus?

Perhaps the main reason for the extended travel time on the Green Bus is the frequent stops the bus makes during its journey. The bus does not adhere to specific stations like squares and main road intersections but stops for anyone signaling to it, even if it's every hundred meters. It stops for every passenger when they want to get off, regardless of the designated stations. Consequently, the number of bus stops increases, increasing the bus travel time by up to half an hour. If traffic congestion were the sole reason for the extended travel time, a third of the passengers would not have indicated that the bus takes more time than other means.

7.2.4 Bus Fare

"Bus fares" refers to the amount of money one has to spend in order to use the bus as a mode of transportation. These fares vary depending on the location, distance, type of bus, and sometimes the time of day. There are many types of fares, such as unified fare, student fare, concession fare, off-peak fare, peak fare, distance-based fare, and zone-based fare. In Greater Cairo, many microbuses and the subway operate on a zone-based fare system. However, most buses, including many of the buses, have a unified fare regardless of the distance, with the green bus being one of them. As for payment systems, the majority of public transportation in Greater Cairo accepts cash. However, intelligent buses like the Green Bus and the

Mowasalat Misr have various payment options, including cash, cards, or the mobile app.

When the Green Bus lines started operating in July 2021, the fare was just ten Egyptian pounds and remained so until August 2021. Later, the fare was increased to 15 Egyptian pounds for cash payments and 12 Egyptian pounds for card and mobile app payments. In 2023, the bus fare was further increased to 20 Egyptian pounds for cash and 14 Egyptian pounds for card and application payments. This fare increase coincided with the rise in fuel prices in Egypt. To gauge passengers' opinions on the Green Bus fare compared to other modes of transportation, they were asked about their views on the fare for riding the Green Bus. Their opinions were summarized as follows:

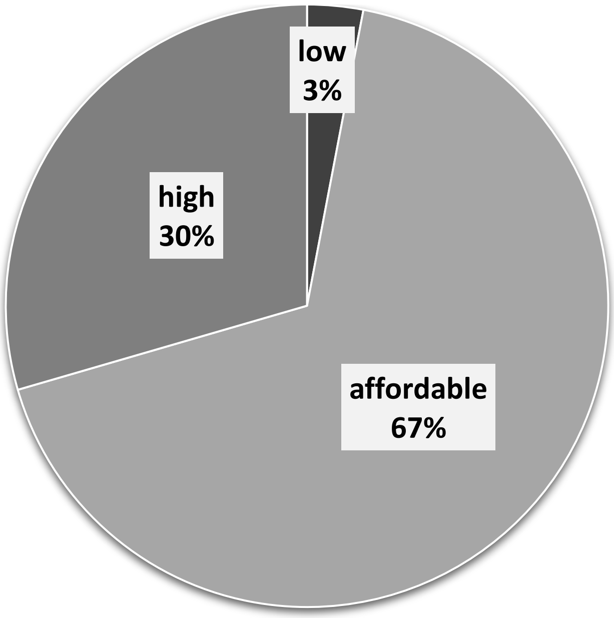


Fig (9) Passenger Assessment of Green Bus Fare

Through the previous figure, it is observed that approximately two-thirds of Green Bus passengers find the bus fare suitable for the distance and service it provides. However, 30% of the passengers mentioned that the bus ticket is expensive, especially after the fare was raised to twenty pounds . These prices have a greater impact, especially on low-income individuals. If a father has three children in various educational stages who take the bus for their daily round-trip commutes, he would be required to cover transportation costs exceeding 2000 pounds monthly. Consequently, there must be several transportation alternatives with varying prices to accommodate all economic and social segments. This approach aims to attract passengers to public transportation.

7.2.5 Comfort

Bus comfort plays a significant role in shaping the overall quality of bus services (De Oña et al., 2013). The definition of public transportation comfort was based on various attributes including cleanliness, air-conditioning, seat availability, low-floor design, crowd levels, accessibility, and travel time (Jain et al., 2014). Whereas about two-thirds of Green Bus passengers spend more than an hour on the bus, making passenger comfort during the journey of utmost Importance. “To assess the level of passenger comfort while dealing with the Green Bus, their responses were as indicated in Table 1.

Table (1) Comfort Assessment * Seat for Sitting During the Trip Crosstabulation

count		Comfort Assessment			Total
		Comfortable	Somewhat comfortable	Uncomfortable	
Seat for Sitting During the Trips	Always	56	16	1	73
	Sometimes	56	61	1	118
	Rarely	6	3	0	9
Total		118	80	2	**200**

Based on the previous table, it is evident that the majority of Green Intelligent Bus passengers find it comfortable compared to other means of transportation. This may be due to several reasons, including:

- The bus is air-conditioned, reducing heat stress for passengers, especially during the summer season.
- The bus is always clean.
- The bus provides comfortable seating and facilities for the elderly and people with special needs, making it easier for them to board and disembark.
- There are various alternatives for ticket payment.

In this context, 1 out of 5 Green Bus passengers believe the bus is somewhat comfortable. When linking the evaluation of passenger comfort on the bus to the presence of a seat during the trip, it is found that most of those who find the bus completely uncomfortable are those who do not find a seat during the trip. Often, the bus has many passengers who cannot find seats to sit on during the trip. In this context, it becomes clear that providing sufficient seating plays a prominent role in improving the passengers’ experience on the bus. Public transportation operators should take steps to ensure the availability of sufficient and comfortable seats to ensure passenger comfort during trips. These observations are important for improving transportation services and meeting the needs and expectations of passengers.

7.2.6 Safety

According to World Health Organization estimates, approximately 1.35 million individuals worldwide succumb to road accidents each year, making them the primary cause of death within the 5-25 age bracket. Egypt ranks among the highest in the world in road accidents, reporting 9,287 fatalities in 2016, equivalent to 9.7 fatalities per 100,000 people (WHO, 2018). Hence, Egypt is actively working to enhance the adoption of intelligent transportation solutions, aiming to significantly bolster road safety and diminish accident rates. Indeed, safety was a significant factor motivating passengers in Cairo to opt for the Green Bus. A notable 27.5% of passengers chose the Green Bus over other modes of transportation, attributing their choice to the evident safety it offers, as depicted in figure 10.

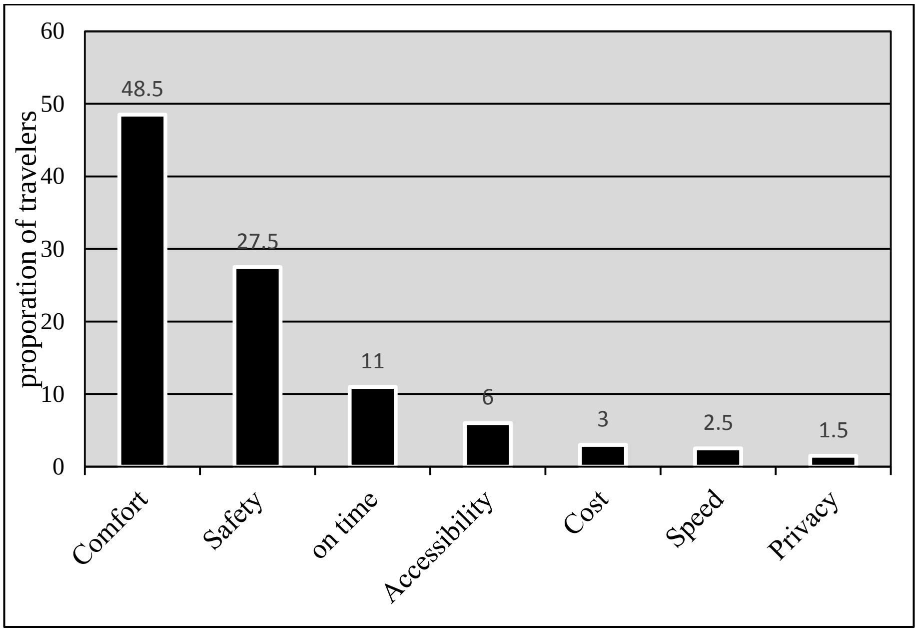
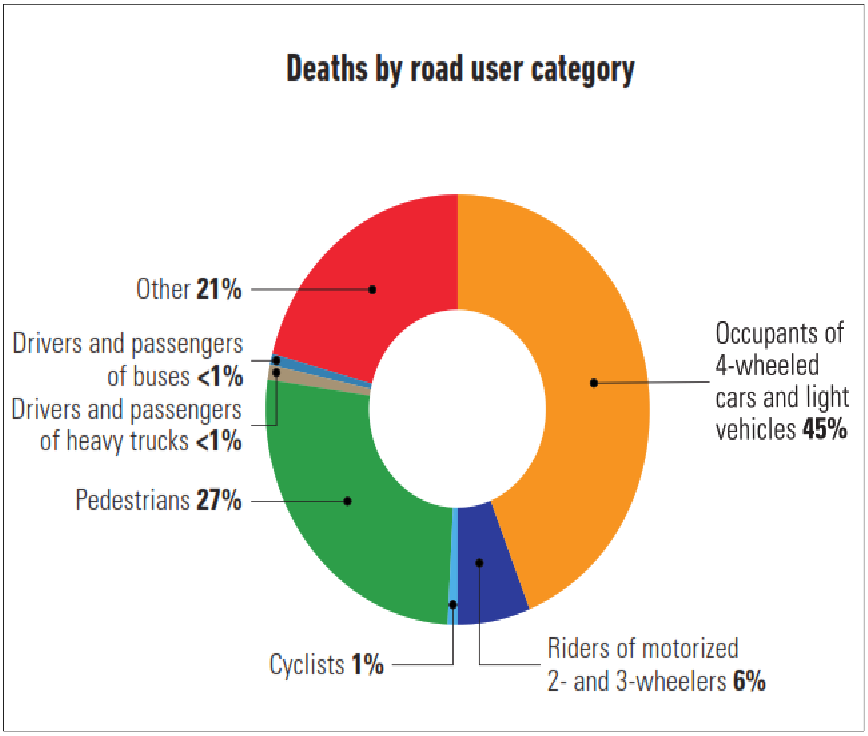


Fig. (10) The reasons passengers prefer intelligent buses over other means of transportation

Approximately two-thirds of Green Bus passengers surveyed consider the bus to be completely safe during their journey, while the remaining proportion view it as relatively safe. None of the Green Bus passengers mentioned it as being unsafe. This perception is not exclusive to Green Buses; buses in Egypt represent the least proportion of road accident fatalities, accounting for no more than 1% of the total fatalities. On the other hand, light vehicles and private cars constitute the majority, making up around 45% of the total estimated accidents in 2018, as illustrated in figure 11.



Source: WHO, 2018

Fig. (11) Deaths by road user category in Egypt

7.2.7. Privacy

Intelligent transportation systems utilize advanced technology, data analysis, and real-time communication to improve the efficiency and safety of transportation. Emerging technologies, including connected sensors, intelligent phones, and intelligent cards, offer exciting prospects for collecting extensive real-time data about travelers. Moreover, intelligent phones enable travelers to proactively share information, such as their planned travel arrangements. Access to this valuable information has the potential to significantly enhance the decision-making and actions taken by those involved in public transportation (Jevinger & Persson, 2019).

The data gathered through ITS holds promise, as previously noted, but it also elicits significant concerns regarding accessibility, storage practices, and retention periods. This information could encompass an individual's identity, address, and travel patterns, underscoring the critical need for stringent data protection measures to deter any misuse. In Egypt, the realm of intelligent transportation primarily involves a blend of local and multinational private enterprises. Additionally, apprehensions persist

regarding the potential tracking of individuals and the potential creation of profiles based on their travel behaviors within these ITS.

In order to gauge passengers' assessment of privacy on the intelligent bus, Green Bus passengers were surveyed regarding their satisfaction with privacy during their journeys. Their evaluation of privacy was notably low, as depicted in the figure. It wasn't just about data handling and its security, as previously highlighted. It was also attributed to the significant overcrowding inside the bus on numerous occasions. Overcrowding leads individuals to lose their personal space, intensifying discomfort and rendering the travel experience far from pleasant for them.

8. Conclusion and Recommendations

In recent years, Egypt has seen the adoption of Intelligent Transportation Systems (ITS) to enhance road efficiency and reduce accident rates. intelligent buses have made a significant impact in Greater Cairo, with various companies like Mowasalat Misr, Green Bus, and Swvl entering the scene. What sets the Green Bus network apart from other ITS is its extensive coverage, connecting neighborhoods throughout Greater Cairo. It links areas like Nasr City, Heliopolis, Downtown, ancient Cairo, and Giza, including Dokki, Haram, and Imbaba. Moreover, it serves new urban communities such as Hadayek Al-Ahram and Hadayek October, along with several prominent universities like Al-Azhar University, Ain Shams University, Cairo University, and the City of Scientific Research and Technology.

Green Bus provides passengers with a range of distinctive services, including air conditioning, Wi-Fi, display screens, and multiple payment options. It offers an interactive map of bus routes and their locations, making it convenient for passengers to plan their journeys. Furthermore, the service caters to the needs of the elderly and individuals with specific requirements. While the majority of Green Bus passengers experience wait times of 15 to 30 minutes, these delays are often attributed to traffic congestion, despite the system's reliance on GPS for bus tracking and time estimation.

The study findings reveal that, in terms of travel time, ITS does not consistently offer a significant advantage over other modes of transportation. In some cases, they may even consume more time, especially when frequent stops are made without adherence to specific bus stations, which significantly extends the duration of the journey. Approximately one-third of Green Bus passengers find ticket prices to be high and burdensome. Nevertheless, the service is generally considered comfortable, thanks to amenities like air conditioning that reduce heat-related discomfort, especially during the summer months. However, privacy concerns arise due to the data collected by intelligent transportation companies, which include individual information, movements, and activities. Moreover, overcrowding during peak hours can lead to passengers losing their personal space.

In addition, the study recommends expanding the use of intelligent transportation systems in various cities in Egypt, considering the benefits they provide to passengers and ensuring a smooth transition and proper practices. It emphasizes the importance of these modes of transportation being sustainable. Additionally, the study highlights the importance of monitoring private companies to ensure their commitment to distinctive intelligent transportation services that respect passenger rights and privacy. It is advised to establish appropriate laws and regulations to protect passenger data during the use of intelligent transportation systems, thereby avoiding misuse by companies collecting this information. The study also recommends the necessity of obligating bus lines to specific stations with a distance between them not less than 1 kilometer and avoiding random stops anywhere.

Finally, the study suggests that the Public Transport Authority should draw insights from the successful experiences of private intelligent transportation companies such as Green Bus and Mowasalat Misr to ensure the success of its own initiatives in this field. The development of the public bus fleet by the Public Transport Authority will enhance its services, but it's essential to recognize that intelligent transportation is a comprehensive system encompassing various components, including management, operation, maintenance, and more, extending beyond buses alone.

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تقييم خدمات النقل الذكي في القاهرة الكبرى بالتطبيق على خطوط أتوبيس جرين باص

ملخص

يشكل النقل الذكي اتجاها عصريا في المدن حول العالم من أجل تحسين جودة حياة قاطنيها، وقد هدفت هذه الدراسة الي تقييم كفاءة خدمات النقل الذكي في القاهرة الكبري بالتركيز على خطوط اتوبيس جرين باص، وتم التقييم اعتمادا على مجموعة من المعايير هي: سهولة الوصول، ووقت الانتظار، وزمن الرحلة، وتكلفة الرحلة، والأمان، والخصوصية. وقد اعتمدت الدراسة على استبانة طبقت على ركاب اتوبيس جرين باص لمعرفة مدي رضائهم عن الخدمات المقدمة، وقد استخدمت الدراسة عدد من البرامج لإجراء عمليات التحليل المكاني والوصفي لبيانات الدراسة هي: Arc gis 10.8.1, SPSS 27, MS Excel.

وقد توصلت الدراسة الي أن وسائل النقل الذكي توفر خدمات للركاب غير متوفرة في وسائل النقل التقليدي مثل طرق الدفع المتنوعة والخرائط التفاعلية لمسارات الاتوبيس وأماكن تواجدها والزمن التوقع لوصولها وتسهيلات لكبار السن وذوي الاحتياجات الخاصة. أيضا توصلت الدراسة ان الراحة والأمان والوصول في الموعد وسهولة الوصول لخدمات النقل الذكي كانت من أبرز دوافع الركاب لاستخدام وسائل النقل الذكي، في حين كانت انخفاض الخصوصية فيما يتعلق بالبيانات التي تجمعها الشركات عن الركاب وضوابط استخدامها، والازدحام وفقد الركاب لمساحتهم الشخصية داخل الاتوبيس، وارتفاع تكلفة الرحلة من أبرز مشكلاته.

وقد أوصت الدراسة بضرورة التوسع في استخدام وسائل النقل الذكي في القاهرة الكبرى ومختلف المحافظات، وأن يكون الانتقال للنقل الذكي بشكل هادئ وممارسات صحيحة تتفق مع ظروف معيشة الناس وثقافتهم، مع ضرورة متابعة تشغيل الشركات الخاصة من حيث التزامها بتطبيق خدمة نقل ذكي مميزة، سن القوانين والتشريعات التي تساعد في الحفاظ علي امان بيانات الركاب اثناء استخدام النقل الذكي لعدم إساءة استخدامها من قبل الشركات المشغلة له، أيضا ينبغي أن تقوم هيئة النقل العام بمحاكاة تجارب نجاح شركات النقل الذكي الخاص للاستفادة منها تجربة النقل الذكي لديها، فالنقل الذكي منظومة تشمل العديد من المقومات: منها الإدارة، والتشغيل، والصيانة.. وغيرها وليس اتوبيسات فقط.

الكلمات المفتاحية: النقل المستدام، الاتوبيس الذكي، القاهرة الكبرى، النقل العام، النقل الجماعي.