J. Egypt. Acad. Soc. Environ. Develop., 25 (1):53-78 (2024) (D-Environmental Studies)
E. mail: easedjournal_egypt@yahoo.com ISSN 1110-8770
www.jades.journals.ekb.eg eISSN 2314-5471 (online)

Sustainability of Urban Transportation Systems in light of the Application of Performance Efficiency Indicators on the Administrative Capital Monorail in Greater Cairo

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Received: August 20, 2024
Accepted: October 24, 2024

ABSRTACT

In response to the growing demand for public transportation in Egypt, transportation authorities face the challenge of selecting technologies that meet often conflicting requirements, such as high capacity, safe service, urban integration, limited environmental impact, and budget constraints. To meet these competing demands, the chosen technology must ensure sustainable urban transportation. Although monorail systems have existed globally for some time, recent developments have led Egyptian transportation authorities to consider the monorail as a key competitor to meet Egypt's mass transit needs .

To assess the sustainability of the monorail, this research focuses on identifying global Transport Key Performance Indicators (KPIs) for sustainable urban transportation and evaluating their applicability to the Egyptian context. These indicators were then applied to the Administrative Capital Monorail project in Egypt. The study concludes that the planning of the monorail in Greater Cairo has a significant environmental, economic, and social impact on the entire region. Furthermore, the monorail is identified as a mode of transport that supports the sustainability of urban transportation. The research concludes with a set of recommendations to align with these KPIs and promote the concept of sustainable urban transportation.

***Keywords*:** Key Performance Indicators (KPIs) – Sustainable Urban Transport – Monorail Administrative capital in Egypt.

INTRODUCTION

Urban transportation plays a crucial role in the daily movement of city residents, forming the backbone of urban life. It enables individuals to carry out their daily activities, such as commuting between work and home, and strengthens social ties while boosting commercial and service activities. By reducing the isolation caused by distance, urban transportation facilitates travel between different areas, particularly remote ones. (Sarah, 2015) Public transportation systems are essential to achieving a comprehensive goal: enabling all users to move to various destinations (work, residence, services, commercial centers, etc.) under the best conditions—quickly, safely, and comfortably. This is especially important in Greater Cairo, where the transport network is strained by severe congestion and overcrowding. Traffic jams have become a common issue, and the public transport network is insufficient in capacity and coverage to meet the growing demand. Additionally, access to new urban communities, such as the New Administrative Capital, remains difficult, increasing dependence on private cars and exacerbating the problem (Jean-Paul, 2006).

Strategic initiatives aim to expand public transport options, particularly those serving new urban areas like the New Administrative Capital. These initiatives also include incentives to reduce private car usage and encourage public transportation use, alongside projects to improve road networks. (Planning),

The establishment of the New Administrative Capital will have a significant impact on the country's transport flows, as it involves relocating all government agencies, legal departments, schools, universities, and creating new job opportunities. The capital's distance from densely populated areas makes it essential to build transport infrastructure to serve it. Moreover, this infrastructure, including transport systems, must be sustainable. Sustainable urban transportation involves striking a balance between present and future environmental, social, and economic factors (Steg and Gifford, 2005).

To ensure the continuous improvement of transportation services like the monorail, performance metrics are a key tool for transportation agencies to align with their strategic goals. A variety of Transport Key Performance Indicators (KPIs) have been developed to describe different aspects of transport services. These KPIs can reflect the perspectives of passengers, transport agencies, and the broader community. From the passenger's viewpoint, they measure satisfaction with the service, while from the agency's perspective, they assess the transport system's performance as a business operation. Community-focused KPIs evaluate the transport system's contribution to societal goals, such as employment, property values, or economic growth. These KPIs also include measures of how transport contributes to community mobility and its environmental impact (Elboli, 2012).

The monorail is one of the key transportation facilities the government is currently developing at a rapid pace. It is considered an environmentally friendly public transport system with high speed and capacity. As such, the monorail is a vital element in achieving sustainable urban transportation, contributing to the efficiency of transport systems and enhancing overall service performance (Sarah, 2015).

Research Problem

The planning of the monorail system in Greater Cairo has a significant impact on sustainable development in environmental, economic, and social aspects. The core research problem revolves around evaluating the effect of the Administrative Capital Monorail's planning on the sustainability of urban transportation in the Greater Cairo region.

Research Objective

The primary objective of this research is to identify and utilize transport KPIs to measure the performance efficiency of the monorail system in Egypt, with a specific focus on the Administrative Capital Monorail. The goal is to assess the extent to which the monorail serves as a sustainable urban transport system, thereby contributing to the transformation of urban transportation in Egypt into a more sustainable model.

METHODOLOGY

The research methodology is based on four consecutive pillars:

1) Conceptual Framework of Sustainable Urban Transport: This pillar addresses urban and technical challenges related to urban transportation. It explores the concept of sustainable urban transport and focuses on sustainable public transport systems, particularly the monorail, as a form of sustainable urban mobility. It also provides a historical overview of monorail systems, followed by the identification of transport KPIs relevant to the performance of sustainable urban transport and specifically tailored to the monorail system.
2) Application of the Theoretical Framework to Global Monorail Experiences: This section applies the theoretical understanding of transport KPIs to global monorail systems,

analyzing how these international experiences reflect on the efficiency indicators of monorail systems in relation to sustainability.

3) Impact of the Monorail on the Administrative Capital and Greater Cairo: This pillar studies the influence of the monorail on the New Administrative Capital and Greater Cairo. It examines the existing transportation challenges in Greater Cairo, the goals of sustainable public transport within the region, and the objectives behind constructing the Administrative Capital Monorail.
4) Link Between the Monorail's Success and Transport KPIs: The final pillar connects the success of the monorail system to transport KPIs by analyzing how the performance of the monorail affects the sustainability of public transportation in Egypt. As Shown in figure (1) It highlights how achieving these KPIs can transform public transportation into a sustainable system.

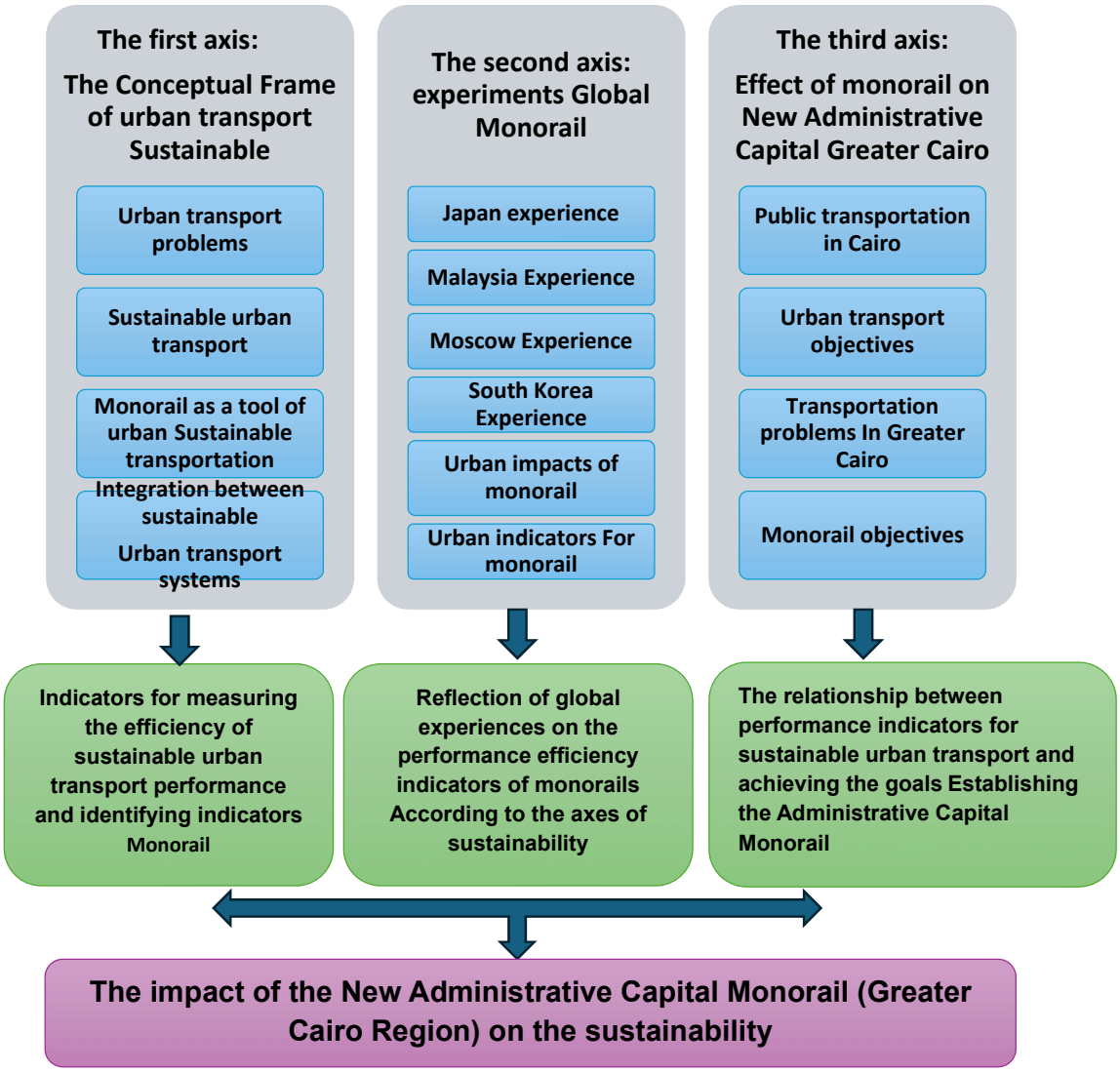

Fig. 1. Research methodology. Source: Author

This comprehensive approach evaluates how effectively the monorail contributes to sustainable urban mobility in Egypt and provides recommendations for ensuring its alignment with transport KPIs for a sustainable future.

RESULTS AND DISCUSSION

1 Theoretical Background

1.1 Urban Transportation

Urban transportation refers to the service that connects various urban hubs, facilitating the movement of people and goods according to a well-structured plan that addresses needs and ensures integration. Its primary goal is to enhance the dynamic flow of city life and guarantee mobility for all users (Jean-Paul, 2006; Transportation, 2014; Mehdi, 2015-2016).

1.1.1 Urban Transportation Problems

Urban transportation issues vary from city to city depending on factors like the city's size and function. Some of the most significant problems associated with urban transportation are ((Jean-Paul, 2006; Sarah, 2015)

1) Urban Problems which include the following:

- Traffic Congestion: Traffic congestion leads to a deterioration in the level of service on road networks. This degradation is manifested in several ways:
  - Delays in passenger journey times.
  - Increased operational costs for public transportation vehicles.
  - Increased stress, fatigue, and frustration among road users.
  - Difficulty for pedestrians both in navigating the roads and crossing them.
- Parking Problems: Parking has become a significant urban issue due to factors like population growth and the concentration of urban activities. Furthermore, parking difficulties contribute substantially to traffic congestion as they hinder smooth traffic flow, leading to time loss. The imbalance between the supply and demand for urban land dedicated to transportation also exacerbates these issues (Sarah, 2015)
- Difficulty Connecting Suburbs to City Centers: The concentration of activities in city centers creates intense traffic towards these areas, making it difficult for suburban residents to travel to the city center. Urban planners and researchers often view suburbs as "push" zones and city centers as "pull" zones. However, the failure lies in poor planning and the weak connection of suburbs to the central area, which should instead promote urban cohesion. It’s crucial to ensure that public transportation can reach all parts of the region, especially new urban communities (Sarah, 2015; Darwish, 2014). (Sarah, 2015), (Darwish, 2014)
- Environmental Impact: Large urban centers, with their growing populations, are associated with an increasing number of motorized vehicles, which are significant contributors to air pollution. According to global reports, the transportation sector accounts for approximately 24% of total commercial energy consumption. Road transportation alone is responsible for 83% of this figure, making it a major contributor to air pollution and a key factor in climate change. Vehicle emissions, especially from fuel combustion, play a critical role in raising ambient temperatures (Sarah, 2015; Korkor, 2021; www.energy.gov, 2023).
- Economic Impact: Traffic congestion and delays in accessing public transportation systems affect economic growth. These issues cause delays in the delivery of goods and people to their destinations, resulting in higher transportation costs and reduced workforce punctuality. This directly affects general revenues and the broader economic output (Sarah, 2015; Reuters, 2022).

In addressing these issues, it is essential to employ Transport Key Performance Indicators (transport KPIs) to measure and improve the efficiency and sustainability of urban

transportation systems. These indicators can provide insights into service performance, user satisfaction, and the system's overall impact on the environment and economy.

2) Technical Challenges in Urban Transportation

- Inefficiency of Transportation Modes: One of the most prominent technical issues in urban transportation is the lack of comfort in certain transport modes, particularly in public transportation systems. This problem is especially significant in urban buses, where overcrowding is common, and passengers often face uncomfortable conditions. These issues negatively impact both mental and physical well-being, as passengers experience noise, discomfort, and stress due to the crowded environment. This inefficiency is exacerbated by poor monitoring and low awareness among users of public transport (Sarah, 2015).
- Traffic Accidents: Key causes of urban traffic accidents include: (Sarah, 2015)
  - High population growth and rapid economic development.
  - Poor land use planning and inadequate urban development.
  - Low rates of public transport usage, non-motorized transport, and walking.
  - Increased heavy vehicle traffic: While heavy vehicles contribute only a small percentage of overall traffic accidents, improving public transport systems will have a positive impact in supporting sustainable transportation Darwish, 2014).
- Noise Pollution: Urban residents are often exposed to traffic noise levels exceeding 15 decibels, which is considered the threshold for causing discomfort and hearing damage. Prolonged exposure to traffic noise can lead to hearing impairment, deafness, hypertension, increased stress, and psychological disorders over time (Sarah, 2015).
- Problems with Private Cars: Comparative studies between public transport and private vehicles have shown that private cars are the least fuel-efficient form of transportation. Additionally, private cars are responsible for 60% of the total urban pollution due to exhaust emissions (Jean-Paul, 2006; Darwish, 2014). .

Addressing these technical challenges is critical for improving urban transportation systems and advancing the development of sustainable urban transport through the implementation of Transport Key Performance Indicators (transport KPIs) to measure and improve efficiency, safety, and environmental impact.

1.1.2 Sustainable Urban Transportation

Although there is no universally accepted definition of sustainability, sustainable development, or sustainable transportation, it is generally agreed that sustainable transportation involves striking an appropriate balance between present and future environmental, social, and economic attributes. However, the exact nature of these environmental, social, and economic characteristics that need to be maintained and balanced remains unclear (Marsden, 2007; (Black, 2004; Transportation, 2014).

Despite multiple efforts to define sustainable transport indicators, a comprehensive set of transport KPIs that specifically address these environmental, social, and economic qualities has yet to be fully established as shown in Figure (2). Ideally, the concepts and operational frameworks for sustainable transport indicators should be theory-driven and developed systematically. This process would begin by clearly defining what constitutes sustainable transportation, and then deriving key performance indicators that allow for the measurement of its efficiency (Steg and Gifford, 2005).

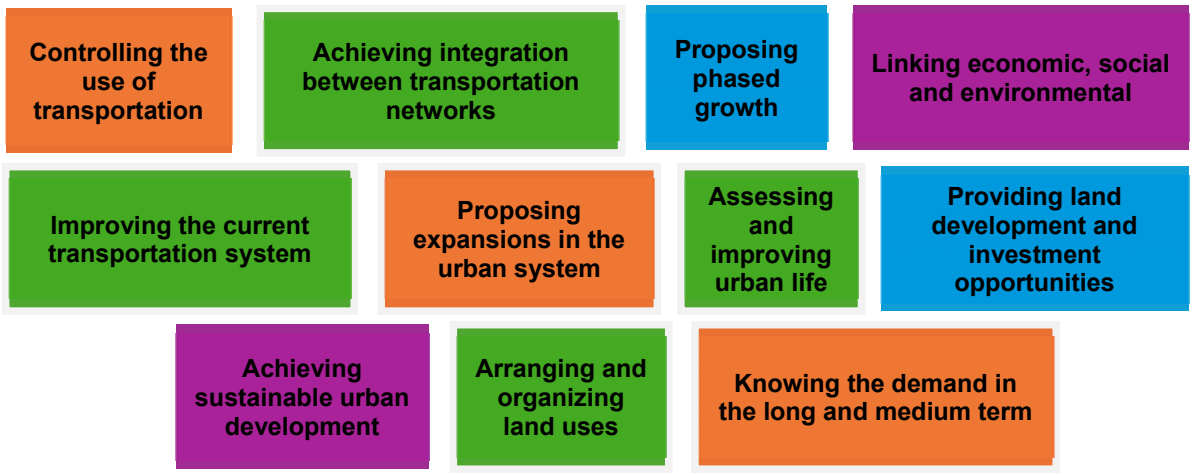

Fig. 2. Sustainable Transport Objectives. Source: (Steg and Gifford, 2005).

Many transport KPIs have been derived from existing practices, such as those found in transportation policies and plans, as well as from stakeholder perceptions of sustainable transport. However, the development of these indicators is often not based on an explicit or well-defined vision of sustainable transportation. Sustainable transportation can be assessed by analyzing the sustainability of the transport system itself, focusing on both its positive and negative externalities as they are presently understood or as they might develop in the near future.

These types of indicators are frequently used by governments to set goals for sustainable transportation and to monitor whether current systems are moving towards greater sustainability. In some cases, future projections are also made to forecast developments in transportation and their alignment with sustainability-related indicators.

1.1.3 Urban Transport Key Performance Indicators (transport KPIs)

Urban Transport Key Performance Indicators (transport KPIs) are essential tools for evaluating and improving the quality and efficiency of transportation systems in cities. These indicators rely on data that reflect service levels, user experiences, and the overall impact of transportation on the environment and society (Elboli, 2012). Here are some of the key transport KPIs used to assess urban transport systems (Prause, 2015; Litman, 2017; (Gadžo, 2024).

1) Time Efficiency:
- Travel time: The average time passengers take to reach their destinations.
- Headway: The time interval between successive public transport services, such as buses or trains.
- Delays and stoppages: The extent of delays in scheduled trips and their impact on passengers.

2) Quality and Service:
- Passenger comfort: The level of comfort experienced by passengers during travel, including ventilation, seating, and space availability.
- Availability: The extent to which transport services are available throughout the day and how well they cover different geographic areas.
- Ease of use: How easily passengers can access information about schedules, tickets, and other services.

3) Cost and Financial Efficiency:
- Cost of transportation: The cost borne by passengers relative to the services provided.
- Economic efficiency: The return on investment in the transport sector compared to operational costs.

4) Environmental Sustainability:
- Carbon emissions: The volume of emissions produced by transportation systems and their impact on the environment.
- Energy consumption: The amount of energy required to operate transport modes and their overall efficiency.
- Noise pollution: The noise levels generated by transportation systems.

5) Safety and Security:
- Traffic accidents: The rate of accidents involving public transport and the number of injuries or fatalities.
- Personal security: Passengers' sense of safety when using public transportation, including protection against crime or harassment.

6) Flexibility and Responsiveness:
- Emergency response: The ability of the transportation system to respond during emergencies, such as natural disasters or accidents.
- Adaptability to demand: The system's ability to accommodate sudden increases in demand during major events or peak times.

7) Connectivity and Integration:
- Integration between transport modes: The ease with which passengers can transfer between different types of transportation, such as from buses to trains.
- Availability of multiple transport options: The presence of alternative transportation methods, such as bikes, car-sharing services, and railways.

These transport KPIs provide a comprehensive evaluation of urban transport operations and services. By using these indicators, transport authorities can make informed decisions to enhance system efficiency, safety, sustainability, and user satisfaction.

1.1.4 Monorail as a Sustainable Urban Public Transport Solution

In response to the increasing demand for public transportation in urban areas, transport authorities face the challenge of selecting technologies that meet often conflicting requirements, such as high capacity, reliable service, urban suitability, low environmental impact, and budget constraints (Michael and Meyer, 2001). While numerous technologies are available today to provide medium to high-capacity public transport services, many of these options can be expensive or unsuitable for specific urban environments. High-capacity systems often necessitate costly underground tunnels or intrusive elevated metro systems, which can disrupt existing infrastructure (Yıldızhan , 2021).

Monorails, although in use for some time, have recently gained renewed attention as a viable public transport solution due to advancements in technology. For example, the Bombardier Innovia Monorail 300 has enabled transport authorities to consider monorails as a significant competitor in meeting their mass transit needs. The advantages of monorails include their ability to operate in urban settings with minimal land use and lower costs compared to traditional rail systems.

1.1.5. Integration of Sustainable Urban Transport Systems with Sustainable Urban Form

This integration involves considering the aspects related to transport systems when planning urban land uses, aiming to create patterns that positively affect the performance of the transport network. Conversely, it also includes directing transport planning to achieve specific urban development goals as shown in figure (3). The strategy advocates for a focus on mixed, dense, and compact land uses, which can reduce reliance on private vehicles, promote greater use of public transportation, increase cycling, and encourage walking.

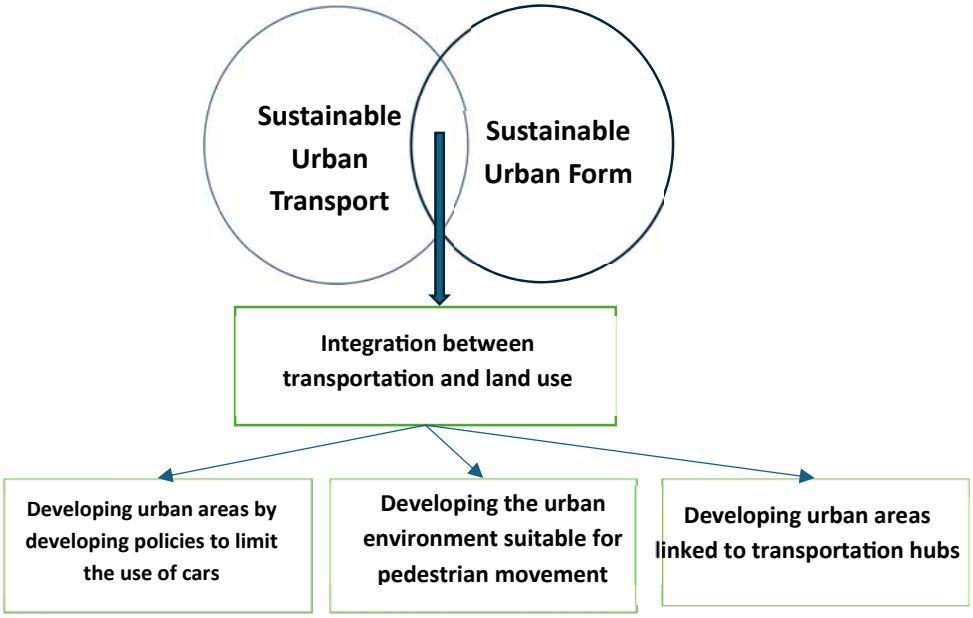

Fig. 3. Integration between sustainable urban transport system and sustainable urban formation Source: (Mohisen & Shahin, 2019).

By generating shorter trips, this approach aligns with one of the primary goals of sustainable urban development. Several strategies have emerged based on this relationship between land use and transport to achieve sustainability goals. These strategies may assist in establishing a set of transport KPIs to measure how light rail and tram projects meet these standards. Importantly, these policies aim to address urban and environmental challenges, such as: (Al-Attar, 2014)

1) Unplanned urban growth: Tackling the issue of disorganized and random urban expansion.
2) Noise pollution: Reducing noise generated by transportation and urban activities.
3) Social issues: Addressing social problems associated with urban transportation systems and planning.

By fostering a synergy between urban land use and transport planning, authorities can develop sustainable urban environments that enhance mobility and overall quality of life.

1.2 Strategies for Implementing Urban Transport Sustainability Policies

1.2.1 Developing Urban Areas Linked to Public Transport Corridors

Improving Access to Public Transport: This involves creating new transit stations or revitalizing existing ones, alongside upgrading bus and tram routes. Enhancements should provide users with efficient intermodal transfer points, enabling easy movement between different modes of transport. These improvements aim to make public transport more accessible and user-friendly. (Al-Attar, 2014) ،

Renovating Existing Railway Stations: The development of railway stations and their surrounding areas can be approached through several key initiatives: (Al-Attar, 2014)
Connecting Transport Nodes: Enhance connections between the station and other public transport modes, such as trams, buses, and bike-sharing locations, as well as car parking facilities.
Aesthetic Upgrades: Renovate the stations to align with the aesthetic objectives of the surrounding urban environment, ensuring they serve as landmarks.
Creating Urban Spaces: Design pedestrian pathways that link railway stations with the surrounding urban areas, integrating multi-purpose spaces for commercial activities.
Revitalizing Surrounding Areas: Intensify land use around stations by introducing administrative offices, retail elements, and necessary services to attract residents. Although these principles often address challenges in developed countries, applying them in developing cities involves enhancing street vendor areas, improving buildings, and optimizing public transport stops to ensure seamless mobility. A strong public transport network is essential for the success of Transit-Oriented Development (TOD) strategies. (Al-Attar, 2014)

1.2.2 Creating Pedestrian-Friendly Urban Environments

This strategy aims to foster environments conducive to walking and cycling, enabling direct door-to-door trips without reliance on cars. It emphasizes alternative transport methods, particularly bicycles and pedestrian pathways, as key components of urban mobility.

Encouraging walking is vital for sustainable urban transport and enhances overall urban livability. It serves as an important counterbalance to the environmental costs associated with car travel and directly improves public health. Additionally, promoting walking contributes to community efficiency and vibrancy. (Al-Attar, 2014) ،(Programme, 2013)

1.2.3Urban Development through Vehicle Use Regulation

One of the most significant urban transport policies related to sustainable urban form is traffic calming. This policy aims to design urban environments that reduce car usage, fostering a harmonious coexistence with road-based transport systems. By creating an environment that discourages excessive car use, cities can promote alternative transportation methods, ultimately contributing to sustainable urban development. (Al-Attar, 2014) ،(Programme, 2013)

By implementing these strategies, urban areas can better align with sustainability goals, enhance public transport accessibility, and foster environments that prioritize pedestrian and cyclist safety, thereby improving overall quality of life in cities.

1.3 Global Monorail Experiences

Global monorail systems showcase diverse experiences, with notable examples from Japan, Malaysia, Moscow, and South Korea. Japan's Kitakyushu Urban Monorail, established in a former industrial hub, spans 8.8 km with 13 stations, connecting Kokura Station and Kikugawaka Station since 1985 (das, 2013). Malaysia’s Kuala Lumpur Monorail, designed with an Alweg straddle-beam, has seen consistent growth, recording 24.4 million passengers in 2012, driven by the city's economic expansion (Amsori muhammad das, 2013). In Moscow, an experimental monorail peaked with 5.5 million passengers annually, prompting redevelopment plans in 2020 to enhance integration with rail and metro networks (A.N. Veronov, 2020). South Korea’s Daegu Monorail, part of the city's larger transit system, opened in 2015, spanning 23.9 km after public demand for better connectivity in underserved areas (Nobuhiko Kimijima, 2017).

1.3.1 Key Findings from Global Monorail Experiences

Across these global examples, the use of mass transit, particularly monorail systems, has led to increased accessibility and ridership, enhancing economic value and spurring urban development, particularly at the city edges. The impact of monorails on urban transport sustainability can be seen in several key areas: (Al-Attar, 2014)

1) Traffic Congestion Reduction: Monorails alleviate congestion in major cities by providing a rapid and efficient transport option that connects various regions. They primarily operate in high-density areas, reducing reliance on private vehicles.
2) Environmental Impact: Monorail systems are environmentally friendly as they operate on electricity, decreasing emissions compared to traditional fuel-powered transport, which is vital in cities like Moscow facing air quality challenges.
3) Sustainable Urban Planning: Monorails promote compact city development, encouraging urban design that focuses on transit hubs, thereby minimizing urban sprawl and optimizing land use.
4) Enhanced Accessibility: By improving access to remote areas, monorails facilitate mobility for individuals across different social strata, fostering social integration and cultural exchange.
5) Increased Capacity: Monorails can transport a significant number of passengers simultaneously, making them ideal for densely populated cities like Moscow.
6) Integration with Other Transport Modes: The Moscow Monorail connects effectively with other public transport options, enhancing overall system efficiency and encouraging public transport use.
7) Improved Quality of Life: Monorails provide a fast and efficient transport option, reducing commute times and freeing up citizens' time for other activities.
8) Improved Transport Efficiency: The Kuala Lumpur monorail has enhanced traffic flow in urban areas, encouraging public transport use over personal vehicles.
9) Successful Case Studies: Japan’s monorail systems exemplify effective integration within public transport networks, serving as a model for other countries aiming to enhance urban transport systems.

   Overall, monorails serve as a crucial sustainable transport solution, significantly improving urban life quality and advancing environmental sustainability.

1.4 Urban Impacts of Monorail as a Sustainable Urban Transport Mode

The introduction of monorail systems has a profound impact on urban planning, especially through Transit-Oriented Development (TOD), which encourages the development of areas around public transit lines. Monorails, spanning up to 56 kilometers, help connect suburban areas to urban centers, reducing car dependency and enhancing public transportation. In city centers and business districts, the creation of pedestrian-only zones, integration with existing bus and subway networks, and the design of transit malls all contribute to improving urban livability and accessibility. The monorail system plays a dual role in transporting users and shaping urban development by promoting denser, mixed-use environments, particularly in suburban areas. (Al-Attar, 2014)

Monorail characteristics, such as station design and alignment, directly influence the urban fabric. Accessibility is a key consideration, with stations needing to be easily reachable by pedestrians, supported by well-planned parking and other transportation connections. Elevated monorail stations typically feature ramps and elevators to improve access for all users, while parking management strategies near stations encourage walking and public transit use. Additional design elements, like fare collection technologies and real-time information systems, streamline operations and enhance user experience. The alignment of monorail routes

and the spacing between stations also affect how well the system integrates with urban surroundings, improving connectivity in both central and suburban areas. (Todd Litman, 2010)
Monorail systems contribute to urban sustainability by influencing land use through three main dimensions: accessibility, convergence, and integration. Accessibility ensures that transit stops connect efficiently to nearby land uses, shaping the demand for services within a walkable distance. Convergence refers to the development of major transit hubs, where various modes of transport meet, attracting commercial and administrative functions. Integration, meanwhile, focuses on aligning land use patterns around key transit points, supporting a mixture of commercial and residential activities that radiate outward from these hubs. These dimensions demonstrate how monorail systems, as part of a mass transit network, shape urban growth and sustainability. (Gupta, 2017)
Overall, monorails serve as a sustainable transport mode that not only enhances urban connectivity but also influences land use, creating more accessible, liveable, and well-integrated urban environments. Their design and operational features foster the development of vibrant communities, contributing to long-term urban sustainability and reducing the reliance on private vehicles.

2 The Monorail Project in Greater Cairo

2.1 Transportation Issues in Greater Cairo

Egypt is recognized as the most polluted country in Africa and the Middle East, with transportation being a significant contributor to this pollution. Urban transportation problems in Greater Cairo present a considerable crisis, with the most pressing issues being traffic congestion, inadequate public transportation, and environmental pollution. These challenges negatively impact individual quality of life and economic growth. To mitigate these transportation problems, there is a shift towards using environmentally friendly and energy-efficient transport options (Mahmoud, 2014; Ibrahim and Ramadan, 2022
Greater Cairo is a densely populated and sprawling city known for its severe traffic jams. The rapid increase in private car ownership, coupled with insufficient rapid transit options, leads to daily congestion on major thoroughfares intersecting the capital (Policy, 2015). The establishment of the New Administrative Capital is expected to have a significant impact on the transportation flow throughout the country. As government entities and legal departments relocate to this new hub, it will create new educational institutions and job opportunities, necessitating the construction of new transportation facilities to connect these areas with the existing urban population. (Hamed S. , 2022)

The monorail is one of the transit systems the government is currently working on, building on the initiatives started in the mid-1970s. The Cairo Transport Authority previously managed most of the collective transportation within Greater Cairo. However, informal microbuses emerged and have become the primary mode of public transport in the city. The routes of these microbuses are being developed according to market needs. Given Egypt's large population, the existing metro system is quite limited, leading to plans for a new metro line designed to meet citizens' needs, along with the introduction of new transit lines that will help reduce traffic congestion and pollution caused by traditional public transport modes, such as buses and taxis, as well as the use of autonomous, satellite-guided vehicles. Green transport is also emerging as a new mode characterized by energy efficiency and reduced pollution and waste (Tunnels, 2023) , (Shaarawi & Et al, 2023).

The transfer of government employees to the New Administrative Capital represents one of the activities undertaken by the New Administrative Capital Urban Development Company. Officials have indicated a four-tier strategy to ensure collective transportation services to and from this new capital: (Ahmed, 2015)

- An electric train (from City of Salam to the New Administrative Capital).
- The New Cairo Monorail as shown in figure (4).
- Organization of private vehicle fleets to transport 51,000 public sector employees to the New Administrative Capital, with each ministry coordinating its transport needs.
- Expanding road networks to connect with the rest of the city. The electric train is expected to terminate at the "Mohammed Bin Zayed Axis" station, located in the central activities zone of the New Administrative Capital, which will be a multi-modal transport hub (Adham Kalila, 2019).

Fig. 4. Implementation of the New Administrative Capital Monorail
source: National Authority for Tunnels, 2023 (Projects, 2020)

2.2 Objectives of Implementing the Monorail in the New Administrative Capital

The primary objectives for the implementation of the monorail include: (Tunnels, 2023)

- Connecting Greater Cairo with newly developed urban areas to the east (e.g., New Cairo, the New Administrative Capital).
- Providing a rapid, modern, safe, and environmentally friendly means of transport for passengers.
- Contributing to sustainable development on both sides of the Nile to achieve Egypt's Vision 2030, as the transportation system is vital for urban and economic development.
- Serving the East Nile Monorail line, facilitating the movement of employees and commuters from Cairo and Giza to New Cairo and the New Administrative Capital, connecting with the third metro line at Al-Istad Station and the LRT at the Arts and Culture Station.
- Generating economic returns through reduced fuel consumption, decreased pollution levels, alleviation of traffic congestion on major thoroughfares, and attracting riders to choose this mode over private vehicles. (El Shafei, 2022), (Ali & Et al, 2021).
- Creating direct and indirect job opportunities during the construction phase, as well as permanent jobs during the operational phase. (Rafik, 2023)

2.3 Transportation Networks in Greater Cairo

The transportation networks in Greater Cairo are characterized by a well-integrated system of roads and railways. This integration is due to its status as the capital region and the convergence of all national road networks. The local road network allows for access to all parts of the region, connecting central areas with peripheral regions (Mahmoud, 2014).

However, Greater Cairo suffers from chronic traffic congestion, with extremely high traffic loads and increasing demand for transportation services. To effectively understand and

manage the network's congestion and its effects on the entire region, a detailed analysis across various geographic locations and time elements is required. This involves assessing each corridor and sector to identify congestion points or hotspots. It is essential to remember that congestion affects everyone: pedestrians, vehicle drivers, public transit users, and private transport users. Consequently, priority should be given to improving public transportation, as it accommodates the largest number of passengers per unit (Adham Kalila, 2019), (Hamed & Abo Almajd, 2022).

2.4 The Monorail in Greater Cairo

The proposed monorail lines are expected too significantly for the following reasons:

- Alleviate traffic congestion in both Cairo and Giza.
- Accelerate urban development in 6th October City, New Cairo, and the New Administrative Capital.

One of the main advantages of the monorail service is its separate track, which enhances its operational speed. Furthermore, it has a larger passenger capacity compared to traditional buses. (Rinkesh, 2023), (Fathy, 2023).

In this context, the Egyptian government, along with local authorities in Greater Cairo, aims to implement future projects that will make Cairo a green, interconnected city, aligning with sustainability goals in the transportation sector (Rinkesh, 2023). The government has initiated a new public transport system (the monorail) to operate in two main directions:

- The New Administrative Capital Monorail, connecting Cairo with New Cairo and the New Administrative Capital as shown in figure (5).
- The 6th October Monorail, linking Giza with 6th October City.

Fig. 5. Final Route of the New Administrative Capital Monorail
source: (Projects, 2020)

The monorail line consists of 22 stations, including: Al-Istad, Hisham Barakat, Nuri Khattab, Seventh District, Thakir Hussein, Jehan Sadat, Marshal Tantawi, 90th Street, Air Forces Hospital, Narjes, Investors, Andalusia, Fountain Park, Beit Al-Watan, Al-Fattah Al-Alim Mosque, Residential Area R1, Residential Area R2, Residential Area R3, Arts City, Ministries District, Egypt Mosque, and Justice City. The proposed monorail line will connect with the third metro line at Al-Istad Station (Tunnels, 2023).

3 Performance Measurement Indicators for Sustainable Urban Transport Achieving the Objectives of the New Administrative Capital Monorail

To evaluate the sustainability of the monorail in the New Administrative Capital, a set of indicators has been employed that are suitable for specific variables that can be measured quantitatively. These indicators are instrumental in establishing baselines, identifying trends, addressing issues, assessing options, and defining the objectives of the monorail project in the New Administrative Capital (Hijab, 2011).

The selection of these indicators is critical as they significantly influence the results of the analysis. Therefore, it is essential to accurately identify and choose indicators related to sustainable transport. The following principles should be considered in this selection process:

1) Inclusivity and Balance: Ensure that the indicators encompass a wide range of aspects of urban transport, representing different dimensions of sustainability.
2) Data Collectability: The indicators should be based on data that can be easily gathered to facilitate monitoring and evaluation.
3) Clarity and Understanding: Indicators must be easy to comprehend, ensuring that stakeholders can interpret the data effectively.
4) Classification: Indicators should be organized in a way that allows for easy comparison and understanding of their implications.
5) Use of Standardized or Benchmark Units: Utilizing standardized units ensures consistency in measurement and comparison across different indicators.
6) Analysis Level: The indicators should be suitable for the intended level of analysis, whether it's a macro-level assessment or a micro-level evaluation.
7) Performance Objectives: The indicators should align with the overarching goals of performance within the transportation system.

Consequently, the performance measurement indicators for the monorail have been categorized based on sustainability dimensions and the objectives of establishing the monorail in Greater Cairo, specifically in the New Administrative Capital. Table (1) illustrates these performance measurement indicators that facilitate the achievement of the monorail's objectives in the New Administrative Capital.

Table 1 Indicators for Measuring the Efficiency of Sustainable Urban Transport that Achieve the Objectives of Establishing the Monorail of the Administrative Capital.

Objectives of Establishing the Monorail of the Administrative Capital	Sustainability Axes – Performance Indicators for Urban Transport				
	Urban Axis	Environmental Axis	Social Axis	Economic Axis	Operation and Service Axis
Connecting the Greater Cairo Region to the new urban areas (East: New Cairo – Administrative Capital)	**Accessibility**: Ease of access for pedestrians and cyclists to transport stations .1Level of service for pedestrians .2 Level of service for cyclists .3 Difficulty of crossing the street		**Equity in service**: Examining those benefiting from the project or service	**Boarding**: Monthly boarding level across the system Daily trip guide	

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Providing a fast, modern, safe, and environmentally friendly means of transport for passengers.	**Speed**: Average speed of conditional transport compared to average speed of spontaneous transport Total travel times compared to total travel time (considering travel time by car to and from metro/bus stations at the end of each trip)	**Emission rate**: Tons of emissions per 100,000 miles of car travel	**Passenger safety**: Injury accidents per passenger/mile		**Maintenance work**: orders Total work orders for each bus model; total requests/total buses
	Service effectiveness: Passenger trips per hour revenue.		**Accident rate**: Number of accidents per specified distance or time		
3. Contributing to sustainable development in East and West Nile to achieve Egypt Vision 2030, where the transport system is one of the arteries of urban and economic development	**Mobility**: Degree of ease of travel between origin and destinations .1 Travel times to the original destination .2 Level of congestion .3 Relative delay rate	**Energy consumption**: Gallons of fuel per mile of vehicle revenue. Electricity consumed per mile of vehicle revenue	**Comfort**: Percentage of stops that have transport service within specified time frames Minimum steps (in minutes) that are at or less than the specified threshold		**Fleet cleaning**: % of the fleet cleaned daily
.4 The East Nile Monorail serves the areas of Nasr City, New Cairo, and the Administrative Capital, facilitating the movement of employees and newcomers from Cairo and Giza to New Cairo and the Administrative Capital, connecting to the third metro line at the Stadium Station and with LRT at the Arts and Culture City Station.	**Service coverage**: Percentage of area covered by the service	**Visual impact**: Ease of recognizing and organizing parts of the natural scene in a cohesive pattern	**Reliability factor**: Percentage of trips or travel time does not exceed % X of the average		**Road calls**: Number of road service calls for unplanned revenue per specified distance or time
	Lost trips: Number of lost trips from the daily schedule		**Customer loyalty**: Percentage of "secure" or "vulnerable" transport customers, based on customer loyalty degree		**Complaint rate**: Number of passenger complaints per time unit
.5 Economic return resulting from fuel consumption savings, reducing environmental	**On-time performance:** Percentage of transport vehicles departing on time to the location	**Energy consumption**: Gallons of fuel per mile of vehicle revenue Electricity consumed per	**Demographics**: % of households without cars %of the population too young to drive Percentage of the population whose income is less than X dollars	**Cost-effectiveness**: Percentage of fare box recovery	**Direct route**: Additional travel time/distance compared to a car making the same trip

pollution rates, and reducing traffic congestion on main axes and streets, attracting a percentage of passengers to use this means instead of using private cars.		mile of vehicle revenue	% of elderly/disabled individuals	Operating ratio: Cost per passenger/PM Subsidy per passenger/PM Revenue per passenger Cost per individual	Number of deviations
			Customer satisfaction: Overall assessment of customer satisfaction with the transport agency service (for example, % of customers "very satisfied")		
6.Creating direct and indirect job opportunities during implementation and permanent job opportunities in the operational phase	**Service hours**: What is the duration of the service provided during one day?		**Employee relations:** Employee turnover rate Number of employees Suggestions/Implemented Number of employees% Employee training	**Employee productivity** Employee tardiness rate Employee absenteeism rate Hours paid to the platform: Total regular and overtime hours monthly Overtime per person per week	**Percentage of hours of work orders**: Total work orders for each bus model; total requests/total buses
			Police officers per crossing vehicle: Police officers or security personnel on board each transport vehicle		

The Relationship Between Factors for Monorail Success and Monorail Performance Measurement Indicators

A study (Al-Attar, 2014) explored the development of urban areas using guided light rail systems, linking the success factors of tram systems to strategies and concepts of sustainable urban transport and urban form. This connection aims to evaluate the extent to which success factors align with sustainable strategies to reach a key conclusion: the impact of effective light rail systems on achieving sustainable urban transport and urban design goals.
In his analysis, the author organized the success factors of tram systems alongside policies for integrating transport and urban form within the context of sustainable urban transport. The evaluation focused on whether these success factors resulted from those policies or whether they served as enablers for achieving the policies.

This analysis led to a conceptual framework that outlines the relationship between the success factors of the monorail (horizontal elements) and the transport Key Performance Indicators (KPIs) that measure the performance of the monorail. The indicators are divided into six main dimensions (vertical elements):

1) Urban Dimension: This includes characteristics of urban areas, and the commercial and economic uses served by the system.
2) Environmental Dimension: This focuses on environmental impacts such as emissions, energy consumption, and visual impact.
3) Social Dimension: This addresses issues of safety, security, service equity, and customer satisfaction.
4) Economic Dimension: This includes indicators like ridership rates, cost-effectiveness, and employee productivity.

5) Planning Dimension: This concentrates on transport planning policies and the planning characteristics of corridors, as well as integration with urban development plans.
6) Operational and Service Dimension: This covers indicators like travel time, complaint rates, and service availability.

By establishing this connection, the study seeks to demonstrate how the success factors contribute to the achievement of performance measurement indicators, ultimately highlighting how sustainable mass transport can be realized through the monorail system. This relationship is further illustrated in Table (2), which showcases the alignment of success factors with performance indicators.

Table 2: Relationship matrix between monorail success factors and indicators measuring the efficiency of monorail performance

Success factors for sustainable urban transport sustainable urban transport plans / **KPIs of Monorail administrative Capital**	**Urban Factors**				**Sociol Economic Factors**			**Operating policies**			
	Locations of areas of commercial and economic activities and land uses in the areas	High density of residential areas along the line	The vitality of the city center through which the line passes	The extent of the presence of radiation axes through which the city developed	Social support and public acceptance of the project	The extent of the population's acceptance of mass transportation	Public transportation usage rates	High service rates for the monorail system	Activate the travel card system	Activating the role of good marketing operations	Secure stations
Urban indicators											
Service Coverage The percentage of area covered by the service	■	■	■	■	■	■	■	■	■	■	■
Missed flights The number of flights missing from the daily schedule	■	■	■	■		■	■	■	■		■
Accident Rate The number of accidents per specific distance or time	■	■	■	■	■	■	■	■	■		■
Accessibility (how easily pedestrians and cyclists can reach transportation stations	■	■	■	■	■	■	■	■	■		
Hours of service: What is the duration of the service provided within one day?	■	■	■	■		■	■	■			
Mobility: The degree of ease of travel between origin and destinations	■	■	■	■		■	■	■	■		■
Environmental indicators											
Emissions ratio: tons of emissions per 100,000 miles of vehicle	■	■		■		■	■	■			

Energy consumption Electricity consumed per vehicle mile"Visual impact											
clarity": the ease with which parts of a landscape can be recognized and organized into a coherent pattern											
The social indicators											
Passenger Safety Injury Incidents Per Passenger/Mile Duration of Incident(s).											
Police officers for each transit vehicle Police officers or security personnel are on board for each transit vehicle											
Equity in Service Examining those who benefit from a project or service											
Reliability factor The percentage of trips or travel time that is not more than											
Customer Satisfaction An overall rating of customer satisfaction with the transportation agency's service											
Customer Loyalty Percentage of "safe" or "vulnerable" transportation customers, based on customer loyalty											
Demographics % of households without cars % of population too young to drive											
Comfort for the percentage of stops that have transit service within a specified time frame(s).											
Economic indicators											
Monthly rides system wide boarding daily rides guide											
Cost effectiveness fare box recovery ratio operating ratio											
Employee productivity, employee tardiness rate, employee absenteeism rate											
Operation and service indicators											
Direct route: Additional travel time/distance compared to a car making the same trip											
Complaint rate: The number of passenger complaints per unit of time											
Route Calls The number of unscheduled revenue service route calls per given distance or time On-time											
performance: The percentage of transport vehicles departing or arriving at the site on time											
Speed Average speed by conditional transfer versus average spontaneous speed											

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Success factors for sustainable urban transport sustainable urban transport plans / KPIs of Monorail administrative Capital	transport planning			planning factors								Urban Planning Policies					
	Integration of bus axes with the monorail line	The availability of parking spaces at the stations	Managing and preventing parking in the city center	planning factors Integration of monorail plans with	Policies of access axes to monorail stations	Integrating monorail plans with regional revitalization and development plans	Integration between monorail stations and main activity sites	The extent to which the system creates a suitable environment for movement operations and access to	The presence of the system in major development	The system does not serve unsafe random areas	The system is in line with urban growth	Urban departments develop urban development plans	The presence of development incentives near the station areas	Joint investment operations to encourage development operations along the monorail axis	Designate lanes for pedestrians only	The presence of development operations in the city center areas or the areas served by the monorail	The presence of urban renewal processes in slum areas and deteriorated areas
Urban indicators																	
Service Coverage The percentage of area covered by the service	■	■		■	■	■	■	■	■		■	■	■		■		
Missed flights The number of flights missing from the daily schedule	■	■	■	■	■			■	■						■		
Accident Rate The number of accidents per specific distance or time	■	■	■	■	■	■		■		■		■			■		
Accessibility (how easily pedestrians and cyclists can reach transportation stations	■	■		■	■			■	■						■		
Hours of service: What is the duration of the service provided within one day?	■	■		■	■	■		■	■			■			■		
Mobility: The degree of ease of travel between origin and destinations	■	■		■	■	■	■	■	■	■	■	■	■		■		
Environmental indicators																	
Emissions ratio: tons of emissions per 100,000 miles of vehicle				■		■		■		■	■	■	■			■	■
Energy consumption Electricity consumed per vehicle mile Visual impact				■		■		■		■	■	■	■			■	■
clarity": the ease with which parts of a landscape can be recognized and organized into a coherent pattern				■		■		■		■	■	■	■		■	■	■
The social indicators																	
Passenger Safety Injury Incidents Per Passenger/Mile Duration of Incident(s).	■	■	■		■				■		■	■			■		
Police officers for each transit vehicle Police officers or security personnel are on board for each transit vehicle				■					■	■	■	■					

Equity in Service Examining those who benefit from a project or service	■	■		■	■				■	■	■	■			■		
Reliability factor The percentage of trips or travel time that is not more than	■	■		■	■			■	■	■	■				■		
Customer Satisfaction An overall rating of customer satisfaction with the transportation agency's service	■	■			■	■		■	■		■	■	■	■	■		
Customer Loyalty Percentage of "safe" or "vulnerable" transportation customers, based on customer loyalty	■	■			■	■		■	■		■	■	■	■	■		
Demographics % of households without cars % of population too young to drive	■	■	■	■	■	■	■	■	■	■	■	■					
Comfort for the percentage of stops that have transit service within a specified time frame(s).	■	■			■	■	■	■	■						■	■	■
Economic indicators																	
Monthly rides system wide boarding daily rides guide	■	■		■	■	■		■	■			■			■		
Cost effectiveness fare box recovery ratio operating ratio	■	■	■	■	■	■	■		■			■	■	■		■	
Employee productivity, employee tardiness rate, employee absenteeism rate	■	■		■	■	■	■		■			■	■	■			
Operation and service indicators																	
Direct route: Additional travel time /distance compared to a car making the same trip	■	■	■	■	■		■	■	■		■	■			■		
Complaint rate: The number of passenger complaints per unit of time	■	■	■		■		■	■	■		■				■		■
Route Calls The number of unscheduled revenue service route calls per given distance or time On-time	■	■	■	■	■		■	■	■		■	■			■		■
Performance: Percentage of transport vehicles departing or arriving at the site on time	■	■	■	■	■	■	■	■	■								
Speed Average speed by conditional transfer versus average spontaneous speed	■	■			■				■						■		

4 Analysis of the Matrix of Relationships Between Monorail Success Factors and Monorail Performance Measurement Indicators

The matrix illustrates the relationship between success factors of sustainable urban transport (horizontal elements) and the Transport Key Performance Indicators (KPIs) that measure monorail performance in the New Administrative Capital (vertical elements). The matrix can be analyzed as follows:

4.1 The matrix serves several important functions:

- Identifying Key Success Factors: It helps pinpoint the main factors that influence the success of monorail projects.

- Measuring Monorail Performance: It allows for performance evaluation using comprehensive indicators that encompass urban, environmental, social, and economic aspects.
- Understanding Interrelationships: It clarifies the interconnections among various project dimensions to enhance planning and execution.
- Comparative Performance Analysis: It enables the comparison of different monorail projects using standardized indicators.

4.2 Interrelationships among dimensions

There are intricate relationships between the various dimensions. For example:

1. Urban Dimension:

- Indicators like service coverage, accident rates, accessibility, and service hours affect how people use the monorail.
- Service Coverage: There is a strong correlation between service coverage and urban characteristics. Increasing the area covered by the monorail improves passenger accessibility, highlighting the importance of routing through high-density urban areas.
- Accident Rates: Reducing accidents per distance traveled demonstrates how radial corridors facilitate access to the monorail, potentially lowering anticipated accidents.
- Accessibility: Enhancing pedestrian and cyclist access to monorail stations boosts system usage, and integration with urban infrastructure, such as parking and bus corridors, optimizes monorail usage.

2. Environmental Dimension:

It emphasizes the relationship between the environmental sustainability of the monorail system and its emissions and energy consumption. There is a significant link between environmental, social, and economic characteristics, reflecting sustainable development goals.

3. Social Dimension:

This dimension explores the relationship between community acceptance of the system and passenger safety. General satisfaction plays a crucial role in project success, reflecting the importance of station security and overall social comfort. It includes aspects like passenger safety, customer satisfaction, and service equity.

4. Economic Dimension:

This analyzes several key factors that impact performance efficiency and system sustainability, which can inform improvements and operational efficiencies.

5. Operational and Service Dimension:

This dimension reflects the system's efficiency through indicators such as accident rates and service hours, indicating the system's ability to provide reliable and stable service.

CONCLUSION

This study emphasizes the urgent need for sustainable urban transport systems in Egypt, highlighting the diverse impacts on social, cultural, and economic values, as well as on our natural and built environments. Implementing Transport Key Performance Indicators (transport KPIs) for urban transport systems, specifically the monorail, can support decision-makers in assessing and improving these systems. Given this context, it is essential to formulate policies and strategies related to the application of these indicators across various urban transport systems. By doing so, stakeholders can better address the challenges and opportunities presented by sustainable urban mobility.

The matrix demonstrates how performance indicators across urban, environmental, social, and economic dimensions integrate to ensure the success of the monorail system. This relationship hinges on aligning urban planning with operational characteristics to guarantee efficiency, environmental sustainability, and economic viability. The interconnections among

these dimensions highlight how urban, environmental, social, and economic aspects can collectively contribute to the success and sustainability of the monorail system. The project's effectiveness relies on balancing these factors to ensure a safe, efficient, and satisfactory service for users.

Using the Matrix for Performance Improvement

The accompanying matrix can be utilized in various ways to enhance the performance of the monorail system, such as:

1. Key Influential Factors: The matrix can pinpoint the factors that most significantly impact the monorail's key performance indicators. For example: (A) Urban Dimension: Enhancing urban planning and linking the monorail with development plans increases accessibility and service coverage. (B) Social Dimension: Improving passenger safety and customer satisfaction enhances community acceptance of the system. And (C) Economic Dimension: Enhancing cost-effectiveness and employee productivity improves financial sustainability.

2. Understanding Variable Relationships: The matrix aids in comprehending the interrelationships among different variables, such as: (A) Urban and Social Dimensions: Improving accessibility boosts system usage and customer satisfaction. And (B) Economic and Environmental Dimensions: Enhancing cost-effectiveness allows for greater environmental investments.

3. Identifying Weaknesses and Opportunities: The matrix helps identify areas needing improvement, such as:(A) High Accident Rates: Indicating a need for enhanced safety measures. (B) Low Customer Satisfaction: Suggesting the need for improved service quality and passenger comfort. (C) It also highlights opportunities for performance improvement, such as: (D) Presence of Major Development Corridors: Provides opportunities to increase ridership and revenue. And (E) Incentives for Development Near Stations: Promotes investment and development.

4. Identifying Key Performance Indicators: The matrix helps identify the most critical transport KPIs for improving monorail efficiency, such as: (A) Fare Recovery Ratio: To enhance financial sustainability. (B) Accident Rate: To improve safety. And (C) Customer Satisfaction: To enhance service quality.

By utilizing these methods and focusing on the most significant factors, the matrix can serve as a powerful tool for comprehensively improving the performance efficiency of the monorail system.

Benefits of the Monorail:

The current study highlights the significant role of monorail as a transport mode in the following:

- Traffic Congestion Reduction: The monorail offers high transport capacity, helping alleviate congestion on the roads.
- Air Quality Improvement: By reducing reliance on private cars, the monorail contributes to lower emissions of harmful gases, such as carbon dioxide and particulate matter, thus improving air quality.
- Economic Development: The monorail enhances the urban infrastructure, attracting investments and boosting economic activity in the areas it serves.
- Facilitated Mobility: The monorail provides a safe and comfortable transportation option, particularly for the elderly and people with disabilities, improving accessibility to public transport.
- Dedicated Pathways: The monorail operates on a completely separate track, increasing its operational speed and passenger capacity compared to traditional buses.

Overall, the Administrative Capital Monorail project represents a qualitative leap in Egypt's transport system, reflecting a commitment to developing modern infrastructure that supports sustainable development.

Specific Findings for the Study Area

A key pillar of the Greater Cairo 2050 Vision is the development of a comprehensive public transport infrastructure:

- Transport Network Development: Enhancing the public transport network to connect key residential areas, ensuring that commuting times do not exceed 45 minutes when using public transport.

- Supporting Transport to New Urban Communities: The first line of the monorail project connects Cairo Governorate with the Administrative Capital, facilitating the movement of employees from Cairo to the Administrative Capital in just 60 minutes. This integration with the third metro line at the "Stadium" station in Nasr City and with the electric train at the "Art City" station enhances connectivity among East Cairo, New Cairo, and the Administrative Capital, with a target to transport 450,000 passengers daily.

The Administrative Capital boasts an integrated transport network, including a modern monorail system that enhances public transport efficiency across various regions. Which can Provide:

- **Key Connections** such as:
  - Ease of Access: The monorail connects the New Administrative Capital with New Cairo, enhancing movement for citizens and improving access to public services and facilities. It is designed to integrate with metro and bus lines, providing a comprehensive transport network throughout Greater Cairo and the Administrative Capital. Spanning 56.5 km, it links the Stadium Station in Nasr City to the Cultural and Arts City in the Administrative Capital, facilitating smooth transitions for residents between the two cities.
  - Strategic Stations: The monorail passes through key stations in New Cairo, such as the Mostafa Mahmoud and Cairo Festival City stations, facilitating access to residential and commercial areas.
- **Supporting Urban Planning** such as:
  - The monorail contributes to enhancing the infrastructure of areas surrounding the Administrative Capital, increasing property values and making the region more attractive to residents and investors.
  - The monorail encourages balanced development between the Administrative Capital and neighboring cities, supporting sustainable urban planning.

    In summary, the Administrative Capital Monorail represents a strategic step toward improving urban planning and promoting sustainable development in the region, positively impacting the lives of residents in both the Administrative Capital and New Cairo.

Recommendations

The planning of the monorail in Greater Cairo has positive environmental, economic, and social impacts. The application of performance efficiency indicators showed that the monorail is a sustainable transport mode in various aspects:

1) The monorail is an automated, comfortable, collective transport solution that adheres to safety standards and is environmentally friendly.
2) Monorail planning supports the emergence of new service uses, such as public parking facilities near stations.
3) The multi-modal transport system is essential, where the monorail is complemented by other transport services that facilitate commuter access. Transportation Demand

Management (TDM) strategies, such as carpooling and fixed-schedule public transport, should be implemented, alongside smart transport initiatives.

4) Establishing commercial service areas near the monorail stations enhances accessibility and local economies.
5) Comprehensive connectivity across Greater Cairo is crucial, linking new urban areas to central and newly developed regions, thereby reducing travel times and easing the burden on public and private transport systems.
6) There is a need to reassess planning for adjacent areas, enhancing mixed-use developments and the foundational infrastructure.
7) New residential zones should be developed, and land near the monorail should be utilized for new housing projects in desert areas, relieving overcrowded populations and expanding urban territories.
8) Improvements in existing road networks adjacent to the monorail line can enhance the social and recreational quality of life for residents.
9) Comprehensive integration of all public transport networks is needed, ensuring intermodal exchange points among various transport modes.
10) The planning of nearby road networks should include pedestrian pathways and bike lanes while preserving and creating new green spaces.

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استدامة نظم النقل الحضري في ضوء تطبيق مؤشرات كفاءة الأداء على مونوريل العاصمة الإدارية بإقليم القاهرة الكبرى

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المستخلص

في مواجهة الطلب المتزايد على النقل العام في جمهورية مصـــر العربية، تواجه ســـلطات النقل تحدياً لاختيار تقنيات تلبي المتطلبات المتضـــاربة في كثير من الأحيان للقدرة العالية، والخدمة الآمنة، والملاءمة الحضـــرية، والتأثير البيئي المحدود وقيود الميزانية وبالتالي يجب أن تكون هذه التقنية وسيلة نقل حضري مستدام حتى تلبي هذه المتطلبات المتعارضة للنقل. وعلى الرغم من أن أنظمة المونوريل كانت موجودة عالميا منذ بعض الوقت، إلا أن التطورات الأخيرة تطلبت من ســـلطات النقل المصـــرية النظر للمونوريل كمنافس رئيسي لتلبية متطلبات النقل الجماعي الخاصة بجمهورية مصر العربية. وحتي نقيس مدى إستدامة المونوريل اهتم البحث بتحديد مؤشرات قياس كفاءة الأداء العالمية لاستدامة النقل الحضرى (KPIs) ومدى ملائمتها للحالة المصرية ثم تطبيقها على مشـروع مونوريل العاصـمة الإدارية بمصـر. وقد خلص البحث إلى أن تخطيط المونوريل في القاهرة الكبرى يؤثر على الإقليم بأكمله تأثيرا بيئياً واقتصادياً واجتماعيا وأن المونوريل وسيلة نقل تحقق استدامة النقل الحضري منتهيا بالوصول الى مجموعة من التوصيات للتوافق مع هذه المؤشرات لتحقيق مفهوم استدامة النقل الحضري.

الكلمات الدالة: النقل الحضري - المستدام - مؤشرات - كفاءة أداء –المونوريل – العاصمة الإدارية – إقليم القاهرة الكبرى