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Transport Key Performance Indicators (KPIs): Developing a conceptual framework for Egyptian urban transport systems

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ABSTRACT

Urban transport systems are critical components of urban development, significantly influencing the movement of people, activities, and goods within any city. These systems are also major contributors to various urban challenges, such as congestion, pollution, and other urgent issues related to sustainability in its social, environmental, and economic dimensions at both local and global levels. Therefore, measuring the performance efficiency of urban transport systems is essential for the development and planning of any city, serving as the cornerstone for identifying current gaps and formulating planning decisions to promote sustainable urban development.

This research aims to formulate a general framework to determine indicators for measuring the efficiency of the performance of urban transportation systems and how to apply them later in the Egyptian case. The researcher prepared this study within the Urban Observatory for Egyptian Cities project at the General Authority for Urban Planning (GOPP), with the aim of application in two case studies, one of which is at the level of urban planning. in small cities in 2018 and the other at the regional and sub-regional level in the Egyptian governorates in 2023. The research focuses on formulating a general framework that includes the process of selecting indicators and the methodology for making indicators at all urban levels. Finally, the research presenting the lessons learned from formulating and composing the various sets of indicators, as well as the most important difficulties and challenges in applying these indicators in the Egyptian case.

Keywords**:** Key Performance Indicators (KPIs) - Regional Transport (KPIs) – Urban Transport (KPIs).

INTRODUCTION

Transport Key Performance Indicators (KPIs) serve as a comprehensive framework for monitoring and evaluating the performance of urban transport systems. They provide a set of essential performance metrics that enable city authorities and transport planners to measure the efficiency, effectiveness, and sustainability of their transport networks. There are hundreds of transport KPIs that can be measured, but it is important to focus on those most relevant to the organization and actionable. These KPIs cover various aspects of transport especially Public Transport Utilization and Travel Efficiency (Yousaf, 2012): The former helps assess the level of public transport usage within a city and it measures factors such as the number of public transport trips taken, the percentage of commuters using public transport, and overall satisfaction levels of public transport users. While, the latter focuses on the efficiency of travel within the city. It measures factors such as travel time, average vehicle speeds, and congestion levels.

Overall, using transport KPIs to evaluate the efficiency of a transport system involves setting objectives, identifying metrics, collecting and analyzing data, establishing KPIs, and monitoring and adjusting performance over time (Šišak, 2022).

Indicators are the selected and defined variables used to measure progress toward a specific goal. They can reflect different levels of analysis, such as decision-making processes (quality of planning), responses (travel patterns), physical impacts (emission rates and accidents), and the effects of these impacts on individuals and the environment (injuries, fatalities, and environmental damage), as well as their economic impacts (costs to society resulting from accidents and environmental degradation). A sustainability indicator can include metrics that reflect different levels of analysis, but it is important to consider their interrelationships in the evaluation to avoid redundancy. For example, reductions in per-mile emission rates from cars can decrease air pollution and its harm to human health; tracking both factors can be useful, but adding them together as if they represent different types of impacts would be incorrect (Litman, 2008).

To establish a comprehensive framework for Transport Key Performance Indicators (KPIs) for urban transport systems, it is required to define key terms that will be frequently used (Litman. 2023): These include the followings:

- Baseline (or benchmark): Existing, projected, or reference conditions if no changes are implemented.
- Overall Goal: The ultimate outcome you want to achieve.
- Objective: A precise plan of action or strategy for achieving a goal.
- Target: A well-defined, achievable, and quantifiable goal.
- Indicator: A defined and chosen variable used to track a goal's advancement.
- Values utilized in indicators are known as indicator data.
- Indicator framework: The theoretical framework that makes connections between indicators and a goal, theory, or planning procedure.
- Indicator set: A collection of indicators chosen to evaluate overall goal progress.
- Index: A collection of indications combined into one numerical number.
- Indicator system: The process for defining indicators, collecting and analyzing data, and applying results.
- Indicator type: The nature of the data used by the indicator (qualitative or quantitative, absolute or relative).

1. Transport Key Performance Indicators (KPIs) :

Transport KPIs are crucial for evaluating and improving the performance of urban transport systems in urban and regional scale. The followings are some reasons why the transport KPIs are pivotal in this context:

- Efficiency (Dubolazov, *et al*.; 2019): Transport KPIs can assess the efficiency of transport systems, including factors like travel time, vehicle occupancy, and route optimization. By identifying inefficiencies, cities can make targeted improvements to their transport systems, resulting in cost savings and improved service for residents.
- Safety (Eden *et al*., 2012): Transport KPIs can measure the safety of transport systems, including factors such as accident rates, pedestrian and cyclist safety, and compliance with traffic regulations. Monitoring these KPIs allows cities to identify safety issues and address them, making their transport systems safer for all users.

- Sustainability (Krmac and Djordjević, 2018): Transport KPIs related to emissions, energy consumption, and pollution can evaluate the environmental impact of transport systems and identify areas for improvement. By implementing measures to reduce emissions and energy consumption, cities can contribute to a more sustainable future.
- Accessibility (Yousaf, 2012): Transport KPIs can evaluate the accessibility of transport systems, including factors such as availability of public transport, affordability of fares, and accessibility options for people with disabilities. Monitoring these KPIs helps cities identify and address gaps in accessibility, ensuring reliable and affordable transport options for all residents.
- Integration (Yang *et al*., 2020): Transport KPIs can assess the integration of various transport modes, such as public transport, cycling, and walking. By measuring the connectivity and suitability of these modes, cities can promote more sustainable and efficient transport choices for residents.

1.1 Case studies of successful Transport Key Performance Indicators (KPIs)

1. Public-Private Partnership (PPP) Transport Projects (Mladenovic *et al*., 2012): KPIs focus on assessing transportation projects undertaken through public-private partnerships. Stakeholders from both sectors utilize these indicators to gauge project performance, align goals, and identify critical success factors. Techniques like brainstorming sessions with experts and surveys validate stakeholder objectives and project characteristics.
2. Efficiency in Ground Transportation (García-Arca *et al*., 2018): KPIs were used to enhance ground transportation efficiency, adapting metrics like Overall Equipment Effectiveness (OEE) commonly used in manufacturing to manage transport operations. Research involves iterative development based on literature review and practical application in retail settings to ensure framework validity.
3. Sustainable Freight Transport Systems (SFTS) (Nazam *et al*., 2020): KPIs were applied for sustainable freight transport systems, focusing on sustainability measurement standards within the freight transport industry. Identified barriers include strategic determinants, information systems, infrastructure management systems, and city logistics services.
4. Modal Choice in Transportation Systems (Kadir *et al*., 2020): Application of Quality Function Deployment (QFD) were used to design transportation modalities, emphasizing consumer perspectives and internal viewpoints. Although not directly KPI-focused, this study provides theoretical and empirical reviews applicable to developing transportation-related KPIs.
5. Energy Efficiency in Transportation (Yousaf, 2012): KPIs were used to measure and track energy efficiency within the transportation sector, identified through literature review of mobility projects, strategies, and policies worldwide. These KPIs assist city authorities in reducing data complexity while assessing and monitoring energy efficiency.
6. National Institute of Standards and Technology (NIST) Framework (Wollman *et al*., 2022).
7. Introduces an H-KPI framework for smart cities and communities, organizing performance indicators for technology, metric platforms, city applications, data, and

management systems. This framework supports smart city system visualization and serves as a basis for developing KPIs.

8. Local Government Transport KPIs: Clear Point Strategy defines KPIs for local governments, including average speed on neighborhood streets and driver satisfaction ratings. These KPIs aid in long-term variance tracking of street speed averages and driver satisfaction evaluations.
9. Optimizing Bus Networks (Yousaf, 2012): In small cities, a practical methodology determines optimal bus routes during network restructuring, involving comparative analysis pre- and post-implementation using necessary bus service performance KPIs.
10. Quality of Experience (QoE) in Smart City Operations (Šišak, 2022): Proposed a comprehensive simulation framework for extensive assessment and prediction in smart city sectors, including transport and urban energy systems, reflecting realistic KPI generation based on urban system dynamics.
11. Cost Reduction and Timeliness Compliance (Ove, 2018): Major transportation companies aim for total cost reduction and improved punctuality in transportation operations. These KPIs also apply to demand-responsive transport services in small cities

It was obvious from the previous case studies that Transport KPIs are essential metrics used to evaluate and improve the performance of transportation systems across various sectors. These indicators serve as benchmarks to monitor and enhance efficiency, safety, sustainability, and accessibility within urban and inter-city transport networks.

1.2 Methods to evaluate the efficiency of transport systems using KPIs

These include the followings: (Makarova *et al*., 2021; Mateichyk *et al*., 2022; Romero-Ania *et al*., 2033):

- Neural Network-Based Performance Indicators System: This method utilizes neural network techniques to develop and apply performance indicators. Neural networks can analyze complex data patterns and provide insights into system performance, aiding in decision-making processes.
- Economic Feasibility Assessment of Proposed Solutions: This approach involves evaluating the economic benefits of proposed solutions alongside their social impact, environmental suitability, and overall sustainability for urban transport systems. It helps in determining the cost-effectiveness and long-term viability of transport interventions.
- Data Envelopment Analysis to Identify Environmentally Preferable Public Urban Transport Vehicles: This technique assists in identifying public transport vehicles that are more efficient and environmentally friendly based on the air pollution criteria. It aids in selecting vehicles that align with environmental objectives for public transport systems.
- Development of Mathematical Economic Models for Transport System Enhancement: This method utilizes mathematical and economic models to analyze, plan, and develop transportation systems. These models help in optimizing routes, schedules, and infrastructure investments to improve overall system efficiency.
- Target Function Component Analysis to Reduce Operation and Maintenance Costs of Vehicles (Buses): This method focuses on analyzing costs associated with vehicle

operation and maintenance. It identifies optimal times for scheduled maintenance to achieve greater efficiency and lower costs in operating public transport fleets.

These methods highlight the diverse approaches in using KPIs to enhance transportation systems, ensuring they meet economic, environmental, and social objectives effectively. By monitoring and analyzing KPIs, cities and transport authorities can make data-driven decisions to improve transport services for residents and achieve sustainable urban mobility goals.

1.3 Using KPIs to identify areas for improvement in transportation systems

Once Transport KPIs are identified, they can be used to pinpoint areas that require enhancement within the transportation system (Krmacand Djordjević, 2018; Jaeger *et al*., 2018; Falahati *et al*., 2019; Kadir *et al*., 2020).

For instance, if KPIs indicate an increasing average travel time, this may signal the need to improve traffic flow or reduce congestion. Similarly, if KPIs show low vehicle occupancy rates, it may suggest a need to enhance public transport options or promote carpooling. In general, using KPIs to identify areas for improvement in transportation systems involves analyzing collected data and comparing it against specific performance indicators. This process helps identify areas where the transportation system is not meeting its objectives and where improvements can be made.

1.4 Prioritizing areas for improvement based on KPI data

Prioritizing areas for improvement based on KPI data involves the followings (Damidavičius *et al*., 2019).

1. Identify the Most Important KPIs for measuring the success of the transportation system.
2. Analyze KPI Data to identify areas within the transportation system that are performing below expectations.
3. Prioritize Improvement Areas based on their impact on the overall performance of the transportation system.
4. Develop Improvement Strategies for prioritized areas.

Prioritization of improvement areas can be based on the weighted values of KPIs. Using these weights, recommendations can be made to prioritize energy use, focus on energy efficiency, enhance environmental labelling, raise environmental awareness, develop environmental technology, and all other aspects and dimensions of the goals of the indicators.

METHODOLOGY

Preocess of developing Transport Key Performance Indicators (KPIs).

Creating Key Performance Indicators (KPIs) for a transportation system involves analyzing system performance and identifying the most important metrics to measure its success. Below are steps that can be taken to establish KPIs for a transportation system as in

Fig. *1*) (Dubolazov, *et al*., 2019; Morri *et al*., 2021; Podskrebko *et al*., 2021; Šišak, 2022).

1. Setting Transportation System Goals: The first step is to define the goals of the transportation system. These goals may include reducing traffic congestion, improving safety, lowering emissions, or enhancing accessibility.

2. Identifying Metrics for Success Measurement: Once goals are established, the next step is to identify metrics that will be used to measure success. For example, if the goal is to reduce traffic congestion, metrics like average travel time, average speed, and vehicle occupancy rate can be used.
3. Data Collection: Data relevant to the identified metrics must be collected for measurement. This data could include traffic sensor data, GPS devices, or surveys.
4. Data Analysis: After collecting data, it needs to be analyzed to determine whether the transportation system is achieving its goals. This may involve comparing data against standards or target objectives.
5. Developing Key Performance Indicators: Based on the analysis, Key Performance Indicators (KPIs) can be developed to track the performance of the transportation system over time. These indicators should be (SMART) time-bound, relevant, quantifiable, realistic, and explicit.
6. Monitoring and Adjusting: Lastly, KPIs should be regularly monitored to ensure that the transportation system is meeting its objectives. If KPIs indicate that the system is not meeting its goals, adjustments may be necessary to improve performance.

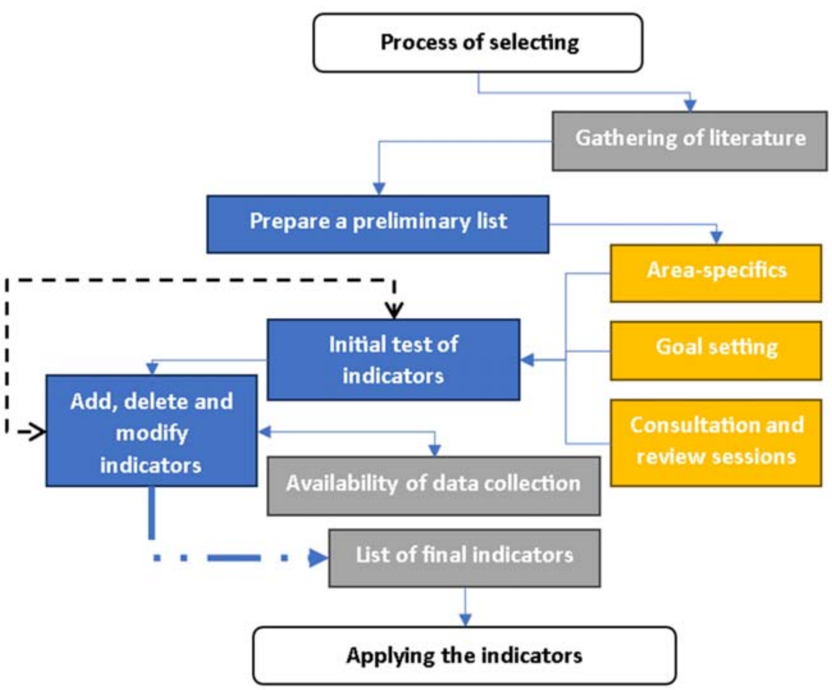

Fig. 1. Process of selecting indicators. Source: Author

The type of transportation system can vary, such as public transport, autonomous shipping, or bike-sharing. KPIs should be tailored to the goals and metrics specific to the transportation system being analyzed. For instance, the AEGIS project proposed a new maritime transport system for Europe that is environmentally friendly, robust, flexible, automated, and capable of linking rural and urban stations. To evaluate proposed solutions in the AEGIS project, a comprehensive set of KPIs was defined, and three specific use cases in

Europe were evaluated based on these indicators. Similarly, a study aimed to develop an estimated arrival time model for electric bus services at Chiang Mai University using Long Short-Term Memory (LSTM) model to capture patterns in data (Torbacki, 2017; Xinlei *et al*., 2022).

RESULTS AND DISCUSSION

2. Developing of the Transport Key Performance Indicators (KPIs) in Egypt

2.1 Process of selecting the indicators

Most indicators are comprehensive and straightforward to understand and calculate, with their effectiveness estimated based on available urban experience. Other systems rely on national evaluation principles. Employing these systems is advantageous as they enable monitoring regional and urban progress. Comparing cities, towns, or other administrative regions is a valuable tool for investment planning and shaping (Damidavičius *et al*., 2019).

In the current study indicators were categorized into a hierarchical gradient comprising Primary Axis with subsidiary axes of both main and sub-indicators. Calculation method of sub-indicators is illustrated in Tables (1 & 2). These tables exemplify the validity matrix for applying primary axes across urban levels as a filtration grade for indicators by applicability validity.

In reviewing the literature for each major performance indicator, the relationship between primary axes and various urban levels was studied to gauge the strength of their application at each level.

Table ***1***) outlines the applicability validity matrix of primary axes at urban levels as a filtration grade for indicators by applicability validity. Consequently, the project team filtered to select the most suitable primary axes for application at each urban level. Additionally, they chose sub-axes, main, and sub-indicators tailored to each urban level, ensuring the primary axis (Accessibility) is universally applicable across urban levels. However, primary and sub-indicators vary within each level. Thus, filtration operations were performed for each subsidiary axis and primary and sub-indicators for each urban level, culminating in final indicator filtration, as indicated in Table 2).

Table 1. Matrix applicability of main axes in urban levels.

key themes	Regional	Sub-Regional	Freight and logistics	Urban cities
Accessibility index	[green]	[green]	[green]	[green]
Safety	[green]	[red]	[green]	[red]
The efficiency of mass transit.	[green]	[green]	[green]	[green]
Network connectivity	[green]	[green]	[green]	[green]
Efficient river, sea and rail transportation	[green]	[green]	[green]	[green]
network performance	[green]	[green]	[green]	[green]
Affordability of mobility	[red]	[red]	[red]	[red]
Availability of urban mobility	[red]	[red]	[red]	[green]
The effectiveness of the road network	[green]	[green]	[green]	[green]
Social containment and land use	[green]	[green]	[red]	[green]
Efficiency of land mass transit	[green]	[green]	[red]	[green]
Efficient Freight and logistics	[green]	[green]	[green]	[green]
smart mobility	[red]	[red]	[red]	[red]

Source: Author.

There is a strong and viable relationship at this level	[green]
Exclude lack of relationship or difficulty in availability of data	[red]

Table 2. The finalization of the selected themes and indicators for the Egyptian case.

Urban Level	No. of Axes		No. of Indicators		References
	Major	Minor	Major	Minor	
Regional	6	14	25	31	(Onatere *et al*., 2014; Tundys, 2015; Prause and Schröder, 2015; Domínguez-Caamaño *et al*., 2017; Hinkka *et al*., 2018; Morri *et al*., 2020; Karjalainen and Juhola, 2021; United-Nations, 2022; Peter *et al*., 2021; Cheng *et al*., 2023; Morri *et al*., 2023).
Sub-Regional	4	8	12	13	(National Research Council (U.S.), 20111 Varma (2018; Rail Net Europe (RNE), 2020; Nazam *et al*., 2020)
Freight and logistics	1	8	8	9	(National Research Council (U.S.), 20111 Varma (2018; Rail Net Europe (RNE), 2020; Nazam *et al*., 2020)
Urban cities	4	14	30	42	(Yousaf, 2012; García-Arca *et al*., 2018; Falahati *et al*., 2019; Kadir *et al*., 2020; Yang *et al*., 2020; Morri *et al*., 2021; Šišak, 2022; Xinlei *et al*., 2022).

Source: Author.

For the level of urban cities: the main (4) axes are divided into the target and (6) and the main (9) dimension owing to the multiple dimensions of urban transport within urban cities.

2.2 Goal Setting

The process of selecting Transport Key Performance Indicators (KPIs) and developing monitoring and evaluation goals relies on specific criteria highlighted in research literature. Various studies provide a diverse set of criteria to consider when choosing indicators, such as representation, practicality, and policy applicability. These criteria include validity, reliability, sensitivity, measurability, transparency, independence, and standardization. It is also essential to identify relevant evaluation indicators related to the specific goal of sustainable mobility and the availability of data needed to measure them accurately. The objective is to use these criteria to develop a technical table of indicators that is easy to understand and use for assessing the sustainable impact of urban mobility. After analyzing different research sources, a significant number of evaluative indicators have been identified for use in this context (Litman, 2017; Damidavičius *et al*., 2019).

Indicators are selected based on internationally agreed standards, leading to politically relevant, comprehensive, understandable, informative, and reliable initiatives for sustainable transport indicators. These indicators measure progress over time and provide valuable information about transport performance in terms of environmental, social, and economic sustainability (Sdoukopoulos *et al*., 2019). They should have a clear link to policies and objectives (Litman, 2023).

Characteristics of Effective Transport KPIs:

- Sensitivity: Indicators must be sensitive enough to highlight significant trends and even minor changes, helping identify problems, prioritize actions, and evaluate different solutions and measures.
- Comparability: Indicators should enable comparisons between different regions or jurisdictions with similar characteristics and illustrate complex phenomena in a simple manner understandable by experts and the public.
- Accessibility and Media Attention: Indicators should be publicly accessible and attract media attention. Their structure must be transparent, scientifically sound, and clearly defined.
- Consistent Data Collection: Data collection should be conducted regularly using consistent and scientifically approved methods.

Objectives of Transport Planning (Litman, 2023)

Transport planning adopts various objectives that align with the identified indicators:

- Diversity of Transport Systems: Travelers can choose from a variety of transport modes, positioning, and pricing options, especially affordable, healthy, and efficient choices that meet the needs of non-drivers.
- System Integration: Different components of the transport system are well integrated, such as pedestrian and cyclist access to transit, and integrated transport and land use planning.
- Affordability: Affordable transport options are available, providing access to low-income households.
- Resource Efficiency (Energy and Land): Policies encourage energy and land efficiency.
- Effective Pricing and Prioritization: Pricing for roads, parking, insurance, and fuel encourages efficiency, and facilities are managed to favor high-value trips and more efficient transport modes.
- Access to Land Use (Smart Growth): Policies support integrated, connected, mixed-use, and multimodal urban development to improve access to land use and transport options.
- Operational Efficiency: Agencies, service providers, and facilities are managed efficiently to reduce costs and improve service quality.
- Comprehensive and Inclusive Planning: Planning is comprehensive (considering all significant objectives, impacts, and options), integrated (coordinating decision-making across sectors, jurisdictions, and agencies), and inclusive (allowing participation from all affected parties).

In summary, developing Transport KPIs involves selecting indicators based on rigorous criteria, ensuring they are sensitive, comparable, accessible, and aligned with transport planning objectives. This approach supports sustainable urban mobility by providing valuable insights and guiding effective policy and investment decisions.

2.3 Evaluation of indicators

Ingram identifies three principles for selecting indicators: health, availability, and reliability. Indicator objectives must be linked to its activities, indicators must be measurable and readily available from secondary data, and indicators should be reliable to ensure comparability of data and indicators (Sdoukopoulos *et al*., 2019) as indicated in Table 3).

Table 3. Criteria for evaluating indicators.

No	criteria	Description
1	importance of goals	Each indicator must show one side of sustainable transport
2	Data availability and measurability	Indicators must be measurable using the UITP database
3	validity	Indicators must actually measure the issue they are supposed to measure.
4	sensitivity	Indicators must be able to detect changes in sustainable city transport
5	transparency	Indicators should be understandable and reproducible for intended users
6	standalone	The indicator must be independent of each other
7	standard	Indicator should be standardized by city size to compare cities

source : Haghshenas and Vaziri (2011).

Urban indicators can not only include environmental indicators, where economic and social issues play a critical role. Measuring the system's operational efficiency performance and measuring transport effectiveness lead to the achievement of urban policy objectives. Indicators of urban mobility should serve not only scientific purposes, but should have a practical impact and allow for their use by urban decision makers and other stakeholders to assess the level of urban mobility. Urban mobility studies are also used to prepare transport policy documents that are implemented, measured and evaluated in different countries around the world (Tundys, 2015).

2.4 Final Transport Key Performance Indicators (KPIs) for Egyptian urban transport systems in cities

The researcher will identify the main axes of the research, as well as a short definition of the axes and the main dimensions within each axis:

- Network performance: means the state of the transport network's physical infrastructure and deals with two situations: maintenance and development of the road network. and measuring the state of the road network.
- Effectiveness of the road network: It is intended to be a person's ability to access the transport service in a reasonable time and is divided into several axes:
  - Effectiveness of the transport network
    - Promotion and improvement of mass transport services
    - Efficient carriage of goods
    - Improved transition time
  - Efficient operation of the transportation system
    - Availability of road components complementing the land network
    - Availability of routing network elements (railways) - river transport(
    - Service and refuelling stations
- Social Inclusion & Land Content: The relationship between urban content and the impact of land uses on population mobility. Transport also plays an important role in urban content as a supportive means of expanding the radius of individuals' work and assisting in vital activities. The following means:

- Affordability and Accessibility: A person's ability to access the service in a reasonable time, considering the density of the road network, and the financial burden of transportation in the average income.
- Mobility :Flight characteristics, choice of mode of mobility, ease of movement and mobility
- Operational Efficiency :Use of resources towards the level of production, such as costs and income
- Infrastructure Condition and Performance :State of the transport network's physical infrastructure

- Efficiency of private parking services: It is intended to demonstrate the level of efficiency of parking service and the city's capacity for both waiting for the banana and waiting for the compound of its types, as it is one of the important indicators in clarifying the level of transportation service in the city
- Safety: The transport system to be measured is intended to reduce accidents of injury, death or crime on transport networks
- Accessibility for poor communities: The transport system is intended to accommodate all users, including those with disabilities, low incomes and other constraints, especially in poor communities without basic services, which in turn require travel to other communities.

As illustrated in

Fig. (*2*), an illustrative example of one of the indicator description cards relied on in the first and second project with a view to identifying the indicator's basic information, including: the characteristics of the indicator, the method of calculating the indicator and its importance, how to demonstrate the indicator on the map or table and source of Data, and so on. The following indicators will be detailed at the level of: Regional, Sub-regional, Freight & Logistics Transport, and Urban Cities.

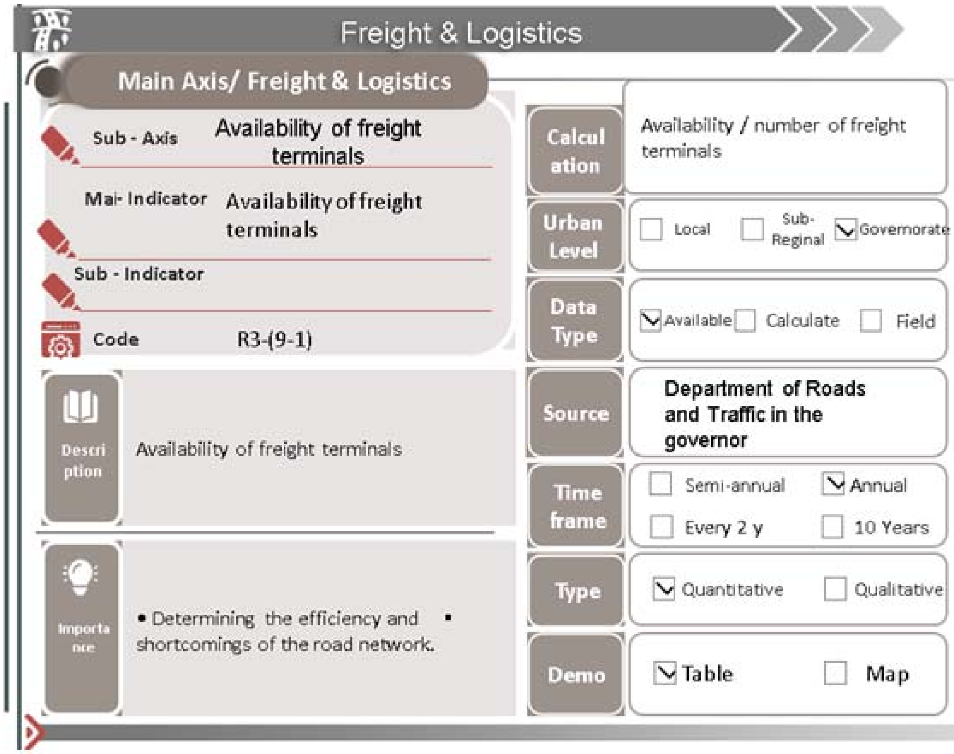

Fig. (2). Example of Indicator description cards. Source: Author

2.4.1 Regional Scale:

Main theme	sub-themes	Main indicator	How to calculate the indicator
Accessibility	Air Transport Capacity	Number of Air Passengers	The total annual number of travellers arriving/departing for the province's targeted airports (with more than 1 million international passengers in 2019)
		Number of Arrivals and Departures at Airports	The total number of international and domestic arrivals and departures based on airline schedules at the province's targeted airports (with more than 1 million international passengers in 2019)
	(Access to the nearest international airport)	Travel Time to Airports	The minimum time required to travel from the provincial airports targeted (with more than 1 million international passengers in 2019) to the provincial capital. In case of more than one airport, the weighted average is calculated according to the number of passengers in each airport
	Transport Comfortability	Commuting Time	Time required for a trip to work or school in the targeted governorate according to the resident's questionnaire
		Traffic Congestion	The level of congestion in percentage of each targeted governorate which compares the average additional travel time accumulated due to traffic congestion
	Access between governorates	Public Transportation Use	The density of train and tram stations located within 10 kilometres of the capital of the targeted province.
		Station Density	Utilization of public transport in the target city according to "traffic"
	Governorate Accessibility Index	Access to high-level transport infrastructure	Weighted arrival time for highway exits, railway stations and airports
		Availability of urban functions	Cities > 50,000 in 60 minutes by road and rail
		Access to regional centres	Travel time to the nearest regional hub by road and public transport/rail
		Daily accessibility of jobs	Jobs can be reached within 60 minutes by road or public transport/rail
Safety	Safety	accident rate	Accident rate (mode of transport)
			Accident rate per person (driver/passenger/cyclist/etc.)
		Accidents	Number of breakdowns; Breakdowns depending on the situation; Commercial vehicle accidents; Injuries to commercial vehicles; At-risk road user accidents in commercial vehicles
		Fatality Rates	Highway deaths; Commercial vehicle deaths; Number of fatal commercial vehicle crashes
Efficiency of land mass transport	Extent to which the means cover the governorate as a whole	Total Group Transport Pathways	Coverage of mass transport for the province as a whole = 100 X (Total mass transport route lengths ÷ Total length of roads in the governorate)
The extent to which networking is achieved	How easy it is to access all parts of the province	Measurement of traffic liquidity	Average transit time between provincial centres = (Average distance between center and city ÷ average speed of traffic)
Efficient river, sea and rail transport	Efficiency of the capacity of railway routes passing through the governorate	Measuring the efficiency of the capacity of railway routes passing through the governorate	Total transported passenger volume per day (The number of passengers per day)
			Total volume of goods (liquid and solid) transported daily (Volume of goods/day)
			Total number of railway stations = 1000 X (total number of railway stations in the governorate ÷ total population of the governorate)
	Efficient river and sea transport capabilities passing through the governorate	Measuring the efficiency of river and sea transport capabilities passing through the governorate	Total transported passenger volume per day (The number of passengers per day)
			Total volume of goods (liquid and solid) transported daily (Volume of goods/day)
			Total number of river and sea ports = 1000,000 X (total number of river and sea ports in the governorate ÷ total population of the governorate in 2020)
network performance	Adequate budget for road maintenance	%of the total budget implemented from the total offered for the development and maintenance of the existing road network at the governorate level	100 X (total budget implemented for the development and maintenance of existing roads at the governorate level ÷ the overall development and maintenance of existing roads at the governorate level)
		The length of the road network for which periodic maintenance is performed from the total of the existing network at the governorate level	The length of road networks maintained from the total length of the network at the centre level of the total existing network at the governorate level = 100 X (total length of roads for which periodic maintenance is performed at the governorate level ÷ total length of roads based at the governorate level)
	Road network distribution efficiency	%of the total length of roads at the governorate level	100 x (total length of national roads passing through the governorate ÷ total length of roads based on the governorate level)
	Traffic pressures and transportation	Total cargo load per year per ton (rail, river and sea transport combined)	Total tonnage of liquid goods per year in tonnes (Volume of goods/year)
			Total cargo load per year per ton (Volume of goods/year)
		Ownership of vehicles (total number of vehicles registered with the governorate traffic departments/1,000 residents of the governorate)	1000 X (total number of vehicles registered with the Department of Traffic in the governorate ÷ total population of the governorate in 2020)
	Congestion/Mobility	rush hour	Total hours of congestion during the week during and after peak hours
		Travel Time Index	The total travel time used to travel from the provincial capital to the surrounding provincial capitals

Source: Author from : (Onatere *et al*., 2014; Tundys, 2015; Prause and Schröder, 2015; Domínguez-Caamaño *et al*., 2017; Hinkka *et al*., 2018; Morri *et al*., 2020; Peter *et al*.,2021;Karjalainen and Juhola, 2021; United-Nations, 2022; Morri *et al*., 2023; Cheng *et al*., 2023).

2.4.2 Subregional scale

Main theme	sub-themes	leading indicator	How to calculate the indicator
Efficiency of land mass transport	Extent to which the means cover the governorate as a whole	Number of mass transport positions at the centre level	100,000 X (total number of official positions of the Centre ÷ total population of the Centre in 2020)
			100,000 X (total number of random positions of the Centre ÷ total population of the Centre in 2020)
		Number of bus stations at the centre level	1000 X (total number of bus stations for the center ÷ total population for the center in 2020)
The extent to which networking is achieved	How easy it is to access all parts of the province	Measurement of traffic liquidity	(Average distance between center and city ÷ average speed)
network performance	Traffic pressures and transport	Center-wide highway coverage (center-wide road lengths (km))	100 X (total length of highways passing through the center ÷ total length of roads based on the center level)
		The length of roads within the centers that suffer from traffic bottlenecks from the total length of roads within the centers	100 X (total length of roads suffering from traffic jams at the centre level ÷ total length of roads based at the centre level)
		%of all main regional roads between centres suffering from traffic bottlenecks from the total length of the main regional roads	100 X (Total of main regional road lengths among hubs experiencing traffic jams ÷ Total of existing regional main road lengths)
	Congestion/Mobility	rush hour	Total hours of congestion during the week during and after peak hours
		Travel Time Index	Total travel time used to travel from the provincial capital to the surrounding provincial capitals
Accessibility for poor communities	Affordability of mobility	Affordability of mobility	Percentage of the city's poorest 10% for whom the urban transport system is affordable (requires less than 10% of monthly household expenditure)
	Availability of urban mobility	Availability of urban mobility	Travel distance to the nearest bus stop (km/mi)
	Access to health care facilities	access to health care facilities	Duration of travel to nearest hospital/health unit
	Availability of higher secondary schools	High Schools Availability	Number of secondary schools within 30 minutes of travel

Source: Author from: (National Research Council (U.S.), 2011; Zaiat, 2014; Varma, 2018; Rail Net Europe (RNE), 2020; Nazam *et al*., 2020;; Peter *et al*., 2021; United-Nations, 2022).

2.4.3 Freight scale

Main theme	Main- indicator	How to calculate the indicator
Efficient Freight transport & Logistics	Total cargo load per year per ton	Total cargo load per year per ton
	Chuen Parking and Maintenance of Heavy Transport Vehicles	Parking space and maintenance of heavy transport vehicles
		At the centre/governorate level
	Percentage of land use related to industry and its complementarities	Percentage of industrial land use - warehouses - charging and unloading places - markets of various degrees - urban storage places at the centre/governorate level
		Market distribution and market qualitative statement (weekly - seasonal) and duration of supply at the centre/governorate level
		Distribution or concentration of industrial uses - crafts at the centre/governorate level
	Value of Freight Flow	Shipping Flow Value
	Tons of Freight Flow	Tons of shipping flow
	Top Commodities Shipped (to/from/within)	Main goods shipped (from/to/inside)
	Access to freight terminals	access to charging stations
	Availability of freight terminals	Availability of charging stations

Source: Author from: (National Research Council (U.S.), 2011; Zaiat, 2014; Varma, 2018; Nazam *et al*., 2020; Rail Net Europe (RNE). 2020).

2.4.4 1.4.4 City Scale

Categories	Goals	main dimensions	main indicator	sub- indicator	**How to calculate the indicator**
network performance	Maintenance and development of road network	Road network maintenance and development rates	Periodic maintenance of the road network	Ratio of the length of road networks maintained from the total length of the existing city network	Network length for which maintenance has been done/Total longest existing network
				Proportion of the length of the road network for which maintenance and development have been carried out from the total length of roads in the annual development plan	Proportion of the length of the road network for which maintenance and development have been carried out from the total length of roads in the annual development plan
				Total budget implemented from the total budget submitted for the development and maintenance of the existing road network	Total budget implemented from the total budget submitted for the development and maintenance of the existing road network/year
	Road Netw ork Effici	Effici ent road netwo	Paved Internal Roads	Proportion of length of paved internal road networks	The length of the paved intranet to the total length of the city grid (within the current urban mass 2018)
				Proportion of land allocated to streets	The total area of the city's inner road network divided by the total area of the city
				Percentage of major roads suffering from traffic bottlenecks	Length of hubs suffering from traffic jams in the city
Effectiveness of the road network	Effectiveness of the road network	Encourage the use of and improve transit and active transport networks	Regional mass transport positions (official/random)	Number of situations relative to the degree of development (with services for citizens and drivers)	Total positions developed to all positions Number of regional positions developed or established/transferred/cancelled
					Total number of regional positions
					Position absorptive capacity
			Inland mass transport situations (official/random)	Total number of internal positions (official/random)	Position absorptive capacity
					Ratio of total/random to total positions
				Number of internal situations developed or created/transferred/cancelled	Ratio of total number of internal situations developed or created/transferred/cancelled to total positions
			Elements of the inland mass transport network	Multiple means (formal - informal)	Number and percentage of types of vehicles engaged in mass transport (angel, taxi, (transport, trailer, tractor) in some cases of small towns with rural background - microbus, bus trips, toktoc, etc.)
				Main and sub-positions (formal - informal)	Main and sub-positions (formal - informal)
				Length and distribution of mass transit routes in the city	Length and distribution of mass transit routes in the city
				Main and branch station locations	Main and sub-stations on mass transport routes
				Service, storage and maintenance premises	Presence of service, storage and maintenance premises (number - area)
			Mass transport capacity	Total mass transport capacity	Total mass transport capacity and mass transport coverage (number of vehicles per 1,000 inhabitants)
				Total number of vehicles in service at the city level	Total number of vehicles in service at the city level
		Efficient carriage of goods	Total cargo load per year per ton	Total cargo load per year per ton	Total cargo load per year per ton
			Chuen Parking and Maintenance of Heavy Transport Vehicles	Chuen parking space and maintenance of heavy transport vehicles	Chuen parking space and maintenance of heavy transport vehicles
				Distribution of Chuen parking and maintenance of heavy transport vehicles	Within the city/city center level
			Land use related to industry and its complementarities	Distribution or concentration of industrial land uses - warehouses - charging and unloading places - markets of various degrees	Percentage of industrial land uses - warehouses - charging and unloading places - markets of various degrees - urban storage places
					Market distribution and market qualitative statement (weekly - seasonal) and duration of supply
					Distribution or concentration of industrial-craft uses at the city level
		Improved transition time	Time to move to the nearest city within the center	Average time to move from the city to the nearest city within the center	Regional route length/average operational speed including delay time (minutes for one-way trip only)
			Time to move to the nearest city outside the center	Average time to move from the city to the nearest city outside the center	Regional route length/average operational speed including delay time (minutes for one-way trip only)
			Time to move from the city centre to the nearest regional mass transport situation	Average time to move from the city centre to the nearest regional mass transport situation	Length of flight/average operational speed including delay time (minutes for trip to go only)
			Road Service Level	Total Number of Flights/Network Flight Generation Rate	The total number of daily city trips per hour or day/estimated capacity of the lane
			Time to move from the city centre to the nearest entrance to the city	Average time to move from the city centre to the nearest entrance to the city	Length of flight/average operational speed including delay time (minutes for trip to go only)
	Efficient operation of the transportation system	Availability of complementary network elements	Availability of road components complementing the land network	Network complements reduce flight time and congestion	Number and whereabouts of bars - expenditure - slides (official or unofficial).... other
			Availability of routing network elements (railways) - river transport)	Number and whereabouts of elements of targeted transport networks (railways) -- river transport)	Number - River ports - Kabari - Tunnel - Slaqanat - Railway stations - Infectious - River ferries... .Other)
					Distribution of places of presence -Riverine ports - Cabari - Tunnels - Slaqanat - Railway stations - Infectious - River ferries... .Other)
					Number of service stations

			Availability of heavy transport service stations	Number and distribution of service and refuelling station premises	Distribution of service station premises
			Availability of service stations for owners and fare	Number and distribution of service and refuelling station premises	Number of service stations
					Distribution of service station premises
Social Inclusion & landuse	Affordability and Accessibility	Improve access to daily destinations by all modes	The energy of mass transport within the range of a longitudinal kilometre of mass transport	The energy of mass transport within the range of a longitudinal kilometre of mass transport	Proportion of population to group transport's capacity within a longitudinal kilometre of mass transport
					Average flight time in minutes
			Affordability of transport	Affordability of transport	Ratio Number of trips * Average cost per trip/per capita income rate Total cost spent on travel throughout the month or ratio of mobility cost to total monthly income
			Ratio of compatibility with land use schemes	Length of roads per 1,000 people (Km)	Length of roads to every 1,000 inhabitants
			Ownership of private vehicles	Ownership of vehicles in the governor	Total number of vehicles registered with the governorate traffic departments/1,000 inhabitants of the governorate
			Modal split	Percentage of modal split	Number and percentage of vehicle types (angel, taxi, transport, trailer, tractor, microbus, bus trips, Toktoc, etc.)
		Inland Road Network Connectivi	Intersection density	The city's intersection density	Number of intersections/km2 of block area built in the city
			Road Network Density	Density of the city's inland road network	Length of road network/building block area of the city
			Road Network Space	Percentage of space allocated to a road network	(Road Network Area/City Built Block Area) * 100
			Average Road Offers	Percentage of roads from 8 m Fakil	Road Network Area/Road Network Density
Efficient Parking Services	**Private parking spaces**	Capacity for parking spaces in the city	ON street	Number of parallel parking spaces allowed on roads	Number of parallel waiting places = Length of permitted parallel waiting methods divided by 6 m
				Space allocated for parking	Total space allocated for waiting for the mosaic
			Off Street) Official - Informal(	Total Number of parking Available in the City And the total space allocated for parking	Number of complexes waiting places and number of multi-role garages
					Space of combined waiting spaces and spaces that are exploited as parking spaces
					Distribution of complex waiting spaces, distribution of multi-role garages and distribution of space land spaces that are exploited as waiting spaces
			Total capacity of parking spaces in the city	Ratio of total number of waiting places available in the city compared to the actual needs of the population	Ratio of total number of waiting places available in the city compared to the actual needs of the population

Source: Author from: (Yousaf, 2012; García-Arca *et al*., 2018; Falahati *et al*., 2019; Kadir *et al*., 2020; Yang *et al*., 2020; Morri *et al*., 2021; Xinlei *et al*., 2022; Šišak, 2022).

Conclusion

Indicators are metrics we use to assess progress toward goals and objectives. They have various uses: indicators can help identify trends, predict problems, evaluate options, set performance targets, and assess the efficiency of a specific transportation system or its components. They shape our understanding and focus by highlighting what is significant. The choice of indicators can greatly influence planning decisions, making it crucial to select those that align with overall goals. It is also important to be realistic when choosing indicators, considering data availability, comprehensibility, and usefulness in decision-making.

Purpose and Framework

The purpose of this research is to formulate a basic framework that provides a general set of measurable, interpretable, and adaptable Transport Key Performance Indicators (KPIs) applicable to the Egyptian context across various planning levels (regional, municipal, urban, and logistics transport). Through a rigorous selection, evaluation, and suitability assessment process, the research identified the most fitting indicators for each level. For instance, safety indicators were excluded due to data collection challenges, such as obtaining accurate death rates by transportation mode in cities. Similarly, smart transport indicators were excluded as they are currently in limited trial phases and not yet widely implemented in Egyptian cities.

Challenges in Developing Transport KPIs

Creating Transport Key Performance Indicators (KPIs) for transportation systems can be challenging due to several factors:

- Identifying the Right Metrics: Determining the most critical metrics to measure the success of a transport system can be difficult. This necessarily requires a deep comprehension of the objectives of the system and the elements influencing its performance.
- Collecting Accurate Data: Accurate data collection is challenging, especially in large and complex transport systems. Advanced technologies like traffic sensors, GPS devices, or surveys are needed.
- Data Analysis: Analyzing data can be time-consuming and requires expertise. To prevent drawing the wrong conclusions, it is imperative to make sure the data is examined accurately.
- Ensuring Relevance: KPIs must be relevant to the transport system's goals. It is important to ensure that KPIs align with the objectives and provide meaningful insights into system performance.
- Monitoring and Adjusting: KPIs should be regularly monitored to ensure the transport system meet its goals. If KPIs indicate that the system is not achieving its objectives, adjustments may be necessary to improve performance.

Practical Application

Creating Transport KPIs requires careful planning, data collection, analysis, and monitoring. It is essential to ensure that KPIs are relevant, accurate, and aligned with the transport system's goals. Transport systems might face various challenges, such as the complexity of rail transport or the need for sustainable solutions in freight transport.

In summary, Transport KPIs serve as crucial tools in evaluating and guiding the performance and development of transportation systems. By carefully selecting and monitoring these indicators, decision-makers can effectively steer transportation systems towards achieving broader goals, ensuring that the selected indicators provide clear, actionable insights that support sustainable and efficient transport solutions.

Recommendation

To overcome the challenges in creating Transport Key Performance Indicators (transport KPIs) for transportation systems, the following recommendations can be implemented:

1- **Identifying the Right Metrics**: which include (A) Comprehensive Goal Analysis: Begin with a thorough analysis of the system's goals and consider the factors that affect its performance. (B) Utilize Expert Insights: Collaborate with transportation experts to identify the most important metrics. And (C) Review Literature: Examine previous studies and best practices in transportation to determine common and effective metrics.

2- **Collecting Accurate Data**: which include (A) Adopt Modern Technology: Use technologies such as traffic sensors and GPS devices to collect real-time data. (B) Data Verification: Implement verification procedures to ensure the accuracy of collected data. And (C) Conduct Surveys and Questionnaires: Regularly carry out surveys and questionnaires to obtain direct input from system users.

3. **Data Analysis**: which include (A) Employ Advanced Analytical Tools: Use advanced data analysis software like Python and R for efficient data analysis. (B) Hire Data Analysis Experts: Work with data analysis specialists to ensure accurate and reliable conclusions. And (C) Provide Training and Development: Offer training to staff on the latest data analysis techniques and tools.

4. **Ensuring Relevance**: which include (A) Periodic Goal Review: Conduct regular reviews of the system's goals to ensure that transport KPIs remain relevant. (B) Feedback Mechanism: Gather feedback from stakeholders and system users to refine the transport KPIs. And (C) Continuous Evaluation: Continuously evaluate the relevance of transport KPIs and adjust them according to changing conditions and goals.

5. **Monitoring and Adjustment**: which include (A) Automated Monitoring Systems: Adopt automated monitoring systems that provide regular updates on system performance. (B) Periodic Performance Analysis: Conduct regular performance analyses to identify strengths and weaknesses. And (C) Quick Response to Deviations: Be prepared to make necessary adjustments swiftly when deviations from set goals are observed.

These recommendations can enhance the process of creating and utilizing transport KPIs for transportation systems, ensuring that these indicators are effective and appropriate for achieving desired goals.

REFERENCES

Cheng, R.; Jiang, Y. and Nielsen, O.A. (2023). Integrated people-and-goods transportation systems: from a literature review to a general framework for future research. Transp. Rev., 43(5):997–1020. doi: 10.1080/01441647.2023.2189322.

Damidavičius, J.; Burinskienė, M. and Ušpalytė−Vitkūnienė, R. (2019). A monitoring system for sustainable urban mobility plans. Baltic J. Road and Bridge Engineering, 14(2): 158–177. doi: 10.7250/bjrbe.2019-14.438.

Domínguez-Caamaño, P. García-Arca, J.; Fernandez-González, A. J. and J. C. Prado-Prado, J.C. (2017). Transport KPIs for Supply Chain Improvement. A Literature Analysis, pp. 251–258. doi: 10.1007/978-3-319-45748-2_27.

Dubolazov, V. A.; Shchelkonogov, A.A. and Temirgaliev, E.R. (2019). Use of Internet of things to assess KPI in the transport logistics service. Atlantis Highlights in Computer Sciences, International Conference on Digital Transformation in Logistics and Infrastructure (ICDTLI 2019), vol. 1, pp. 275–279, 2019.

Eden, N.; Tsakarestos, A.; Kaparias, I.; Gal-Tzur, A.; Schmitz, P.; Hauptmann, S. and Hoadley, S. (2012). Using Key Performance Indicators for traffic management and Intelligent Transport Systems as a prediction tool. Paper presented at the 19th ITS World Congress, 22 - 26 October 2012, Vienna, Austria.

Falahati, M.; Zokaei, M.; Asady, H.; Mojre, M.N.; Biabani, A. and Torshizi, Y.F. (2019). Model of the Selection KPI for assessing the performance of the Urban HSE management system.. http://ioh.iums.ac.ir

García-Arca, J.; Prado-Prado, J.C. and Fernández-González, A.J. (2018). Integrating KPIs for improving efficiency in road transport. Int. J. Physical Distribution and Logistics Management, 48(9):931–951. doi: 10.1108/IJPDLM-05-2017-0199.

Haghshenas, H. and Vaziri, M. (2011). Urban sustainable transportation indicators for global comparison. Ecol. Indic., 15(1):115–121. doi: 10.1016/j.ecolind.2011.09.010.

Hinkka, V.; Porkka, J.; Fatima, Z. and Hyvärinen, J. (2018). Terminal Planning: The Selection of Relevant KPIs to Evaluate Operations, Vienna, Austria: 7th Transport Research Arena TRA. doi: 10.13140/RG.2.2.31916.92807.

Jaeger, F.A.; Müller, K Petermann, C. and Lesage, E. (2018). LCA in Strategic Decision Making for Long Term Urban Transportation System Transformation, in Designing Sustainable Technologies, Products and Policies, Springer International Publishing, pp. 193–204. doi: 10.1007/978-3-319-66981-6_22.

Kadir, A.R.; Kamariah, N.; Ganna, O.R.; Pono, M. and Yamar, I. (2020). Mode selection in transportation system: Implications of quality function deployment, in IOP Conference Series: Earth and Environmental Science, Institute of Physics Publishing, May 2020. doi: 10.1088/1755-1315/473/1/012118.

Karjalainen, L.E. and Juhola, S. (2021). Urban transportation sustainability assessments: a systematic review of literature. Transp. Rev., 41(5): 659–684. doi: 10.1080/01441647.2021.1879309.

Krmac, E. and Djordjević, B. (2018). An Evaluation of Indicators of Railway Intelligent Transportation Systems using the Group Analytic Hierarchy Process. Electronics Science Technology and Application, 4(2). doi: 10.18686/esta.v4i2.57.

Litman, T. (2008). Sustainable transportation indicators a recommended research program for developing sustainable transportation indicators and data.

Litman, T. (2017). Developing Indicators for comprehensive and Sustainable Transport Planning, VTPI. www.vtpi.org

Litman, T. (2023). Well measured developing indicators for sustainable and livable transport planning. National Research Council. doi: 10.3141/2017-02.

Makarova, I.; Shubenkova, K. and Pashkevich, A. (3021). Efficiency assessment of measures to increase sustainability of the transport system. Transport, 36(2):123–133. doi: 10.3846/transport.2021.14996.

Mateichyk, V.; Śmieszek, M. and Kostian, N. (2022). Evaluation of transport system configuration by efficiency indicators. Transport technologies, 2022(2):52–62. doi: 10.23939/tt2022.02.052.

Mladenovic, G.; Vajdic, N.; Wündsch, B. and Temeljotov-Salaj, A. (2012). Use of key performance indicators for PPP transport projects to meet stakeholders' performance objectives. Built Environment Project and Asset Management, 3(2):228–249. doi: 10.1108/BEPAM-05-2012-0026.

Morri, N.; Hadouaj, S. and Ben Said, L. (2020). Towards an Intelligent control system for public transport traffic efficiency KPIs optimization, in Proceedings of 2020 Global Mosharaka Congress on Electrical Engineering, GC-ElecEng 2020, Institute of Electrical and Electronics Engineers Inc., Sep. 2020, pp. 33–37. doi: 10.23919/GC-ElecEng48342.2020.9286268.

Morri, N.; Hadouaj, S. and Ben Said, L. (2021). Agent-based intelligent KPIs optimization of public transit control system, in Proceedings of the 18th International Conference on Informatics in Control, Automation and Robotics, ICINCO 2021, Sci. Te. Press, 2021, pp. 224–231. doi: 10.5220/0010616302240231.

Morri, N.; Hadouaj, S. and Ben Said, L. (2023). Toward real-time multi-objective optimization for bus service kpis, in lecture notes in electrical engineering, Springer Science and Business Media Deutschland GmbH, pp. 18–36. doi: 10.1007/978-3-031-26474-0_2.

National Research Council (U.S.). (2011). Transportation Research Board. *et al*., Performance measures for freight transportation. Transportation Research Board.

Nazam, A.; Muhammad, A.J.; Syed, A.H. and Muhammad, A. (2020). Key Performance Indicators for Sustainable Freight Transport and Scenario-based Impediments in Pakistan Freight Industry. IPTEK J. Proceedings Series, 5:1–8.

Onatere, J.O.; Nwagboso, C. and Georgakis, P. (2014). Performance indicators for urban transport development in Nigeria, in WIT Transactions on the Built Environment, WITPress, pp. 555–568. doi: 10.2495/UT140461.

Ove, A. (2018). Tools and Techniques for Advanced Traffic Analytics. Ph.D. Dissertation, Aalborg University, Denmark. https://doi.org/10.54337/aau717360907

Peter, N.; Batty, M. and Bartlett, C. (2021). Global Power City Index.

Podskrebko, O.S.; Ivanchenko, N.O. and Tkachenko, V.V. (2021). Modeling of the System of Evaluation of Retail Enterprises on the Basis of KPI and Process Approach. Business Inform, 4(519):66–72. doi: 10.32983/2222-4459-2021-4-66-72.

Prause, G. and Schröder, M. (2015). On KPI sets of green transport corridors, in Lomonosova, The 15th International Conference Reliability and statistics in transportation and communication–2015, p.1019. https://www.researchgate.net/ publication/313933015

Rail Net Europe (RNE) (2020). Guidelines-Key Performance Indicators of Rail Freight Corridors-Version 3.0. www.rne.eu

Romero-Ania, A.; De Vicente Oliva, M.A. and Gutiérrez, L.R. (2023). Economic evaluation of the urban road public transport system efficiency based on data envelopment analysis. Applied Sciences (Switzerland), 12(1). doi: 10.3390/ app12010057.

Sdoukopoulos, A.; Pitsiava-Latinopoulou, M.; Basbas, S. and P. Papaioannou, P. (2019). Measuring progress towards transport sustainability through indicators: Analysis and metrics of the main indicator initiatives. Transp. Res. D. Transp. Environ., 67:316–333. doi: 10.1016/j.trd.2018.11.020.

Šišak, I. (2022). Transportation-geographical analysis of the public transportation system: a case study of the Sesvete District and the municipalities of Gornja Stubica and Marija Bistrica. Hrvatski Geografski Glasnik, 84(1):93–125, 2022, doi:10.21861/ HGG.2022.84.01.04.

Torbacki, W. (2017). Dematel method in ERP systems for TSL branch. Transport Problems, 12(4):27–36. doi: 10.20858/tp.2017.12.4.3.

Tundys, B. (2015). Key performance indicators as element of assessment and towards the development of sustainable mobility. https://www.researchgate.net/publication/ 277328361

United-Nations (2022). The Sustainable Development Goals Report.

Varma, A. (2018). Measurement Sources for Freight Performance Measures and Indicators. http://www.lrrb.org/PDF/200812.pdf

Wollman, D.A.; Griffor , E.; Greer, C.; Dunaway, M.; Serrano, M.; Burns, M. and Rhee, S. (2022). Smart cities and communities: A Key Performance Indicators Framework. Special Publication (NIST SP), National Institute of Standards and Technology, Gaithersburg, M.D. doi.org/10.6028/NIST.SP.1900-206-upd1

Xinlei, M.; Wen, C.; Zhan, G. and Tao, Y. (2022). Adaptive decision support model for sustainable transport system using fuzzy AHP and dynamical Dijkstra simulations. Mathematical Biosciences and Engineering, 19(10):9895–9914. doi:10.3934/mbe. 2022461.

Yang, L.; van Dam, K.H. and Zhang, L. (2020). Developing goals and indicators for the design of sustainable and integrated transport infrastructure and urban spaces. Sustainability (Switzerland), 12(22):1–34. doi: 10.3390/su12229677.

Yousaf, M.S. (2012). Diagnosing Transportation: Developing. School of Urban Planning McGill University.

Zaiat, A. (2014). Faculdade de Engenharia da Universidade do Porto integrated multimodal transportation dashboard. Mestrado Integrado em Engenharia Informática e Computação. https://repositorio-aberto.up.pt/bitstream/10216/75070/2/31598.pdf

مؤشرات الأداء الرئيسية للنقل الحضري: صياغة إطار نظري لقياس كفاءة أداء أنظمة النقل الحضري بالتطبيق على الحالة المصرية

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المستخلص

تعتبر أنظمة النقل الحضـــري من أهم مكونات العمران الحضـــري والتي تحدد بشـــكل رئيســـي طبيعة حركة الأشخاص والأنشطة والبضائع في اى مدينة، وتعتبر أيضا من أهم مسببات العديد من مشاكل العمران من حيث الازدحام والتلوث وغيرها من القضـــايا الملحة لتطبيق الاســـتدامة بابعادها الاجتماعية والبيئية والاقتصـــادية على المســـتوى المحلي والعالمي. ولذلك تعتبر قضية قياس كفاءة أداء أنظمة النقل الحضري من القضايا الملحة عند تطوير وتخطيط اى مدينة حيث تعتبر حجر الأساس في تحديد فجوة الوضع الراهن وأيضا في صياغة القرارات التخطيطية وتطوير المدن نحو الاستدامة. ويهدف هذا البحث الى صـياغة اطار عام لتحديد مؤشـرات قياس كفاءة أداء نظم النقل الحضـري وكيفية تطبيقها لاحقا في الحالة المصـرية، وقد قام الباحث باعداد هذه الدراسـة ضـمن مشـروع المرصـد الحضـري للمدن المصـرية بالهيئة العامة للتخطيط العمراني GOPP ، بهدف التطبيق في حالتين دراســيتين احدهما على مســتوى العمران الحضـــري في المدن الصغيرة عام 2018 والأخرى على المستوى الإقليمي والشبه إقليمي في المحافظات المصرية عام 2023. ويركز البحث على صياغة اطار عام يشمل عملية اختيار المؤشرات ومنهجية عمل المؤشرات على كل المستويات العمرانية. وأخيرا تم عرض الدروس المستفادة من صياغة وتكوين مجموعات المؤشرات المختلفة وأيضا أهم الصعوبات والتحديات في تطبيق هذه المؤشرات في الحالة المصرية.

الكلمات الدالة: مؤشرات قياس كفاءة الأداء – مؤشرات أداء النقل الإقليمي – مؤشرات أداء النقل الحضري.