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URBAN SMART-MOBILITY PROJECTS EVALUATION: A LITERATURE REVIEW

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Abstract
This work aims to reorganise theoretical and empirical research on urban smart mobility projects evaluation through the systematic literature review approach. The research goal is to identify methodologies and socio-economic indicators according to the different types of urban smart – mobility projects. The article provides a summary of the state of the art of methodologies and socio-economic indicators categorised within the SMART mobility projects framework developed by Fernandez-Anez (2018). The results can have broader impacts in developing urban smart mobility strategic plans and decision making processes of selecting smart mobility projects. In particular, the results will be a reference for public administration practitioners helping them in identifying appropriate methodology and performance indicators according to the particular type of urban smart mobility project.
Keywords: Urban smart-mobility; Evaluation; Socio-economic indicators

1. INTRODUCTION

The concentration of the world's population in several large cities in the 21st century is constantly growing. While 30% of the world's population lived in cities in 1950, this figure rose to 54% in 2014, with the UN (2014) predicting that in 2050, up to 66% of the world's population will live in cities. Thus, in the last decade, cities have faced new challenges associated with population growth, such as urban public and static transport, sustainable waste management, crime or access to education, or pre-school care. In the context of the structure and intensity of these challenges, it is necessary to consider the socio-economic and urban development of new so-called "smart and intelligent" concepts aimed at minimising the negative impacts of human activity in the urban environment. Schaffers et al. (2011) consider the Smart city (SC) concepts one of the ideological solutions of sustainable city development. Thus, SC's concept has become a central concept of academic discussions on urban and urban models in recent years Zygiaris (2013). Initially, the SC concept was intended to provide intelligent solutions to traffic or waste management through the efficient use of ICT and technology companies such as IBM, HP, Siemens or Cisco Harrison and Donnely (2011). The current literature provides several definitions of the SC concept.

For example, in urban planning, the smart city is used as an ideological dimension, according to which being smarter means strategic direction Albino (2015). According to Schaffer et al. (2011), the SC concept responds to today's cities' challenges in achieving sustainable urban development. Shifting from the "technocentric" perception of the SC concept is confirmed by the view that the creation of the SC should be a response to the needs and expectations of the urban population e.g. Hollands (2008); Vácha, Přibyl, Lom and Bacúrová, 2016) and meet sustainable goals e.g. Ahmad and Mehmood (2015); Ismagiloiva et al. (2019); Yigitcanlar et al., (2019a, 2019b). According to Caragliu, Del Bo and Nijkamp (2011) or Chourabi et al. (2012), SC can be defined as a city that, in cooperation with its inhabitants and with the support of modern technologies, provides innovative solutions to specific problems associated with the city's territory in areas such as mobility, economy, administration, environment, life or people. Despite numerous approaches to analysing the performance of smart cities in overcoming or addressing the urban challenges provided by various scholars e.g. Chourabi et al. (2012); Caragliu et al. (2011); Lombardi et al. (2012); Fernández-Güell et al. (2016); Giffinger et al. (2007), a standardised methodology for evaluating smart cities is still lacking.

That may be due to the diversity of challenges facing cities globally, reflecting in smart cities projects and programs. According to Fernandez-Anez et al. (2018), there are two main gaps in implementing a smart city. The first is related to evaluating smart cities projects as the main tool of the smart city programme. The second gap is the need to describe and know the relationship between the impacts of smart city strategies and the challenges that cities are facing today. The first problem can be generally explained as the need to understand the importance of urban projects and the city's specific challenges and needs. The same authors also describe two main approaches to SC project evaluation. The first involves benchmarking and comparative analysis. The second methodology seeks to correlate the essential elements of the SC concept. The methodologies within this second group use a triple helix approach, analytical network processes or fuzzy logic, including expert opinions on processes. Both approaches are based on the collection of indicators to analyse the city's performance. This leads to identifying another problem in the SC evaluating process because most SC projects are currently in the pilot stage (Policies, 2014). The same study describes the practical problem of evaluation. In most cases, the objectives of the project and the program are not well defined (they are not specific and measurable), and at the same time, there is a lack of information on its baseline value. Moreover, the evaluation of SC projects is limited by their completion. The high demand for the development of standardised smart city performance indicators is thus in place. Caird & Hallett (2018) highlighted two critical challenges for smart city evaluation; standardised citizen-centred development indicators and identification of smart cities projects and program values and their broader impacts. On the other hand, the same authors argue that there is no need for an agreement on standardised development indicators because, as already mentioned, smart strategies and projects are very diverse, so it is challenging to agree on a standard set of indicators to adapted to the unique needs of each city and project. It is possible to evaluate the development of a smart city project and strategy by measuring existing KPIs related to implementing various other city strategies. Distribution of SC projects' value and tangible impact and programs on city development is also challenging in complex urban relations. Another issue identified in evaluating an SC performance is the need to change how the city works.

Therefore, cities will need to change how they traditionally operate to reap the full benefits of smart cities programs and projects PAS 181: 2014 (2014). The traditional operating model for the city was based on functionally oriented service providers who act as inflexible vertical forces, which are often not based on user needs. Smart cities need to develop new operating models that will drive innovation and collaboration across these vertical forces. Jouili et al. (2017) argue that economic actors, politicians, and civic organisations are currently in the stage of a new multidimensional reality in which several problems are related to cities' functioning. Therefore, indicators and KPIs developed based on the traditional city modus operandi are unlikely to suit new operating models and multidimensional reality in future cities. According to Craid, Hudson, & Kortuem (2016), existing evaluation approaches have been criticised as inadequate, focusing on implementing projects and programs, not on smart city projects and programs on the city's strategic results and progress. The key challenge in the evaluation process is how to measure the impact of smart city programs on the city's performance on a larger scale. In cities with various smart projects and programs, there is currently no problem with data availability, as cities usually collect a significant amount of data at the project level. The question of what methodology to use to assess the value of a project in a particular area for the city and its citizens remains open.

The important part of the SC concept is SMART mobility. One of the main purposes of the SC concept is to improve the quality of life for the citizens. Urban mobility is one of the crucial issues that modern cities have to face to with aim to improve everyday life quality of its citizens. Brčič (2018) Urban mobility plays a key role in the ecosystems of complex smart cities. It is considered a key factor in enabling cities to become more intelligent Maldonado et. al. (2020) Therefore, this article aims to answer the question of what methodologies and indicators are used to evaluate smart city mobility projects. The paper is organised as follows: this introduction addresses the presentation of the research problem. Then, Section 2 presents the research methodology used, while Section 3 is devoted to content analysis and discussion of results. Finally, Section 4 summarises the conclusions.

2. METHODOLOGY

A systematic description of the methods and indicators used to evaluate smart city mobility projects is based on a content analysis of the state-of-the-art research into smart mobility. The literature review presents a structured, explicit, and reproducible approach to selecting and interpreting an existing set of documents Fink (2019). The literature analysed in this article includes peer-reviewed articles published in journals indexed in WoS and Scopus databases. The second category of analysed documents are working papers and materials available on Google Scholar.

The analysed articles for the purposes of this article were categorised according to the breakdown of the SMART mobility projects framework developed according to Fernandez-Anez (2018). For each subcategory, articles from foreign literature dealing with evaluating projects falling into these subcategories were collected and analysed.

To analyse the available methodologies, we performed an analysis of case studies focused on the application of different approaches to the assessment of social benefits in the field of SMART-MOBILITY at the city level. The SMART MOBILITY area itself is relatively heterogeneous in terms of various applications, but mainly in terms of social benefits they provide. Therefore, for a deeper look into the issue, we decided to examine the individual areas of SMART-MOBILITY separately. In the first step, we categorised the studies by approach (Fernandez-Anez, Velazquez, Perez-Prada, & Monzón (2018). This gave us a deeper look at the issues.

For searching the case studies, we have used as keywords the name of the subcategory (from already mentioned classification see Table 1) plus following key words:

- Project evaluation;
- Approach – methodology to project assessment;
- Approach – methodology to program assessment;
- Assessment of social benefits;
- Indicators.

After collecting the case studies abstracts were first analysed, with aim to verify the suitability of the paper. Selected articles were then analysed in full text with focus identify following information:

- Methodology used for Smart mobility projects evaluation;
- Socio-economic indicators used for impact evaluation of the project.

We then classified the analysed studies into and under the SMART-MOBILITY category and examined the methods and indicators separately on main category level. The following table shows the structure of the categories and subcategories with the total number of studies identified and analysed.

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3. CONTENT ANALYSIS

Table 1 shows the structure of the categories and subcategories with the total number of studies identified and analysed. Thus, a total of 50 articles and studies dealing with the evaluation of smart mobility projects were identified and analysed for the needs of this article.

TABLE 1 SUMMARY OF ANALYSED ARTICLES

Category	Subcategory	No of articles	Reference
Accessibility	Enhancing cultural accessibility	1	Velaga et al., 2012
	Enhancing digital accessibility	1	Litman, 2018a
	Enhancing physical accessibility	2	Litman, 2018a; Shah & Adhvaryu, 2016
	Enhancing socio-economical accessibility	2	Saif et al., 2019; Fontes et al., 2017
Clean and non-motorised transport	Alternative motorised options	2	Schmale et al., 2015; World Bank, 2009
	Clean energy in traffic and parking	2	Sullivan & Meyer, 2014; Creutzig et al., 2012
	Cycling options	0	…..
	Walking options	0	…..
ICT infrastructure	Payment systems & Ticketing	1	Litman, 2014
	Systems and procedures to ensure the quality of data	2	Ferreira et al. (2014a) Rodrigues et al. (2014).
	Systems and protocols for communication data	1	Lee et al., 2010
	Systems for collection of data	2	European Social Fund, 2016; Pticina, 2011
Logistics	Fleet tracking & management	1	Stein et al., 2013
	Improvement of the track ability & traceability of goods	1	Petrova-Antonova & Ilieva, 2018
	Last-mile solutions	1	Harrington et al., 2016
	Stock management	1	Lukinskiy & Lukinskiy, 2017
Multimodality	Freight multimodality	4	The National Academies of Sciences, Engineering, and Medicine, 2017 Dampier and Marinov (2015) Reis (2014). Kelle et al. (2019)
	Passenger multimodality	1	Chen et al. (2017),
Public transport	Integrated payments systems	2	Fang and Zimmerman (2015) Warnars et al. (2017),
	Public transport alternatives	1	Piantanakulchai and Saengkhao (2003)
	Real-time operator information	1	Mattsson et al., 2016
	Real-time traveller information	1	Cachulo et al. (2012)
	Safety and security enhancement	1	Joewono and Kubota (2006).
Traffic management	Incident management	6	Taale & Pel, 2015; Yazici et al., 2015; Ozbay, 2004; Li et al., 2018; Line et al., 2006, Adler et al. (2013)
	Parking management systems	2	Dieussaert et al., 2009; Kurauchi, 2008
	Real-time traveller information	4	Harmony & Gayah, 2017; Bruglieri et al., 2015;Ebadi et al., 2017; Walker & Marchau, 2017
	Safety enhancement	5	Gichaga, 2017; Hoekstra & Wegman, 2011; Schepers et al., 2014; Tomek & Vitásek, 2016; Wegman, 2020
	Traffic restrictions	2	Mohan et al., 2017 Li & Guo (2016)

Source: Author's elaboration

Following subchapters summarise the outcomes from analysis of methods and indicators on the main category level.

3.1 Accessibility

Accessibility can be defined as the "potential of opportunities for interactions" Hansen (1959) or as the ease with which individual services can be reached from a particular location using an existing transport system Dalvi & Martin (1976). Accessibility is, therefore, the goal of the vast majority of transport activities. Accessibility is influenced by many factors such as demand for transport and activities, mobility, transport options, available information, degree of integration of transport services, affordability Litman (2018a). From the point of view of evaluating projects aimed at addressing the issue of accessibility, there are also studies published in the areas of improving physical accessibility and improving socio-economic accessibility. Most analysed studies in this category have been published in subcategories addressing physical and socio-economic accessibility.

Velaga et al. (2012) point to the importance of flexible transport systems for accessibility in rural regions. Among the widespread approaches to accessibility solutions in rural areas is demand-oriented transport "Demand Responsive Transport - DTR" and flexible transport services "Flexible Transit Service FTS" Papanikolaou et al. (2017). These approaches supplement or replace a fixed transport system with specified transport routes and arrival and departure times by a flexible system based on the current need to reach goods or services. According to Litman (2012), current evaluation methods focus on measuring mobility rather than accessibility. Therefore, several aspects should be taken into account when evaluating accessibility projects; accessibility should be measured as door-to-door accessibility, taking into account the routes and travel time from the point of departure to the means of transport, the entire route and time in the means of transport, and the route and time from the means of transport to the destination of the route. Evaluation criteria should also include comfort and convenience when travelling because congestion or crowding in public transport increases social costs. Shah and Adhvaryu (2016) use the Public Transport Accessibility Level methodology to assess the availability of public transport, which considers the average walking speed of the distance to public transport stops, congestion at peak times and different types of transport. With the help of these data and based on GIS maps, it is thus possible to compile levels of accessibility of individual city districts by public transport.

When evaluating projects aimed at improving transport accessibility, it is essential to focus also on traditional evaluation indicators to describe the socio-economic importance of accessibility. As concluded in (Saif et al., 2019) not just the performance of public transportation but its impact on other social aspects should be considered while planning the public transport facilities. At the same time, it is very essential to

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taking into account the socio-economic differences between groups of travellers (Fontes et al., 2017). For the overall assessment of impacts, however, methods such as Cost-Benefit Analysis and Social Rate of Return are particularly important, but they must be based on correct socio-economic indicators. The following table briefly summarises the appropriate methods and indicators for evaluating transport accessibility based on an analysis of the available empirical literature.

TABLE 2 - METHODS AND INDICATORS FOR EVALUATING TRANSPORT ACCESSIBILITY PROJECTS

Method	Indicator
Cost-Benefit Analysis	Indicators quantifying the effects are influenced by traffic growth
Social Rate of Return	Indicators describing the quality of transport
Traffic models for displaying and modelling accessibility	Indicators describing availability for different focus groups
Contingent valuation	Valuation of time spent waiting, searching for a parking space
	Valuation of social costs of discount when travelling
	Time indicators based on the current (not average) traffic situation
	Perceived accessibility
	Valuation of walking to the means of transport as a positive externality
	Indicators of social exclusion concerning the availability of different services according to various focus groups
	Valuation of costs of acquisition and holding of means of transport for individual modes of transport as total costs

Source: Autor's elaboration

3.2 Clean and non-motorised transport

Clean and non-motorised transport is often a key element in improving clean and sustainable urban transport. This type of transport includes other small means of transport such as bicycles, scooters or electric scooters. In cities, it can be a desirable mode of transport over minor to medium distances. From the point of view of projects supporting clean and non-motorised transport, it is possible to mention especially the construction of safe sidewalks and bicycle routes, support for bicycle-sharing, and city planning more focused on prioritising this type of transport for individual car transport. According to Litman (2018b), the benefits of pedestrian cycling can be divided into two basic groups. The first group contributes to the activity of the population, which can be evaluated through the involvement of the population, the improvement of public health and fitness of the population and the improvement of community coexistence (which often leads to increased safety). The second group of impacts is the restriction of individual car traffic.

As to example of approaches to evaluation (Schmale et al., 2015) uses the multicriteria analysis for capturing synergies in categories that include environmental considerations as well as road safety, eco-mobility, and quality of life. In (World Bank, 2009) the non-motorised tranport was evaluated through the cost-effectivenss and cost benefit share against the traditional public transport. Sometimes these two approaches are combined (Creutzig et al., 2012), used multi-criteria assessment of social costs and benefits as a useful complement to cost–benefit analysis of climate change mitigation measures. An interesting approach based predominately on qulitative approach is inroduced in (Sullivan & Meyer, 2014).

Table 3 summarise suitable methods and indicators for the evaluation of the area of clean and non-motorised transport.

TABLE 3 - METHODS AND INDICATORS FOR EVALUATING CLEAN AND NON-MOTORISED TRANSPORT

Method	Indicator
Cost-Benefit Analysis	Environmental impacts (noise, CO2 emissions)
Agent modelling	Safety
Multicriteria Analysis	Quality of life
Contingent valuation	Road infrastructure occupancy, Vehicle occupancy
Structured interview	Valuation of the social benefits of active travel

Source: Autor's elaboration

3.3 ICT infrastructure

ICTs are an essential tool for deploying intelligent transport systems at all levels Smith (2016). In their studies, Ferreira et al. (2014a; 2014b) analysed the use of mobile phones and mobile payments for the purchase of public transport tickets. They found that the main problems with using mobile phones and paying for tickets in public transport were the slow and challenging verification of such processes. Customers preferred prepaid services before linking the ticket purchase app to their bank account. Monsalve et al. (2016) point to the current state of ticket purchases in Poland, where there are different systems for purchasing tickets in public transport that do not communicate with each other. Thus the limited level of interoperability in public transport and rail networks makes it difficult to travel throughout the country. A study by Mallat et al. (2008) also addressed the adoption of mobile payments in public transport. Analysing the questionnaires using factor analysis and multiple regression analysis found that the main factor in successfully adopting technology is compliance with consumer behaviour. Thus social impacts, mobility, human attitudes, trust, simplicity, and usefulness also significantly impact the adoption of new technology.

Litman (2018a) points out that different evaluation methods provide different results, and therefore it is necessary to introduce a comprehensive evaluation of particular transit service. He also argues that the impact of parking spaces, the financial impact on people due to car prices, the positive impact of lower car use on the overall traffic speed in the city are often underestimated.

Other studies describe the possibility of payment via MobiPag, which works on the NFC communication protocol e.g., Ferreira et al. (2014a), Rodrigues et al. (2014). The speed of pairing and the simplicity of this communication interface, on the other hand, contrast with the security issue of this system. However,

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information about successful payment, the need to bring the phone closer to the terminal, and the vibrational response of NFC connections contribute to a better perception of the security and trust of the system.

Regarding to the methodologies or approaches used for evaluation of ICT infrastructure in mobility projects there are again several approaches. (Litman, 2014) describes the use of cost benefit analysis as the tool for full impacts evaluation. In (Lee et al., 2010) authors used several simulation scenarios for estimation of end-to-end communication delay reduction. Pticina (2011) recommends developing a data collection methodology for evaluating the quality of urban public transport in which components such as availability, time, customer care, comfort, safety and the environment are to be monitored. In his study, he proposes an "Urban Public Transport Quality Indicator", which requires a household survey, a customer satisfaction survey and a census of passengers on individual routes. The complete guidance on data collection and validation is described in (European Social Fund, 2016)

Table 4 presents the methods and indicators described in the literature to evaluate ICT infrastructure projects in SMART mobility.

TABLE 4 - METHODS AND INDICATORS FOR EVALUATION ITC INFRASTRUCTURE

Method	Indicator
Cost-Benefit Analysis	Quality of travel
Factor analysis – regression analysis	Time to ticket
Multicriteria analysis	Use of mass public transport
Structured interview	Accessibility
	Safety

Source: Autor's elaboration

3.4 Logistics

In today's globalised world, the transport of people, goods and materials increases demand on transport infrastructure. It is the intelligent solutions in this area that should help improve the efficiency of logistics. An analysis of the current state of the literature revealed that the vast majority of studies dealing with the economic evaluation of logistics projects deal with the evaluation of efficiency concerning the efficiency of the logistics system itself e.g. (Petrova-Antonova & Ilieva, 2018), (Harrington et al., 2016), Stein et al., 2013 and (Lukinskiy & Lukinskiy, 2017), not with evaluating its socio-economic benefits. Therefore, the methods for evaluating the impact of projects in logistics and the indicators are mainly identical to the category of accessibility and, in general, to problems of solving traffic intensity and congestions.

3.5 Multimodality

In general, we can consider multimodal transport to combine at least two types (modes) of transport. The following studies present the evaluation of multimodal transport projects divided into multimodal freight and passenger transport.

Dampier and Marinov (2015) point to the unsustainability of the current freight transport model in Newcastle and Killingworth based on truck transport, analysing the possibilities of using electric vehicles connected to bicycle and tricycle couriers. They used the simulation software COBALT (Cost and benefit to accidents-light touch), which helps to demonstrate the monetary benefits of the proposed transport model. The savings thus represent "accident costs" that the proposed model can avoid. A similar study of multimodal freight transport was conducted by Reis (2014). He designed a multimodal transport model using agent modelling for the Portuguese port. The model combined container transport with rail transport. Kelle et al. (2019) presented a system simulation model involving road, rail and water transport in the city of Louisiana. They evaluated the performance of the multimodal transport model through the benefit of changes in the transport regime by assessing environmental and other factors. These factors include the mobile phone (as the duration of the transport), reliability (coefficient of the total variation in the time of the transport), energy consumption (especially fossil fuels) and the degree of pollution. The result was time savings in the form of an increase in the average speed of motorway traffic and reduced fossil fuel consumption and pollution levels in tonnes. On the other hand, the shift to rail has led to a 5% reduction in mobility. According to the The National Academies of Sciences, Engineering and Medicine (2017), there is no uniform methodology for cost-benefit analysis of multimodal corridors, as individual participants and stakeholders see these costs and benefits differently. What represents a significant benefit at the national level in terms of increasing the transport capacity of the transport network and the resulting economic benefits is perceived at the local level as a cost of noise, pollution or reduced utility. For this reason, the authors warn evaluators to make cost-benefit analyses for multimodal transport conditional on careful consideration of all relevant costs and benefits such as time interval, investment timing, monetisation of externalities, assumptions, risks, data needs, geographical and other constraints while respecting national and local interests.

The current problem of passenger transport in the medium term is the transport infrastructure's capacity and its low elasticity to transport demand. Chen et al. (2017), in their analysis of the spatial accessibility of multimodal transport in the city, used a realistic multimodal door-to-door approach based on an Internet service aggregating maps and charts of public transportation. Their proposed method evaluates the proposed multimodal solutions through several indicators. One of these factors is accessibility (journey time and potential availability), which, unlike other studies, used realistic data on arrival time at the first station, journey time, transfer time or duration of regime change based on historical data - available online for the city transport system in Nanjing. This led to an adjustment of the availability factor and the realisation of its values, used for cost-benefit evaluating methods. According to the above studies, it is possible to summarise suitable evaluation methods and indicators for evaluating the multimodal transport category as presented in Table 5.

TABLE 5 - METHODS AND INDICATORS FOR EVALUATING THE MULTIMODAL TRANSPORT PROJECTS

Method	Indicator
Cost-Benefit Analysis	Savings generated as eliminated "accident costs"
Simulation models	"Door to door" mobility of goods and persons
Multicriteria Analysis	Reliability of transport
Agent modelling	Duration of transport
	Transport network capacity
	Noise
	Pollution
	System costs of goods transport

Source: Autor's elaboration

3.6 Public transport

The evaluation of smart mobility projects in public transport focuses mainly on payment options, alternative forms of public transport, collection and real-time information for passengers and carriers, and increasing public transport safety. Fang and Zimmerman (2015) argue that passengers are sensitive to the total fare and how many times they have to pay the fare during the trip, favouring car transport. Warnars et al. (2017), dealing with the integrated public transport payment system in Jakarta, propose introducing a payment system based on NFC technology, which would enable its interconnection with the payment systems of other transport operators.

The analysis of transport alternatives to public transport serves as a decision-making process for transport investments. Ex-ante evaluation models were used to evaluate the public transportation alternative of Broward, Florida. In most cases, it was a multi-criteria evaluation using criteria such as system connectivity, the cost-effectiveness of availability, flexibility, frequency, capacity, environmental impacts. When evaluating alternatives in transport, the ex-ante AHP method is most often used in combination with the expert method or the Delphi method Piantanakulchai and Saengkhao (2003) with groups of decisive factors such as transport impact, economic impact, social and environmental impact.

Cachulo et al. (2012) introduced a simplified version of an intelligent transport system that displays information in real-time to passengers and enables operators to manage traffic efficiently. The system for operators enables GPS location of the vehicle fleet and its status and fast monitoring of traffic services based on the number of passengers in vehicles and routes. In connection to this, the study (Mattsson et al., 2016) provide information about the importance of data collection from the operator point of view.

Research on perceived safety in public transport was addressed by Joewono and Kubota (2006). Using a questionnaire survey of residents and passengers in Bandung, Indonesia, they examined the impact of factors on perceived safety. The results show that the most crucial factor is the driver and his education, followed by the quality of the vehicles, the sensitivity of the passengers, the driver's experience.

TABLE 6 - METHODS AND INDICATORS FOR EVALUATING THE PUBLIC TRANSPORT PROJECTS

Method	Indicator
Questionnaire surveys	Traffic congestion
Expert evaluation (Delphi method)	Environmental factors
Panel regression analysis	Security - perceived security
AHP (Analytic Hierarchy Process) method	Number of black passengers

Source: Autor's elaboration

3.7 Traffic management

Line et al. (2006) deal with measuring and evaluating the incident response management system, an integral part of the incident management system. For evaluation, they have developed a system of indicators that adequately measure the incident response management system's performance. Such indicators include the number of incidents, the average time to respond to an incident, the consequences of incidents, and the cost of the incident. Yazici et al. (2015) evaluate a transport incident management system using mathematical and transport models that aim to model different incident management strategies and their impact on the speed of response and elimination of the consequences of incidents. Adler et al. (2013) sought to estimate the value of reducing the duration of an incident, determining that a 1-minute reduction in incident duration could reduce social costs by € 57 in sparsely populated areas to € 1,200 per incident high-traffic areas. From evaluation point, simulation based evaluations are used in incident management projects e.g. (Ozbay, 2004) or (Li et al., 2018)

Kurauchi (2008) describes a method of evaluating a parking reservation system that simulated the selection of a parking space according to the drivers' preferences found in a previous questionnaire survey. Dieussaert et al. (2009) used a more comprehensive approach using agent modelling to evaluate the parking system.

Harmony and Gayah (2017) describe a real-time assessment of passenger information. The authors used a questionnaire survey for evaluation. According to this survey, the most inquired data were information on the vehicle's current position and the least requested information on the type of vehicle and the number

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of seats. Mobile applications have been identified as the most sought-after way of disseminating information. Bruglieri et al. (2015) argue that insufficient information for passengers is one of the main problems of current public transport systems and should be given sufficient attention. Another approach was used by (Ebadi et al., 2017), where data from students cards were collected and evaluated. A future problems with the automated taxis and real-time passengers are dealt in (Walker & Marchau, 2017)

In (Gichaga, 2017) socio-economic impact of road improvement in Kenya with the use of several socio-economic indicators were analysed. A relatively unique evaluation was made by (Hoekstra & Wegman, 2011), where authors used statistical analysis for evaluation of campaigns aimed at improving road safety. Similar approach was used in (Schepers et al., 2014) where conceptual road safety framework comprising mutually interacting factors for exposure to risk resulting from travel behaviour (volumes, modal split, and distribution of traffic over time and space) and for risk (crash and injury risk) was used. A look on future problems of road safety with connection to its evaluation issues are presented in (Wegman, 2020)

In (Tomek & Vitásek, 2016;) authors introduce improved method for evaluating the economic efficiency of road construction at the scientific level, with the support of the real practice experience.

(Li & Guo, 2016) and (Mohan et al., 2017) describe how to evaluate a restriction measure in Delhi, India, where restrictions have been set for entry into the city centre based on the vehicle's registration plate. Indicators such as the number of vehicles on the road depending on the type of vehicles, the occupancy of vehicles and the content of harmful substances in the air were used in the evaluation. The authors of the study found that the volume of traffic on most roads decreased by 20%, but at the same time, there was an increase in the number of motorcycles, buses and rickshaws. The surprising finding was that there was practically no increase in car occupancy or a significant reduction in harmful substances in the air.

TABLE 7 - METHODS AND INDICATORS FOR THE EVALUATION OF TRAFFIC MANAGEMENT PROJECTS

Method	Indicator
Agent modelling	Quality, passenger satisfaction
Transport models	Environmental factors
Questionnaire survey	Number of traffic incidents
	Traffic incident response time
	Security - perceived security
	Traffic congestion

Source: Autor's elaboration

4. STANDARD METHODS AND INDICATORS FOR THE EVALUATION OF SMART MOBILITY PROJECTS – SUMMARISATION

Based on the content analysis of the literature dealing with the evaluation of projects in individual categories and under the categories of smart mobility, a general summary of methods and indicators was created. This summary can be used as the "list" of suitable approaches when setting up the project goals and evaluation strategy for smart mobility projects. Table 8 describes the basic categories of these indicators concerning their socio-economic impact and the possible way for its monetisation.

TABLE 8 - DESIGN OF INDICATORS FOR THE EVALUATION OF SMART MOBILITY PROJECTS

Group of indicators	Indicator	Socio-economic impact	Method of indicator monetisation
Real-time traffic intensity indicators	Transport speed	Environment	Shadow price
	Traffic congestion/density		
Time indicators (door-to-door accessibility)	Time spent in traffic jams	Quality of life	Shadow price
	Walking time from the door of the first transport option		
	Walking time from vehicle to destination		
	Waiting time for transport		
	Speed of transport ticket processing		
	Loss of time due to traffic incidents		
	Loss of time due to traffic restrictions		
Traffic quality indicators	Perceived quality of public transport	Quality of life	Contingent valuation - willingness to pay (WTP)
	Perceived quality of passenger transport		
	Discomfort on public transport		
Safety indicators	Perceived safety	Safety	Contingent valuation and WTP
	Accidents - material damage		Market price
	Accidents - damage to health		The value of statistical life
Transport cost indicators	Acquisition costs of a means of transport	Economic costs	Market price
	Operating costs of the means of transport		
	Transport costs (ticket price, parking)		
	Lost profit (black passengers, inefficient activity)		

Source: Author's elaboration

The advantage of the presented indicators is that; many can be monetised using the shadow prices usually available in the transport sector. However, it may be challenging to estimate the input data for their monetisation correctly. For some of the proposed indicator shadow prices cannot be used for monetisation. These are primarily indicators of quality of life. In this case, contingent valuation, specifically the WTP method can be used for estimation of the monetary value.

As for the methods of evaluation of smart mobility projects described in the previous section, these have their advantages and limitations. Following table summarise the methods from the content analysis of the literature dealing with the evaluation of smart mobility projects.

TABLE 9 - METHODS FOR THE EVALUATION OF SMART MOBILITY PROJECTS

Cost benefit analysis
Social return on investment
Willingness to pay
Agent modelling
Transport models
Multicriterial analysis
Regression analysis
AHP - Analytic Hierarchy process
Expert methods (Delphi, interview)
Questionnaire surveys

Source: Author's elaboration

For the overall evaluation of the project, only a cost-benefit analysis is appropriate in terms of its financial and socio-economic benefits. However, this method is highly dependent on the ability to monetise the economic benefits and costs. There exist well established frameworks for monetising traditional indicators through shadow prices (time savings, the value of statistical life etc.) for standard transport projects. However, in smart-mobility projects, it is often necessary to consider other socio-economic costs and benefits.

Another possibility for the overall evaluation of the smart mobility project is the method of "social return on investment", which also allows evaluating the project's impact, but only through social benefits and costs, i.e. without a direct financial dimension. Another disadvantage of this approach is that there are not enough developed standards for applying this method in the field of transport. Nevertheless, in some cases, using this method can be very useful in the decision-making process especially when deciding about in smart-mobility project.

Next group of methods are predominately used for estimation of smart-mobility projects benefits. This group includes agent and transport modelling. In transport projects including smart mobility projects the correct estimation of project benefits is crucial and these two methods are very useful for its estimation.

The most common application is the modelling of saving time or money or the number of traffic incidents that can be easily monetised subsequently.

The third group consists of decision-making methods - multi-criteria evaluation, AHP (Analytic Hierarchy Process) and regression analysis, which help to understand the relationship between indicators and determine the hierarchy of projects according to their benefits.

The last group of methods focus on estimating qualitative subjectively perceived indicators such as perceived quality - benefit. For this purpose, qualitative expert methods such as questionnaires and interviews are usually used. Another method used to value subjectively perceived benefits is contingent valuation - the willingness to pay method. We recommend this method to estimate the benefits - costs of smart-mobility projects for society. We assume that if it is not possible to evaluate the project sufficiently using common indicators such as shadow prices, WTP can be a suitable approach for evaluation and decision-making.

5. CONCLUSIONS

In this paper, we conducted a systematic literature survey on methods and indicator used for evaluating smart city mobility projects on the local level. Based on literature review we conclude that there exist set of available and suitable methods for smart-mobility projects evaluation, although the use of particular method will depend on type of smart-mobility project and also on data availability.

As already mentioned the smart-mobility projects are very heterogeneous in the meaning of its potential impact on society. Selection of correct output indicators is therefore more sensitive on particular type of the smart-mobility project. This paper also summarises standard indicators for each category of the smart-mobility projects. Selecting the suitable indicators is not important only in the process of the project evaluation, but also and maybe more important in the process of developing strategic development plans in area of smart-mobility. Correct selection and monitoring of socio-economic indicators in planning phase is crucial condition for correct evaluation of the development plan as well as the effective decision making process from the pool of the proposed smart-mobility project. This can approach can support the public administrations to improve and prove the socio-economic impact of implemented smart-mobility development plans and projects.

The information obtained from research papers is important for city managers and planners as well as consultants dealing with smart-mobility strategic documents design and projects selection. Results provided in this will provide them with information about the suitable evaluation methodologies and socio-economic indicators according to different categories of smart mobility projects.

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