

Strategic choices impact on urban mobility improvement: A case study of Tehran

Morteza Khashaypoor *, Fernando Nunes da Silva **,
Amir Reza Mamdoohi ***

* Lusofona University,
Lisbon, Portugal,
Department of Urban Planning
m_khashaypoor@yahoo.com

** University of Lisbon,
Lisbon, Portugal,
Instituto Superior Técnico (IST)
fnsilva@ist.utl.pt

*** Tarbiat Modares University,
Tehran, Iran,
Department of Civil and Environment Engineering
armamdoohi@modares.ac.ir



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Abstract: Concerning the upcoming issues in attaining urban mobility improvement, this research investigates the impact of changes in strategic policies to improve urban mobility. Accordingly, a novel policy approach and its evaluation methodology are proposed, and Tehran's urban mobility and outcomes are appraised in a real-large scale case study. Founded on the outlined approach, strategic policies and policy options are suggested through stakeholders' participation. This paper presents a methodology for assessing the amelioration of urban mobility through the change of policy approach as a conceptual framework in five steps. In line with this, a model-based tool is applied to quantify policy options according to the proposed criteria. To accumulate the required data on the mobility behavior of city inhabitants, a household travel survey is conducted. Based on the presented assessing framework and the process of identifying alternatives and utilizing the macroscopic transportation models, the best alternative is chosen using a Multi-Attribute Decision Making (MADM) method. This research shows that making changes in the policy approach can take the lead overriding role in improving urban mobility. As such, the study finds that development-nature alternatives alone cannot significantly boost urban mobility in developing cities if they do not combine improvements in public transport and soft modes of mobility with restrictions on the

Corresponding author: Amir Reza Mamdoohi
E-mail: armamdoohi@modares.ac.ir

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use of private cars. The proposed approach and opted alternative are shown to mitigate total travel time in Tehran Central Business District (CBD) by 6.8 per cent.

Keywords: urban mobility improvement, strategic policies, policy options, modelling, stakeholders' participation

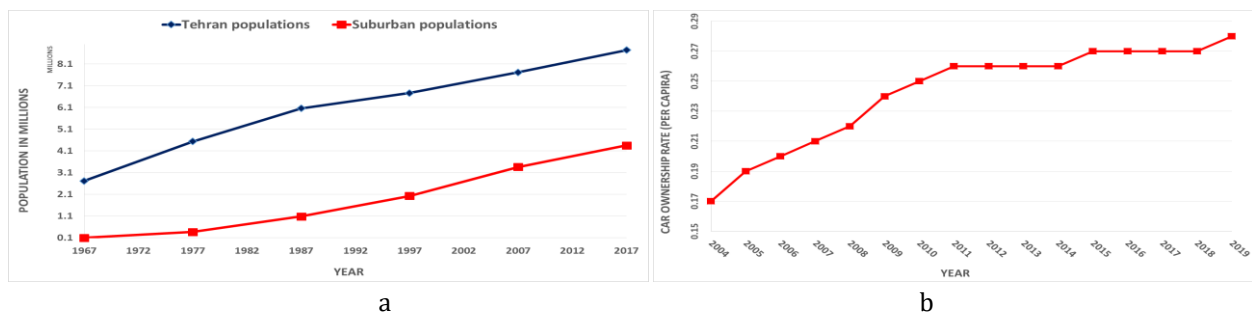
1. Introduction

Today, most developing cities are becoming increasingly urbanized (Rodrigue, 2013), and demand for daily trips is growing simultaneously. Therefore, it causes congestion and pollution (Mehdizadeh et al., 2019). Street congestion is one of the common problems in urban networks (de Barros Baltar et al., 2021), and cities' authorities are constantly striving to overcome this issue. It is expected that more than US\$ 14 trn to be invested globally in mobility infrastructure projects between 2016 and 2025 (Thomopoulos & Nikitas, 2019). Most underdeveloped cities meet numerous restrictions and challenges, while many policies work out the setbacks.

For this reason, it is significant to designate problems and then specify the best urban mobility policies to boost sustainable options. According to Iran's population and housing census in 2017, the rate of urbanization has increased from 37.9 % in 1967 to 74 % in 2017. In most developing cities like Tehran, the capital of Iran, private cars have opted as the preferred means of mobility by the dominance of motorization. Hence, this metropolis has a complex urban mobility system that needs changing policy approaches to improve its urban mobility.

This research shows that the Tehran street network has developed much faster than developing public transport infrastructure or non-motorized transport. This city is organized based on the priority of vehicle movement, and policies were planned based on car-oriented development. Figure 1-a shows the demographic trends of Tehran and its suburbs. Compared to the last few decades, the population of Tehran has increased by 3.2 times, while the suburban population of Tehran has intensified by 42.3 times. The suburban population often needs access to Tehran Central Business District (CBD). Moreover, per capita car ownership has grown from 0.17 to 0.28 in recent years (Figure 1-b). Consequently, the elaboration of this metropolis and the growth in using private cars alongside the continuation of a very centralized CBD have resulted in progressive traffic congestion in this area and significant environmental impacts. Hereupon, the most crucial challenge of Tehran's urban mobility is a drastic increase in personal vehicles that have resulted in a massive increase in the density of CBD. In this paper, a new policy approach is suggested in Tehran's urban mobility. Accordingly, the new approach based on human characteristics and needs in urban mobility is proposed versus car-oriented urban mobility. Concerning the proposed approach, strategic policies, and strategic policies, policy options are provided through stakeholders' participation to improve urban mobility.

Figure 1: a) Population trend of Tehran and its suburbs, b) Car ownership rate trend in Tehran



This paper has proposed a methodology as a conceptual framework in five steps for appraising urban mobility improvement by changing the policy approach. In this method, to evaluate the impact of policies through the implementation of policy options, a model-based tool (EMME software) is applied to quantify policy options according to the pre-defined criteria. A household travel survey and on-street questionnaire on urban mobility melioration objectives are carried out to gather the required data about the mobility behaviour of the city residents. Founded on the proposed framework for assessing the

effects of policy options on improving urban mobility and identifying alternatives, modelling the suggested alternatives was conducted using the EMME software. Considering the comparison of alternatives based on the pre-defined analysis criteria, selecting the best alternative that had the most significant impact on improving urban mobility in Tehran CBD was performed using a Multi-Attribute Decision Making (MADM) technique. The study found that in the city of Tehran, due to the extreme interest in using private cars, the development of non-motorized transport infrastructure alone cannot result in significant improvements in urban mobility.

2. A general overview of urban mobility and policy-making notions

The urban mobility concepts return to about half a century ago and are related to the measurement of urban activities (Antov, 2015). Urban mobility refers to the spatial dimension of mobility, which consists of different conditions for the temporary movement of people in urban space (De Souza et al., 2019). According to previous studies on significant challenges facing metropolitan cities, urban mobility has been an essential issue in major cities (Van Audenhove et al., 2014). Urban mobility issues have increased with urban development. Car dependency and mobility cultures are also affected by the economic growth of developing countries (Heinonen et al., 2021), which is recognized as a symbol of personal freedom. Therefore, many developing countries consider motorization as a condition for development. In the first of the 20th century, urban mobility challenges became crucial in most European cities. The main challenges in urban mobility in different European cities are classified into five categories (Varies & van Eijl, 2016): Health, Congestion, Safety and security, Participation, and Strategic planning. New approaches to urban mobility planning have led local authorities to request to change the old approaches and apply new solutions to make cleaner and more sustainable modes of transport, and as a result, the European Green Paper (EGP) was prepared in 2007 (Stead, 2007). EGP is based on five principle challenges for urban mobility (European Union Regulation, 2007; Stead, 2007). In 2011, a transport White Paper that has considered more robust policies was prepared with two goals 1-The gradual phasing out of gasoline cars by 2050, and 2- Achieving co2-free in the main centers of cities by 2030 (TNS Opinion & Social & European Commission, 2013). European Union (EU) has provided various policies for planning and implementing sustainable urban mobility policies. Simultaneously with the design and implementation of urban mobility improvement policies in Europe and the development of the EGP plan, a program called CIVITAS (City-VITAlity-Sustainability) was developed to increase cleanliness, safety, and sustainable development in urban mobility (Defranceschi, 2016). This program includes eight main strategies for achieving sustainable urban mobility, such as providing high-quality public transportation services (Gaggi et al., 2013; Korver et al., 2012). Sustainable urban mobility continues to be one of the unresolved local worries (Foltýnová et al., 2020). The Sustainable Urban Mobility Program (SUMP) is a strategic plan that will boost the quality of life of the urban residents and includes goals and actions to create a safe, efficient, and accessible urban transportation system (Böhler-Baedeker et al., 2014). The planning process for SUMP is presented in previous literature (European Union, 2017; Wefering et al., 2013; Rupprecht co, 2019). Sustainable strategies in urban mobility endeavour to change car-based urban mobility in favour of public transit and soft modes (e Silva et al., 2013).

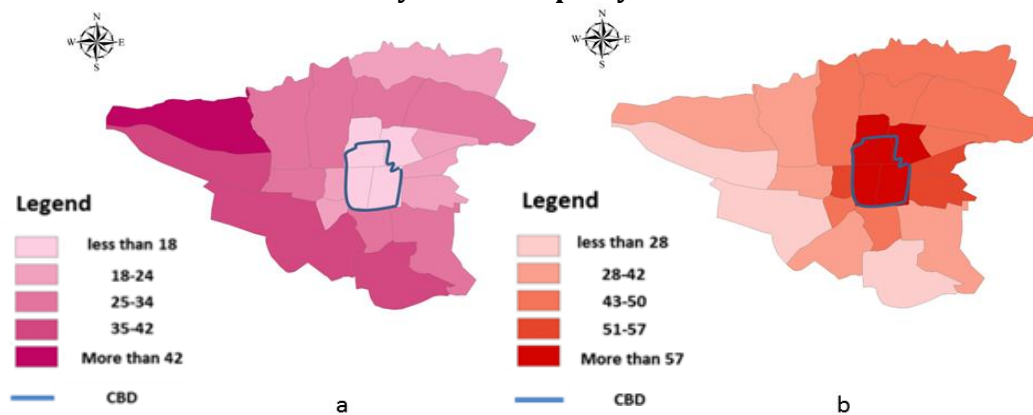
Overall, the policy-making process is classified into six steps (Steenberghen et al., 2013) 1- Definition of objectives and target, 2- Identify the problem, 3- Option generation, 4- Model development, 5- Strategy appraisal, and 6- Monitoring and evaluation. They are adopting an Integrated decision-making approach in urban mobility, in addition to the characteristics of transportation systems and its evaluation, required to consider other factors comprising environmental quality, economic development, and social justice (the United States Environmental Protection Agency, 2011). The policy is a dynamic process that responds to an issue, is directed to specific goals, and defines values or allocates resources (Nudzor, 2009; Ward, S. C. et al., 2016). The strategy could be defined as a means of success by considering different goals and allocating required resources (Grant, 2021). Strategic policy means "having a strategy and action based on it" (Nickols, 2016). Providing strategic policies can be understood as solving a puzzle in three different parts (Lyon, 2015) 1-Understanding a complete environment, 2-Identifying our regional and global role, and 3-Identifying a set of constraints that limit this role. Policy options refer to ways in which they can implement strategic policies. Hence, the policy options designate the solutions. The five steps must be accomplished (European commission, 2017) 1-

Creating a baseline to assess the impact of policy options, 2-Starting generating policy options by considering a range of possible alternatives, 3-Initial identification of appropriate options, 4-Reviewing the appropriateness of selected policy options, 5-Explaining the details of critical aspects of the remaining policy options to analyze its effects in the following steps comprehensively. Policy options to improve urban mobility have a wide range of options, including various methods such as congestion pricing, motivating public transport use, and so on (Pisoni et al., 2019).

3. Study on urban mobility problems in Tehran and proposing a change in policy approach

Since 1988, the strengthening of the Tehran street network has been put on the agenda by the government and municipality. Construction of urban highways has been commenced promptly, and highway network expansion has been speeded. The intense desire to use private cars (8.5 million private daily trips) causes many problems in Tehran CBD. According to Figure 2, the average speed of vehicles (Km/hr) in the city street network (a), as well as the proportion of delays to the total vehicles travel time (Percentage) (b), is the lowest and highest amount respectively compared to other municipality districts of Tehran. Hence, the main Tehran urban mobility problems are high interest to use private cars, weakness of the public transportation system, and worn-out vehicles. Addressing these setbacks and offering the best policies to improve urban mobility is the primary goal of this research.

Figure 2: a) Average speed of vehicles in the street network, b) proportion of delay to total vehicle travel time by 22 municipality districts of Tehran



By reviewing Tehran spatial expansion and its urban street network development in different eras (since 1960), it can be concluded that Tehran urban mobility System was designed generally to provide service to private cars, and special attention was paid to the development of the street network at different periods of Tehran's spatial expansion. For instance, according to the Tehran comprehensive transportation plan with the horizon year of 2025, the construction plan of the street network has been completed, while public transportation is still under development. Hence, the Tehran street network has been developed much faster than developing public transport infrastructure or non-motorized transport, and its motility structure is car-oriented. Therefore, as alluded to earlier, the most overriding urban mobility challenge is a dramatic growth in private cars that influence the CBD and result in congestion in this area. Accordingly, in this research, an approach based on human characteristics and its needs in urban mobility versus car-oriented urban mobility has been suggested as the most critical change in the policy approach in Tehran. This modified policy approach is called "Human-oriented urban mobility" (HOUM). Strategic policies and policy options need to be developed to attain the proposed policy approach, referred to in the following parts.

HOUM is a system designed to respond to most human social needs, prioritizing human access and mobility. This system also considers environmental parameters and their economic impacts. For example, this system can include a combination of soft modes with one of the public transport modes (Galychyn & Üstundağ, 2017). Environmental parameters about HOUM mean using a set of practical strategies to mitigate adverse environmental impacts. Furthermore, the HOUM system, besides meeting

social needs and considering environmental parameters and characteristics, also needs to be economically sustainable. Hence, the characteristics of the HOUM system could be addressed from three social, economic, and environmental points of view (Duncan & Hartman, 1996; Jeon & Amekudzi, 2005).

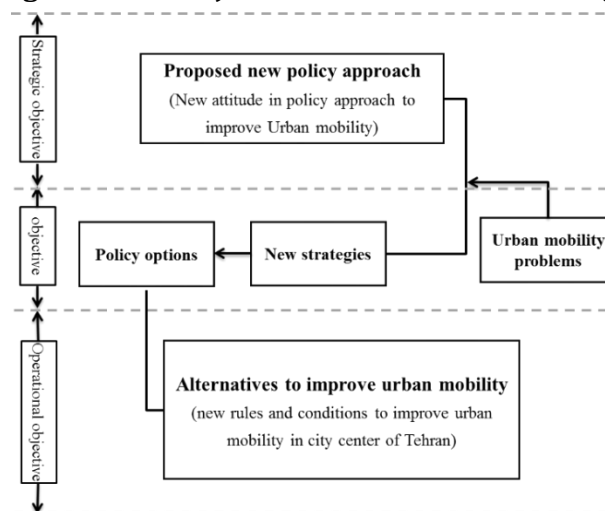
4. Research methodology

This section outlines the conceptual framework of methodology and policy options appraising methods. Accordingly, distinct analysis criteria propose to consider mobility characteristics, environmental aspects, and cost components. Furthermore, the data gathering process is provided herein.

4.1. Definition of a conceptual framework for research methodology

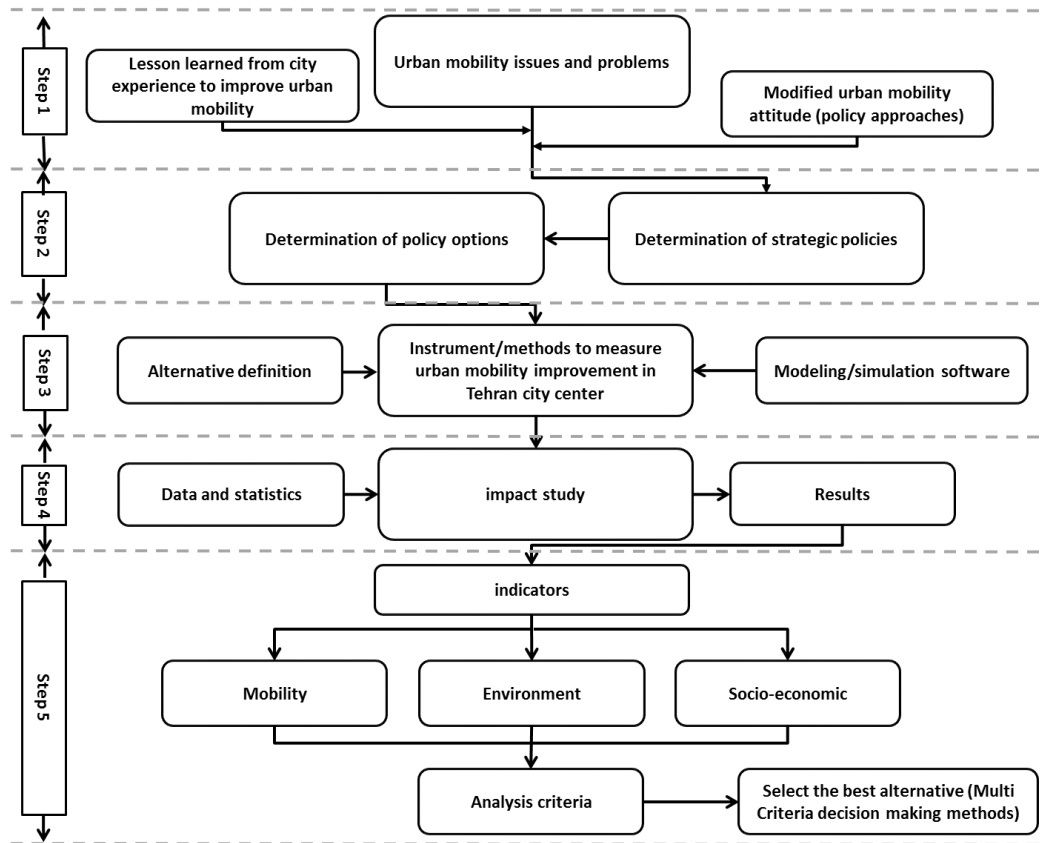
Before providing methodology, based on the primary research goal and considering the proposed policy approach, the following scheme (Figure 3) is outlined as an objective tree to determine methodology.

Figure 3: The objective tree of the methodology



To achieve the objectives mentioned in Figure 3 in each of its main strings, the methodology of this research is presented. Therefore, to determine the impact of changes in policy approach on urban mobility improvement, the conceptual framework shown in Figure 4 is proposed in five steps.

It is imperative to examine the issues and problems in urban mobility, identify the experiences of different cities, and present the modified attitude in urban mobility as the primary policy approach. In the second step, strategic policies are designated according to the proposed policy approach. Next, based on selected strategic policies, it is required to present solutions (policy options) to improve urban mobility for Tehran CBD. This step has been done with the participation of various stakeholders. In the subsequent step, a tool should be proposed based on which it would be possible to provide a quantitative comparison of each alternative in improving urban mobility. A required variety of data and statistics is gathered in the fourth step. In the last step, the following modelling and comparing different alternatives, it is essential to compare the results based on the proposed analysis criteria and opt for the best alternative through decision-making techniques.

Figure 4: Conceptual framework of the methodology

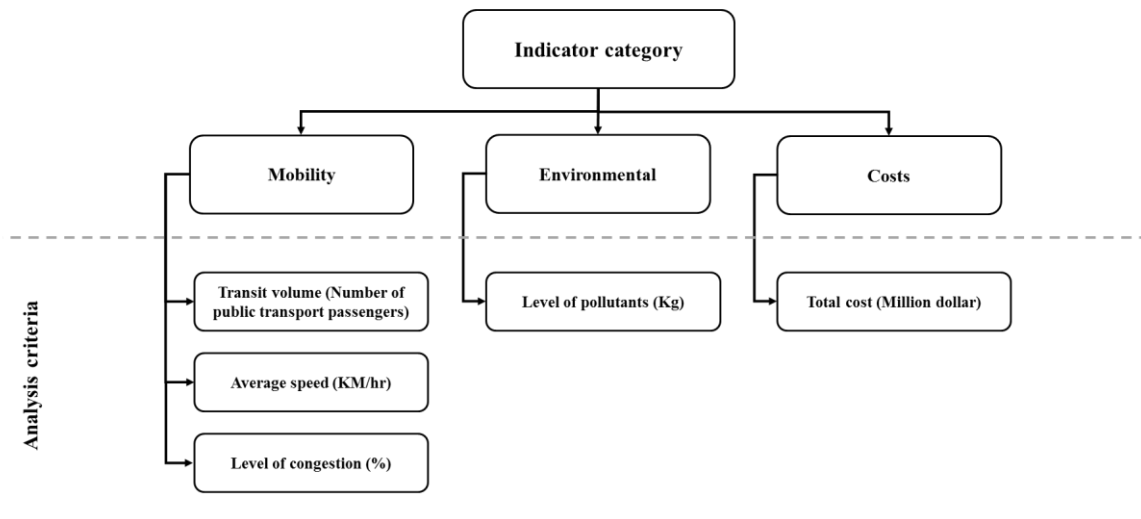
4.2. Determining the assessing method of policy options impact on urban mobility

The methods of assessing the impact of policies are different and include quantitative and qualitative techniques. Routinely, quantitative methods are based on model making (Lopez-Ruiz et al., 2013). The method used in this paper has the required potential to compare the effects of each alternative and analyze before-after effects. This method is a model-based approach; different alternatives are appraised, and their quantitative results are compared to an initial condition. Many cities have used transportation models classified into macroscopic and microscopic models to analyze the impacts of proposed policies (Rudolph, 2017). These models are typically based on two main parts of demand and supply; they can measure the effects of each alternative (Gallo & De Luca, 2016). The software used in this paper is EMME that has been used in Tehran for more than two decades. The EMME software is a static deterministic user equilibrium model based on four-stage models developed by Florian et al. in the center for research on transport at the University of Montreal (Florian, 2008).

4.3. Designation of indicators and analysis criteria

Indicator-based comparisons and the use of the model provide the possibility of quantitative analysis of alternatives and make a more accurate comparison. Suggested indicators in this research are classified into three categories 1-urban mobility, 2-environmental, and 3-cost. For each indicator, analysis criteria are considered for the quantitative calculation of values (Figure 5).

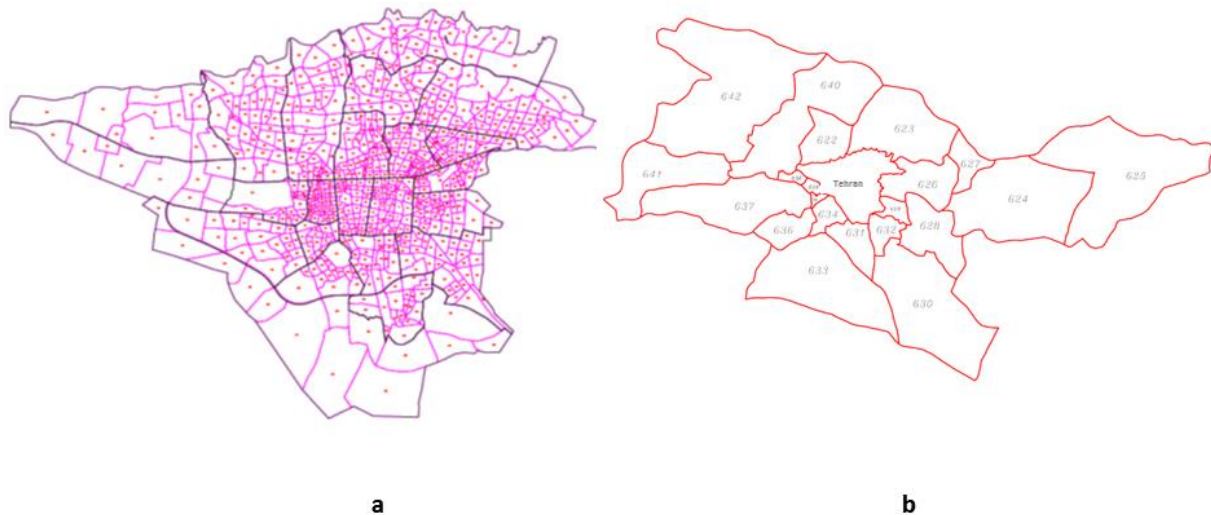
The transit volume criterion is the number of passengers boarded and alighted in the public transport system. The congestion level indicates the percentage of critical or congested networks and reflects the quality of services experienced by traffic participants at road infrastructures. The level of pollutants is representative of total emissions by Co, HC, and NOx. In the cost criterion, the cost of implementing and operating each alternative in 20 years is considered. Besides, the daily fuel consumption costs and the cost of delays in routes are computed over the operation period. The analysis criteria are calculated for a peak hour at the Tehran CBD by using the EMME software.

Figure 5: Indicators and their criteria to evaluate alternatives

4.4. Data collection and preparation

The decision to manage, plan, and evaluate urban mobility policies requires adequate access to data and statistics (OECD, 2012). Survey and data collection concerning the traveller's behaviour is a prerequisite for developing urban mobility policies (Ehteshamrad et al., 2019). This part is one of the most costly and time-consuming stages of each study. Consequently, this crucial part of the research was carried out in collaboration and coordination with the Tehran Traffic and Transportation Organization (TTTO). According to the joint agreement with TTTO, issues such as zoning, proposing the structure of conducting the survey, Household Travel Survey (HTS) questionnaire designing, sample selecting, fieldwork interview procedures designing, coding questionnaire and creating database were proposed in this research and another filed survey duties such as the implementation of the survey, data collection, data entry and preparation of databases carried out by TTTO. Transport planning models can be constructed based on the data collected, and the effects of different policies on improving urban mobility can be measured.

A travel survey is the primary source of information about how people travel in Tehran and how they reach the CBD. Based on this data, can be used urban planning policies to improve urban mobility. Therefore, it is inevitable to collect the characteristics of household trips in conjunction with the socio-economic status of residents of Tehran. The field survey and data collection procedure in the city of Tehran are comprised of two parts: Tehran Household Travel Survey (THTS) and an On-street questionnaire on urban mobility improvement objectives. In the THTS, the travel pattern of each person in the household is determined based on traffic zones. In this survey, socio-economic information, such as household size, age, gender, education status, work status, household car ownership, and trip specifications of a person in the household, including origin-destination information, travel mode, travel time, and travel purpose, were collected. Before conducting THTS, it is essential to divide the city into smaller parts. This part of the research is called zoning, and accordingly, the city of Tehran was divided into 603 internal zones (Figure 6, a) and 21 external zones due to the considering of several satellite towns around Tehran (Figure 6, b).

Figure 6: a) Zoning of Tehran for household travel survey, b) External zones of Tehran

The random sample size selection method was used to draw the sample. According to the latest census survey in the city of Tehran, it had around 2.7 million households. Therefore, with a confidence level of 99% and a margin of error of 0.5, the sample size calculator's sample size is equivalent to 65,000 households. It was suggested that 130,000 forms be distributed considering the response rate of 50%. HTS can be carried out in a different method, such as face-to-face interviews, telephone interviews, emails, etc. Concerning the cultural and social conditions in Tehran and the low response rate with the telephone interviewing method based on a pilot interview, it was decided to conduct THTS in the face-to-face method with the help of junior high school students (who have learned the necessary training by their teachers) and teachers (who have learned the essential training by the technical expert). To arouse the interest of teachers and their further collaboration in providing the necessary training for students to conduct an interview, the decision was made to provide a free tablet to teachers. As a result, teachers collect daily trip specifications from the four other households through the tablets, and students collect their household daily travels specifications and their neighbours through paper questionnaire forms. It should be underlined that software is designed to work on the Android system; teachers can perform the data collection process with the help of the tablet. The teachers' questionnaire forms (long questionnaire form) are more detailed and in addition to household travel specifications. It also includes various social and economic information. Students' questionnaire forms (short questionnaire forms) are used to collect a more household travel characteristic. Afterward, coding the questionnaires and creating databases was the next step. As outlined before, the On-street questionnaire on urban mobility improvement objectives is done by personal interviews according to the main urban mobility problems in the Tehran CBD. Several questions have been asked of people travelling by private cars and public transport to the CBD (The questionnaire is completed for 1 percent of the total daily private cars and public transport). These questionnaire analyses have shown the primary incentive for using private cars, travellers' purposes, other means of transport.

5. Proposing strategic policies and policy options to improve urban mobility

The HOUM policy versus car-oriented mobility has been the principal policy-making approach to this paper. As highlighted before, the main challenge of urban mobility in Tehran is the density of urban areas, especially in the Tehran CBD. Also, three problems of urban mobility in Tehran are cited earlier. In light of the chosen policy approach and Tehran urban mobility problems, strategic policies were selected and proposed to achieve HOUM versus car-oriented mobility in four areas 1-Development of sustainable transportation against infrastructure-based development, 2-Travel demand management instead of a single response to trips demand, 3- Quality in transportation services versus quantity in the transportation system, and 4- Creation areas with the lowest pollutant emission and private car traffic versus the lack of restriction on a private car.

The policy options generation is one of the essential elements in the development of SUMP. This process and considering a wide range of options is crucial to choose the options that provide the most

efficiency (May & Khreis, 2015). There are various methods and tools to identify policy options available to researchers and urban planners. The approach used to set the stages of policy options elaboration has been using various stakeholders' viewpoints. These views were inconsistent in some cases. For example, some stakeholders aimed at implementing the least costly options, while others suggested the most effective options, regardless of the cost.

Next, considering the strategic policies and following reviewing a broad spectrum of policy options, initially, eight independent options were introduced to the stakeholders: 1- Development of public transport in the CBD to improve urban mobility, 2- Development of pedestrian and public spaces to improve the quality of life in the CBD, 3- Restrictions for private cars in the CBD, 4- Restrictions for private cars with high pollution, 5- Develop and complete street network to enhance urban mobility, 6- Goods delivering improvement to enhance urban mobility, 7- Additional charges for the use of particular roads at specific times, 8- Awareness campaigns to encouraging inhabitant to dwindle the use of private cars. Stakeholders selected in this study included representatives from the City Council (as representing citizens' views), city managers (as executive part), traffic police (as enforcement part), and the Society of Consulting Engineers (as technical experts). Subsequently, to select final policy options, technical workshops were started with stakeholders' participation. In this regard, all stakeholders were requested to determine the importance of each proposed option to meliorate Tehran's urban mobility. After several stages of intensive feedback and interaction and rectifying the options, the final agreement was reached on the four selected options.

Consequently, the policy options proposed in this research, which are the solutions for improving urban mobility in the Tehran CBD, are 1-Public transportation development in the CBD, 2-Development of walking and cycling in the CBD, 3-Implementing private cars restrictions in the CBD, and 4-Congestion pricing for private cars entering the CBD. It is worth mentioning that the first and second proposed policy options provide the development facilities and thus have a development nature. In comparison, the following two policy options have restrictive nature and include limitations on the entry of cars or pricing. In this research, policy options are the basis for alternatives building to improve urban mobility.

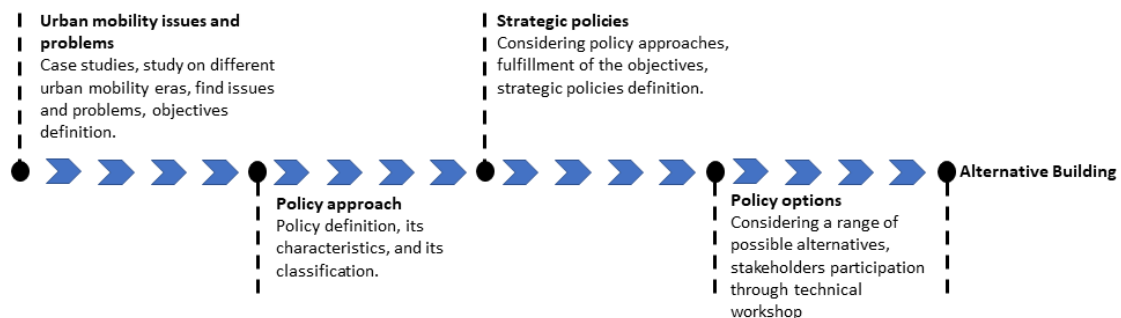
6. Appraising the impacts of alternatives on urban mobility and selecting the best alternative

Following introducing alternatives in this section, analysis criteria are measured by the modelling tool. Next, a superior alternative is opted using the MADM method.

6.1. Introduction of alternatives and their characteristics

The use of alternatives in planning and strategic decisions dates back to the 1970s (Blyth, 2005). Alternatives are defined concerning the objectives of improving urban mobility as well as policy options. To summarize, the process of determining alternatives is shown in Figure 7.

Figure 7: The process of determining alternatives to improve urban mobility in the Tehran CBD



The definition of new alternatives makes it possible to compare the alternatives with the baseline alternative. As outlined earlier, based on this study's main goal and the suggested strategic policies, four policy options were proposed through stakeholders' participation to improve urban mobility in the

Tehran CBD. The definition of alternatives is conducted according to proposed policy options. Consequently, seven alternatives are provided according to Table 1.

Table 1: Definition of each alternative, its approach, and focus

Alternative	Description	Focus
A1	Current condition (Do nothing)	- current mobility status
A2	Public transportation development in CBD	- developing buses & railway lines - improvement timetabling
A3	Development of walking & cycling in CBD	- Walking - Cycling
A4	Implementing private vehicles restrictions to CBD	- Motor vehicle traffic
A5	Congestion pricing for private vehicles entering CBD	- Mobility management
A6	Combination of alternative 2 & 4	
A7	Combination of alternative 3 & 5	

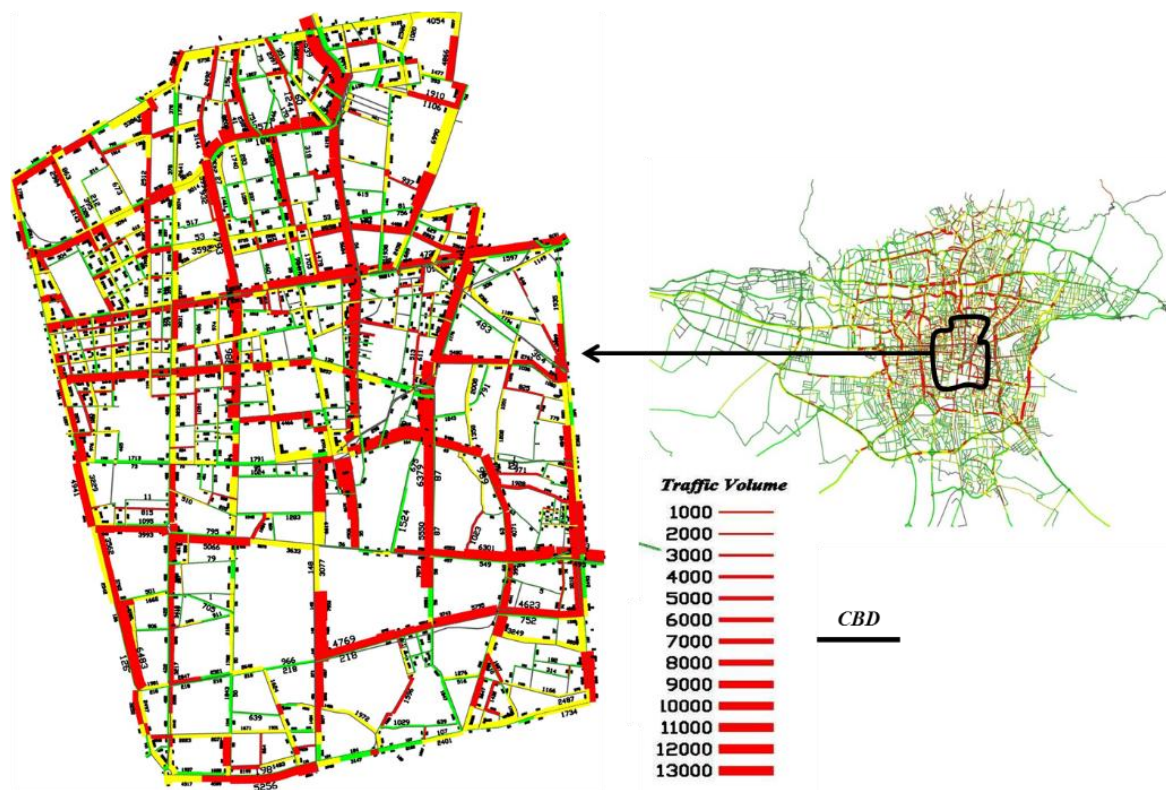
Alternatives A2 and A3 have a developmental nature and are accompanied by the development of public transport facilities or non-motorized transportation. On the contrary, A4 and A5 have restrictive nature and include restrictions on the pricing of private cars entering the CBD. Therefore, in proposing mixed scenarios, the combination of these two natures is considered.

Regarding alternatives, a tool can be used to convert alternatives into quantitative options. One of these tools is a transportation model commonly used to plan and determine sustainable urban mobility plans. In this regard, macroscopic models are most applicable (Okraszewska et al., 2018). As alluded to before, considering the use of the macroscopic model and the EMME modelling software, the characteristics of the defined alternatives are presented. Alternative A2 has been attempted to make it easier for passengers to access the CBD through public transport systems by changing the current condition. The most critical assumptions in this alternative were 1-Increasing access coverage in the 200-meter radius of regular bus stops and Bus Rapid Transit (BRT) in the CBD (and also 600-meters radius of metro lines), 2-Reforming feeder lines, 3- Setting up more integration between public transportation systems within the CBD, and 4-Boosting the capacity of public transportation systems and improving timetabling. The most significant presumptions in alternative A3 were 1-Proposing pedestrian malls in attractive routes, 2- Providing integrated cycling routes in the form of a network to make the connection between land use and public transport stations, 3-Considering technical limitations on facilities development, and 4-Examining alternate routes for private cars. In alternative A4, there are restrictions on the entry of private vehicles into the Tehran CBD. Hence, personal vehicles were classified into four categories based on the magnitude of pollution, and the last two categories of cars, including carburetor and worn-out vehicles, were not allowed to enter the CBD (12.46% of total private cars). In alternative A5, it is presumed that private vehicles must pay for entering the Tehran CBD. A fixed fee is considered for entering private cars into the Tehran CBD. The main assumptions in this alternative were 1-A fixed fee. It is considered for the entering private cars to the Tehran CBD (during the day), 2-The average daily cost of using private cars is considered 160,000 IRR (Iranian Rial) based on insurance costs, gasoline cost, depreciation cost and other costs (like a car wash), and 3-The cost of entering the Tehran CBD is 1.5 times the daily cost of using private cars.

6.2. Modeling and designating quantitative analysis criteria in alternatives

As alluded to earlier, EMME software was applied to model the proposed alternatives. The software is based on four-step models that have been updated concerning THTS and socio-economic data. In conformity with the characteristics of each alternative (As the supply part) and travel demand in each alternative (As the demand part), as well as the cost functions part, alternative modelling was performed using the EMME software. For instance, the traffic assignment map in terms of traffic volumes in alternative A1 is shown in Figure 8. In addition to showing the traffic volume derived from the traffic assignment and illustrated based on the line thickness in the map's legend, the level of congestion on the street network is also provided in three different colours.

Figure 8: Results of Traffic assignment in EMME Software in alternative A1



According to the definition of the various analysis criteria and the software outputs, the quantitative values of analysis criteria in each alternative are shown in Table 2.

Table 2: Quantitative values of criteria in each alternative

Criteria	Alternative	A1	A2	A3	A4	A5	A6	A7
Transit volume (N.O. passengers)		223452	340110	290436	293718	293387	354477	298059
Average speed (km/hr)		9.65	10.1	9.93	10.13	9.7	10.98	10.07
Level of congestion (%)		68.96	68.09	68.42	68.06	68.12	66.62	67.66
Level of pollutants (kg)		94129	92211	92936	92832	94171	86743	91802
Costs (million dollars)		4936	6423	4838	4742	4937	6055	4784

6.3. Evaluating alternatives and choosing the best alternative

Five analysis criteria were measured for each alternative to appraise and opt for the best alternative. Therefore, Multi-Criteria Decision Making (MCDM) methods have been used to choose a superior alternative. Decision-making is a selective choice of an option among other options (Majumder, 2015) and consists of different main steps. MCDM methods are very utilitarian for policy making, new technology selecting, and evaluating (Kolios et al., 2016). MCDM is currently a well-known technique in the multiple criteria decision process that focuses on decision aid (Ferreira & Ilander, 2019). There are several methods for classifying MCDM methods and tools used in each method. For instance, in a general classification, MCDM methods can be divided into two groups of Multi-Objective Decision Making (MODM) models and Multi-Attribute Decision Making (MADM) models (Sabaei et al., 2015). Due to the proposing of several criteria and several distinct alternatives, the decisive issue in this paper is a MADM. This method can also be categorized based on data availability and data processing. When the attributes data are available, different MADM methods like AHP, ANP, TOPSIS, ELECTRO, HRM, etc., can prioritize alternatives (Sabaei et al., 2015). The method used in this paper is an Analytical Network Process (ANP). ANP models decision-making processes as networks (Kadoić et al., 2017; Penadés-Plà et al., 2016) and

nonlinear structure (Saaty, 2004), which dependencies and feedbacks between criteria and alternatives are created (Hussey, 2014). Applying the ANP model consists of four main steps (Bottero & Lami, 2010; Chen, 2007): 1-ANP model construction, 2- Pairwise comparison and determination of priority vectors, 3-Supermatrix formation, and 4-Final priorities. The calculations and operations mentioned in the four steps are done in Super Decision 2.10 software. This software has been developed specifically for decision-making by ANP. The inner dependence between the elements of the same cluster as well as the outer dependence between the elements has been determined based on a specific method. This method considers the interaction and relationship between the proposed elements in this research and the experts' viewpoints. According to the results of Super Choice software, the prioritization of alternatives was A7, A6, A4, respectively.

6.4. Results

The proposed alternative in this study, alternative A7, was to combine alternatives for developing walking and cycling in the CBD along with congestion pricing for private cars entering CBD. This alternative will mitigate the level of congestion in CBD by 1.9 percent and the level of pollutants in this area by 2.5 percent compared to the current situation. It should be highlighted that the decrement in the congestion of Tehran CBD is on average in the whole region and is entirely significant. For instance, with a decrease of 1.9 percent in congestion, the total travel time in the Tehran CBD is dropped from 83418 to 78076 vehicle hours in peak hours. The lower cost of implementing and operating the proposed alternative compared to other alternatives has been another feature of this alternative. The total cost of the proposed alternative was 34 percent lower than the most costly alternative (A2). The proposed alternative will increase the number of public transport passengers by 33 percent compared to the current condition.

7. Conclusion

The rapid urbanization of Iran's largest city, Tehran, and the development of this metropolis in a short period has caused the dominance of motorization with a deeply rooted car culture that has resulted in urban mobility challenges. Consequently, this metropolis requires a change in policy approach to improve its urban mobility. This paper shows that this metropolis is organized based on the priority of private car use and its urban mobility system is car-based. Therefore, the most crucial problem of Tehran's urban mobility is a drastic increase in private cars that affect CBD and result in a density in this area and significant environmental impacts. Hence, a new policy approach was proposed: Human-Oriented Urban Mobility (HOUT) approach. Put differently, as the car-oriented strategy has failed, the new policy approach was necessary according to human needs and characteristics. In this vein, strategic policies and policy options through stockholders' participation have been proposed in reliance on the outlined approach. Suggestions were based on the population's actual accessibility and transport demands (and not only those who have a car) and more respectful of the environment. Next, seven alternatives were designated and appraised based on policy options to enhance urban mobility in the CBD.

This research has presented a methodology for assessing urban mobility improvement through the change of policy approach as a conceptual framework. Besides, in the proposed method to appraise the implementation impacts of policy options, a model-based tool was applied to quantify alternatives according to the pre-defined criteria. A wide range of HTS and other required data gathering was conducted in an actual large-scale area. Modelling the proposed alternatives was carried out using EMME software. The best alternative was opted using the MADM method considering the comparison of alternatives based on the analysis criteria. The ANP model is proposed to compare the alternatives and to select a superior alternative.

This paper outlined that changing the policy approach played a principal role in improving urban mobility. Based on the findings, mixed strategies, including infrastructure development alternatives and alternative applying restrictions for private cars, were selected as solutions with the highest priority. Thus, in addition to concentration on a single mode of active transport, the mix of coherent interventions in soft modes complemented by the congestion pricing for private cars entering the CBD is the best solution to face the diversity of accessibility needs to reduce environmental impacts. It can be

inferred that in developing countries, where healthy financial travellers have a drastic interest in the use of private cars, development alternatives alone cannot significantly meliorate urban mobility if they do not combine improvements in public transport and soft modes of mobility with restrictions to personal vehicles. Therefore, it can be stated that to increase the effectiveness of urban mobility solutions in Tehran, a capital city in a developing country, in addition to making the required sustainable infrastructure to boost urban mobility, it is also essential to implement restrictions for private vehicles.

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References

- Antov, D. (2015). *Alternative strategies for the urban mobility improvement in the municipality of the Cluj-Napoca* [Doctoral dissertation, Polytechnic University of Timișoara].
- Blyth, M. J. (2005). *Learning from the future through scenario planning. Four Scenes Pty Ltd.*
- Böhler-Baedeker, S., Kost, C., & Merforth, M. (2014). *Urban Mobility Plans: National Approaches and Local Practice. Moving towards Strategic, Sustainable and Inclusive Urban Transport Planning* (No. Sustainable Urban Transport Technical Document# 13).
- Bottero, M., & Lami, I. M. (2010). Analytic network process and sustainable mobility: an application for the assessment of different scenarios. *Journal of Urbanism*, 3(3), 275–293.
- Chen, Z. (2007). The application of the analytic network process for the sustainable built environment. *International Journal of Construction Engineering and Management*, 17(2), 137–147.
- de Barros Baltar, M. L., de Abreu, V. H. S., Ribeiro, G. M., & Santos, A. S. (2021). Evaluating Impacts of Traffic Incidents on CO₂ Emissions in Express Roads. In *LCA Based Carbon Footprint Assessment* (pp. 35-53). Springer, Singapore.
- De Souza, J. V. R., De Mello, A. M., & Marx, R. (2019). When is an innovative urban mobility business model sustainable? A literature review and analysis. *Sustainability*, 11(6), 1–18.
- Defranceschi, P. (2016). *CIVITAS Guide : Procuring Sustainable Mobility solutions.*
- Duncan, B., & Hartman, J. (1996). Sustainable urban transportation initiatives in Canada. In *CANADA to the APEC Forum on Urban Transportation Seoul* (pp. 1–12).
- e Silva, J. B., Félix, R. M., Gonçalves, A. B., & da Silva, F. N. (2013). A Participative Bike Route Planner to Improve Adaptive Cycling Strategies in Cycling Starter Cities - typology of cyclists and cycling preferences in Lisbon. *AESOP-ACSP Joint Congress, Dublin, Ireland.*
- Ehteshamrad, S., Saffarzadeh, M., Mamdoohi, A., Saffarzadeh, S., & Figueira, F. M. (2019). Car Use Behavioral Study for Commuting Trips : Parents ' Work Trips and Children's s School Trips. *International Journal of Transportation Engineering*, 6(3), 207–216.
- European Commission. (2017). *Better regulation toolbox:Tool#17.how to identify policy options.*

- European Union. (2017). *sustainable urban mobility: European policy, practice, and solutions*. <https://doi.org/10.2832/827766>
- European Union Regulation. (2007). The application of the analytic network process for the sustainable built.
- Green Paper: Towards a new culture for urban mobility | European Union regulations | European Encyclopedia of law (lawlegal.eu)
- Florian, M. (2008). Models and Software for Urban and Regional Transportation Planning: The Contributions of the Center for Research on Transportation. *INFOR: Information Systems and Operational Research*, 46(1), 29–49.
- Foltýnová, H. B., Vejchodská, E., Rybová, K., & Květoň, V. (2020). Sustainable urban mobility: One definition, different stakeholders' opinions. *Transportation Research Part D: Transport and Environment*, 87, 102465.
- Gaggi, S., Fluhrer, T., & JANITZEK, T. (2013). Innovation in urban mobility policymaking and planning.
- Gallo, M., & De Luca, G. (2016). A methodology for evaluating urban traffic plan scenarios from the point of view of traffic noise, 15, 187–197.
- Galychyn, O., & Üstundağ, K. (2017). Organic Urbanism: Human-oriented Design for Metropolises. *Procedia Environmental Sciences*, 37, 396–407.
- Grant, R. M. (2021). *Contemporary strategy analysis*. John Wiley & Sons.
- Heinonen, J., Czepkiewicz, M., Árnadóttir, Á., & Ottelin, J. (2021). Drivers of Car Ownership in a Car-Oriented City: A Mixed-Method Study. *Sustainability*, 13(2), 619. <https://doi.org/10.3390/su13020619>
- Hussey, L. (2014). *Analytic Network Process (ANP) for Housing Quality Evaluation: A Case Study in Ghana*.
- Kadoić, N., Ređep, N. B., & Divjak, B. (2017). Decision-making with the analytic network process. In *The 14th International Symposium on Operational Research in Slovenia*.
- Kolios, A., Mytilinou, V., Lozano-Minguez, E., Energies, K. S.-, & 2016, undefined. (2016). A comparative study of multiple-criteria decision-making methods under stochastic inputs. *Energies*, 9(7), 566.
- Korver, W., Stemerding, M., Van Egmond, P., & Wefering, F. (2012). *CIVITAS Guide for The Urban Transport Professionals: Results and lessons of long-term evaluation of the CIVITAS initiative. CIVITAS CATALIST*.
- Lopez-Ruiz, H. G., Christidis, P., Demirel, H., & Kompil, M. (2013). *Quantifying the Effects of Sustainable Urban Mobility Plans. Report EUR, 26123*
- Lyon, R. (2015). *Strategic insights- Making strategic policy: What's involved?*
- Majumder, M. (2015). *Impact of urbanization on water shortage in the face of climatic aberrations*. Springer.
- May, A. D., & Khreis, H. (2015). Option generation for policy measures and packages: An assessment of the KonSULT knowledgebase. In *climate change targets and transport policy conference, Malta* (Vol. 6, pp. 1–24).
- Mehdizadeh, M., Nordfjaern, T., & Mamdoohi, A. (2019). Environmental norms and sustainable transport mode choice on children's school travel: The norm-activation theory. *International Journal of Sustainable Transportation*, 14(2), 137–149.
- Mihyeon Jeon, C., & Amekudzi, A. (2005). Addressing sustainability in transportation systems: definitions, indicators, and metrics. *Journal of Infrastructure Systems*, 11(1), 31–50.
- Nickols, F. (2016). *Strategy, strategic planning, strategic thinking, strategic management. Distance Consulting*.
- Nudzor, H. (2009). What is “ policy ”, a problem-solving definition, or a process conceptualization? *Educational Futures*, 2(1), 85–96.
- OECD. (2012). The OECD Glossary of Statistical Terms.
- Okraszewska, R., Romanowska, A., Wołek, M., Oskarbski, J., Birr, K., & Jamroz, K. (2018). Integration of a multilevel transport system model into sustainable urban mobility planning. *Sustainability*, 10(2), 479.
- Penadés-Plà, V., García-Segura, T., Martí, J., & Yepes, V. (2016). A review of multi-criteria decision-making methods applied to the sustainable bridge design. *Sustainability*, 8(12), 1295.
- Pisoni, E., Christidis, P., Thunis, P., & Trombetti, M. (2019). Evaluating the impact of “Sustainable Urban Mobility Plans” on urban background air quality. *Journal of environmental management*, 231, 249–255.

- Rodrigue, J. P. (2013). *The Geography of Transport Systems* (third edition). New York: Routledge.
- Rudolph, F. (2017). Analyzing the impact of walking and cycling on urban road performance: a conceptual framework, FLOW project (Funded by European Union), Bernard Gyergyay, Rupprecht Consult
http://h2020flow.eu/fileadmin/templates/documents/Deliverables/FLOW_Conceptual_Framework_FIN_AL_web.pdf
- Saaty, T. L. (2004). Fundamentals of the analytic network process-Dependence and feedback in decision-making with a single network. *Journal of Systems Science and Systems Engineering*, 13(2), 129–157.
- Sabaei, D., Erkoyuncu, J., & Roy, R. (2015). A review of multi-criteria decision-making methods for enhanced maintenance delivery. *ScienceDirect*, 37, 30–35.
- Stead, D. (2007). The European green paper on urban mobility. *European Journal of Transport and Infrastructure Research*, 7(4), 353–385.
- Steenberghen, T., Pourbaix, J., Moulin, A., Bamps, C., & Keijers, S. (2013). Study on a harmonized collection of European data and statistics in the field of urban transport and mobility. *Final report*.
- Thomopoulos, N., & Nikitas, A. (2019). Editorial: Smart Urban Mobility Futures. *International Journal of Automotive Technology and Management*, 19(1–2), 1–9.
- TNS Opinion & Social, & European Commission. (2013). Attitudes of Europeans towards urban mobility. *Special Eurobarometer 406*.
- The United States Environmental Protection Agency. (2011). Guide to sustainable transportation performance measures. https://doi.org/www.epa.gov/sites/production/files/2014-01/documents/sustainable_transpo_performance.pdf
- Van Audenhove, F.-J., Korniiichuk, O., Dauby, L., & Pourbaix, J. (2014). The Future of Urban Mobility 2.0: Imperatives to Shape Extended Mobility Ecosystems of Tomorrow, 1–51.
<https://trid.trb.org/view/1317253>
- Varies, D., & van Eijl, H. (2016). *TRIP Research Theme Analysis Report – Urban Mobility - TRT Trasporti e Territorio*.
- Ward, S. C., Bagley, C., Lumby, J., Hamilton, T., Woods, P., & Roberts, A. (2016). What is ‘ policy ’, and what is ‘ policy response ’? An illustrative study of the implementation of the Leadership Standards for Social Justice in Scotland. *Educational Management Administration & Leadership*, 44(1), 43–56.
- [PDF] [What is ‘policy’ and what is ‘policy response’? An illustrative study of the implementation of the Leadership Standards for Social Justice in Scotland | Semantic Scholar](#)
- Wefering, F., Rupprecht, S., Bührmann, S., & Böhler-Baedeker, S. (2013). Guidelines. developing and implementing a sustainable urban mobility plan. *In Workshop* (p. 117).



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