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Research Paper

An Overview of Challenges and Plans to Improve Urban Mobility: A Case of Approach and Strategies in Tehran

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Abstract

The world's population is trending up, while a striking proportion of it resides in urban areas. Today, with the development of urbanization and the deficiency of sustainable transport infrastructure in most developing cities, urban mobility has become one of the staple challenges in such metropolitan areas. In this paper, research on urban mobility issues, their challenges and, policy approaches are succinctly reviewed. Furthermore, a review of the Sustainable Urban Mobility Plan (SUMP) and the approaches of distinct countries in this connection along with their lessons from these experiences are outlined. Finally, a new approach to improving Tehran's urban mobility has been proposed, and assorted alternatives have been compared and appraised. In the same vein, the transportation macroscopic model was applied to measure and compare proposed alternatives.

Research findings depict that car-based cities confront intricate urban mobility issues and the approach of most cities has been to develop sustainable urban mobility based on improving the quality of their residents' life. Apart from that, for the city of Tehran, applying a combination of alternatives has been more effective in boosting the sustainable urban mobility of this metropolis. Put differently, by examining distinct strategies, a mixed alternative involving the development of soft modes along with congestion pricing for private cars entering CBD has been proposed. It is projected that founded on the proposed policy approach alongside the implementation of a superior alternative, the proportion of the congested network in the central area will be diminished by 1.9 percent.

Keywords: Urban mobility challenges, SUMP, Policy approach, Improvement strategies, Private cars, Case study

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1. Introduction

Scientists and engineers are using state-of-the-art reports as a means of summarizing the current knowledge in specific areas of science and technology (Water Resources Scientific Information Center, 1968) and it is invaluable for identifying useful research paths (Palmatier et al., 2018). Thus, distinct references with the most relevance to the subject area of this research are reviewed. Next, the new policy approach and suggested strategies for improving Tehran's urban mobility are outlined (Khashaypoor, n.d.).

1.1. A General Definition of Urban Mobility

The history of the word "urban mobility" goes back to about half a century, and this concept is 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). While transport demand is derived from the needs of the community and the city's economic requirement, mobility is a wider concept that comprises the opportunities and access provided by the transportation system (Bachtler & Mendez, 2010; Schadev et al., 2012). It is believed that user characteristics (like monthly income), urban environment characteristics, and access to transportation, can affect urban mobility (Costa et al., 2005). The concept of mobility involves, in the short term, travel; and in the long term, the choice of place (Antov, 2015) and is thus, used for moving and refers to concepts such as travel behavior and displacement. The notion of mobility identifies as a plan with goals and priorities for the long-term expansion of transportation systems (Interreg central Europe, 2017). Urban mobility aspects are different and divided into seven themes including accessibility, freight displacement, intelligent transportation systems, low carbon transport technologies, sustainable public transport, sustainable urban mobility plans, and urban land use (Horton et al., 2016).

1.2. Urban Development Eras and the Form of Urban Mobility

The staggering rate of urbanization brings issues such as an astounding increase in transport demand, that emerge especially in developing nations in terms of congestion and pollution (Mehdizadeh et al., 2019). Urbanization and urban rapid development around the world have led to growth in the number of passengers and freight movement in the cities. A review of previous research (Table 1) shows that urban development has seen four general eras, each with different forms of urban mobility (Rodrigue et al., 2016)

Table 1. Urban development pattern and urban mobility relationship

Era (period)	Era (title)	Urban mobility	Land use pattern
1800-1890	The walking-horse-car era	* prevailing mean of commuting on foot * Development of first public transit in the form of omnibus service * railroad facilitated the first real change in urban morphology	* Land use was mixed and density was high * City was compact and its shape was more-or-less circular * satellite towns occur simultaneously with the location of the rail station and stretched out from the city center
1890-1920	The electric street cat or transit era	* Electric traction motor innovation makes a revolution in urban mobility	* The street city was able to spread outward 20 to 30 kilometers along the streetcar lines, creating an irregular, star-shaped pattern * Urban fringes become an area of rapid residential development

			* City core was further mixed-use and high-density zone
1930-1950	The automobile era	* Private car ownership growth up rapidly	* Developers were attracted to green-field areas located between the suburban rail corridors
1950-onward	The freeway era	* Great spread of the private car and highway construction had significant impacts on urban mobility	* Automobile reduce the travel time and distance, which led to urban sprawl * Commercial activities also began to suburbanized

Since the early nineties, with the introduction of urban transit systems, urban form and spatial structure have been affected. From a different perspective, three main categories of cities can be found in terms of this relationship (Rodrigue, 2016): 1- adaptive cities (transit-oriented cities), 2- adaptive transit (private car have dominated the share of mobility), and 3- hybrids (a balance between transit development and private car affiliation).

2. A Glimpse on the Global State of Worldwide Mobility

Urban mobility issues have built up with urban development, so trends reflected the growing size of cities and the increasing urban population. By 2005, approximately 7.5 billion daily trips were made in cities worldwide. It is estimated that in 2030 about 60% of the population will live in urban areas while this percentage will reach more than 75% in 2050 (United Nations Human Settlements Programme., 2008). It is projected 82% of European populations live and work in urban areas this year (Gaggi et al., 2013). Moreover, in 2050 urban mobility will cost €829 bn per year across global, more than four times larger than in 1990 (Lerner & Audenhove, 2012). Besides, It is expected that more than the US $ 14 trn to be invested globally in mobility infrastructure projects between 2016 and 2025 (Thomopoulos & Nikitas, 2019). It is anticipated that by 2050, the average time of urban residence spends in traffic congestion will be 106 hours per year, which is three times higher than today (Lerner & Audenhove, 2012). This is shown in Figure 1.

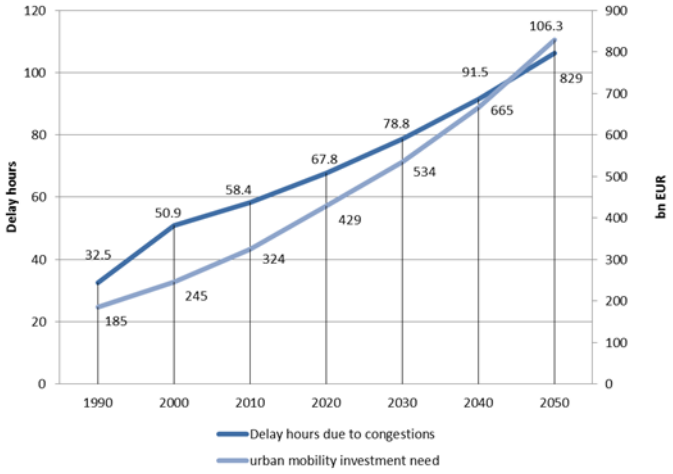

Figure 1. Urban mobility trend

The number of non-heavy vehicles (cars, sports utility vehicles, light trucks, and mini-vans) is envisaged to reach nearly 1.6 billion in 2035, mostly found in developing countries, especially China, India, and other Asian countries. With an increase in car ownership in Asia and the Pacific region, available information depicts that the car ownership is less than 200 vehicles per 1,000

population for most developing countries such as Iran and about 600 to 725 in the developed countries, like Australia and Japan (*Vehicles in use | OICA*, 2015). As shown in Figure 2, the main growth takes place in countries like Azerbaijan, China, Georgia, Indonesia, Iran, Kazakhstan, the Russian Federation, and Thailand. Other countries have remarkably lower per capita vehicle ownership.

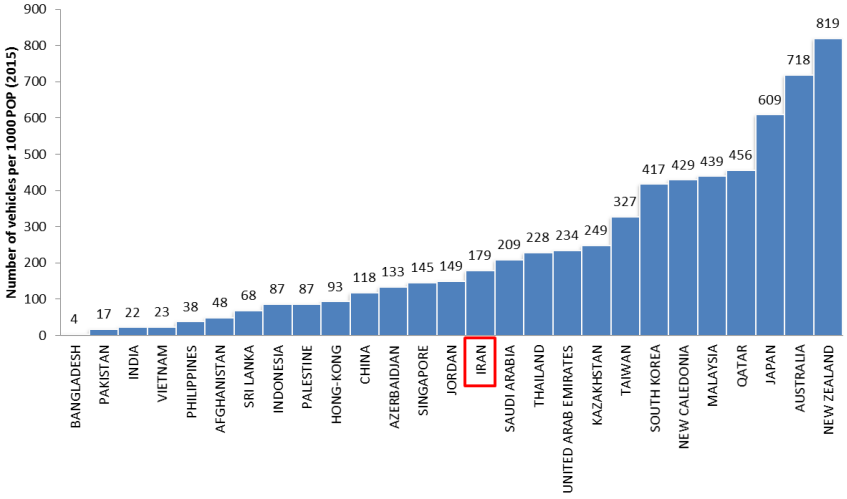

Figure 2. Total number of vehicles per 1000 populations for some Asian countries in 2015

In terms of developing infrastructure for private motorized transport, there are assorted conditions in different cities in the world. For example, the length of freeways per person in Western Europe is about three times greater than in Eastern Europe (Habitat, 2013). Also, the provision of infrastructure for private motorized transport in Europe is lower than in North America and Australia. In connection with car ownership in some Asian cities, Tehran's comparison with four cities whose car ownership is approximately equal to or greater than Tehran indicates that the length of freeways per person in Tehran is higher than in other analogous cities. This is illustrated in Figure 3 (Habitat, 2013).

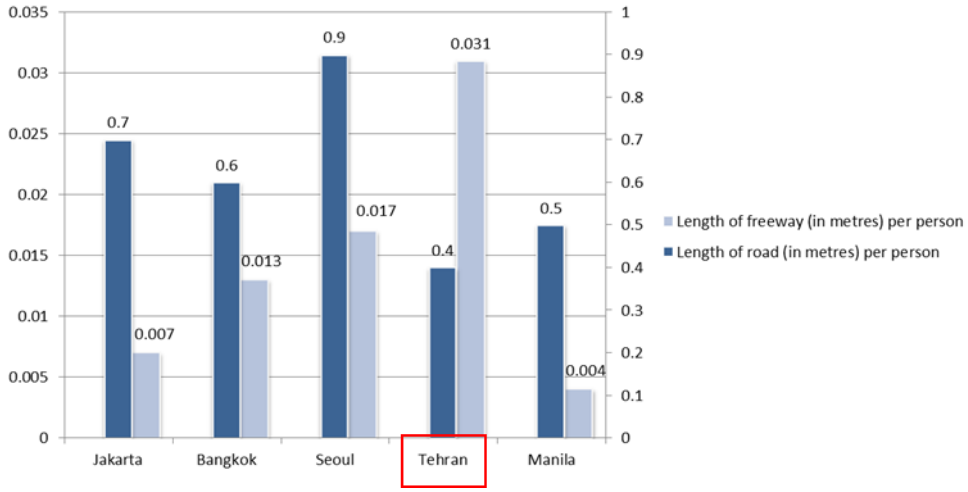

Figure 3. Road transport infrastructure in the selected Asian city

Accordingly, it can be concluded that due to the noticeable expansion of Tehran freeways, the development of road transport infrastructure has been ahead of the enhancement of public transport.

3. General Challenges in Urban Mobility and Attaining SUMP

In this section, the general challenges facing urban mobility are reviewed and then these challenges in European cities are examined. Following, the concepts and approaches related to sustainable development programs are provided. It should be highlighted that sustainability is known as the development that fulfills communities' necessities without compromising the capability of coming generations to meet their needs (Kurowksa et al., 2021). in this vein, sustainable development amalgamates economic, social, and political measures along with environmental protection (Abualfaraa et al., 2020).

3.1. Challenge Ahead in Urban Mobility

Former researches on urban mobility have shown that cities encountered several key challenges in terms of mobility. These challenges are divided into six general categories (Horton et al., 2016): Growing urbanization, Increasing aging population, Communications progress, Congestion, Accident and safety, Greenhouse gas, and air-quality-related emissions. Furthermore, the staple challenges in the growth of urban transport in European cities have been identified by the European Commission (Okraszewska et al., 2018). From another standpoint, Urban mobility improvement plans in different European cities, the main challenges in urban mobility are (Korver et al., 2012): health, congestion, safety and security, participation, and strategic planning.

Traffic congestion is the most obvious problem of urban mobility in cities and has a substantial negative impact on GDP (de Barros Baltar(Korver et al., 2021; Vujadinovi(Korver et al., 2021). Increasing road congestion in the first of the early twenty century due to the spread of the automobile in most European cities had been made urban mobility a crucial drawback. Consequently, in European cities increased traffic in town and city centers has resulted in chronic congestion, with many harmful outcomes in terms of delays and pollution. Therefore, European cities endeavored to find common solutions. New approaches to urban mobility planning have led local authorities to request the change of old approaches and exploit nascent solutions to create cleaner and sustainable transport modes (European cities and regions networking for innovative transport solutions, 2015). Hence commission of the European communities has carried out a comprehensive public consultation in 2007. This consultation process result was presented in the Green Paper. Consequently, the urban mobility action plan has been adopted on 30 September 2009 and prepared a framework for 20 EU-level actions, which can be performed by the European Commission until 2012 and through existing instruments and inventions (European Commission, 2012). Based on the Green Paper, a general framework on five major urban mobility challenges in European cities was provided (Stead, 2007). Considering the economic significance of urban areas and the challenges facing urban mobility, the European Union (EU) needed to contemplate more robust policies for improving urban mobility. wherefore, in 2011, a transport White Paper with two goals as follow was prepared (TNS Opinion & Social & European Commission, 2013). The White Paper refers to the notion of sustainable urban transport plans and represents a comprehensive plan for considering all modes of urban transport (Schade et al., 2012).

The EU has provided assorted policies for planning and implementing sustainable urban mobility policies. These policies are classified into seven distinct approaches (Morchain & Fedrizzi, 2011). Simultaneously with the design and implementation of urban mobility improvement policies in Europe and the development of a Green Paper program, CIVITAS (City, Vitality, sustainability) plan was developed in 2002 (As a program of ‘cities for cities’) to improve urban mobility (Gaggi et al., 2013). Therefore, following local actions, the European Commission launched this program to encourage and make funds in various European cities to implement sustainable

urban mobility. The CIVITAS program put forward a new culture on urban mobility according to integrated urban transportation planning (Gaggi et al., 2013). The performed strategies in this program have been aimed at increasing the mobility of urban residence and prepare sustainable urban transport systems. One of the main traits of this program is the transfer of experiences and findings in this sphere in various European cities.

3.2. Sustainable Urban Mobility Plan (SUMP)

Urban mobility plan (UMP) is a planning instrument that includes goals and actions to create a safe, efficient, and accessible urban transportation system (Böhler-Baedeker et al., 2014). A successful UMP can provide possible and strong strategies to conquer the challenges of urban mobility. The Sustainable Urban Mobility program (SUMP) considers factors such as system integration, stakeholder participation, and evaluation of results to meet the mobility needs of citizens in the current and future. The goal of SUMP is to improve access to urban areas and create high-quality and sustainable mobility in cities (Adell & Ljungberg, 2014). Sustainable urban mobility continues to be one of the unresolved local worries (Foltýnová et al., 2020).SUMP is a strategic plan that will enhance the quality of life. For several years the (EU) has promoted the sustainable urban mobility planning connotation (European Union, 2017) and one of the regions that have more experience in the implementation of UMP is Europe (Guzman et al., 2020). However, due to the intricacy of the SUMP approaches and its diversified goals, it is arduous to provide a comprehensive definition of a sustainable urban mobility plan, but it could be contended that its definition is necessary to include the terms shown in Figure 4 (Rupprecht Consult & Edinburgh Napier University, 2012). It should be pointed out that a process has been defined in connection with how to prepare SUMP. This process embodies eleven main steps with thirty-two activities (Figure 5) to improve mobility and quality of life for citizens (Frank Wefering et al., 2013). These steps and activities are part of a regular planning cycle in the uninterrupted improvement process. Timing and coordination for any of the activities mentioned in Figure 5 are very considerable and activities can be done in parallel or feedback loops.

Figure 4. Key terms for defining a SUMP (Rupprecht Consult & Edinburgh Napier University, 2012)

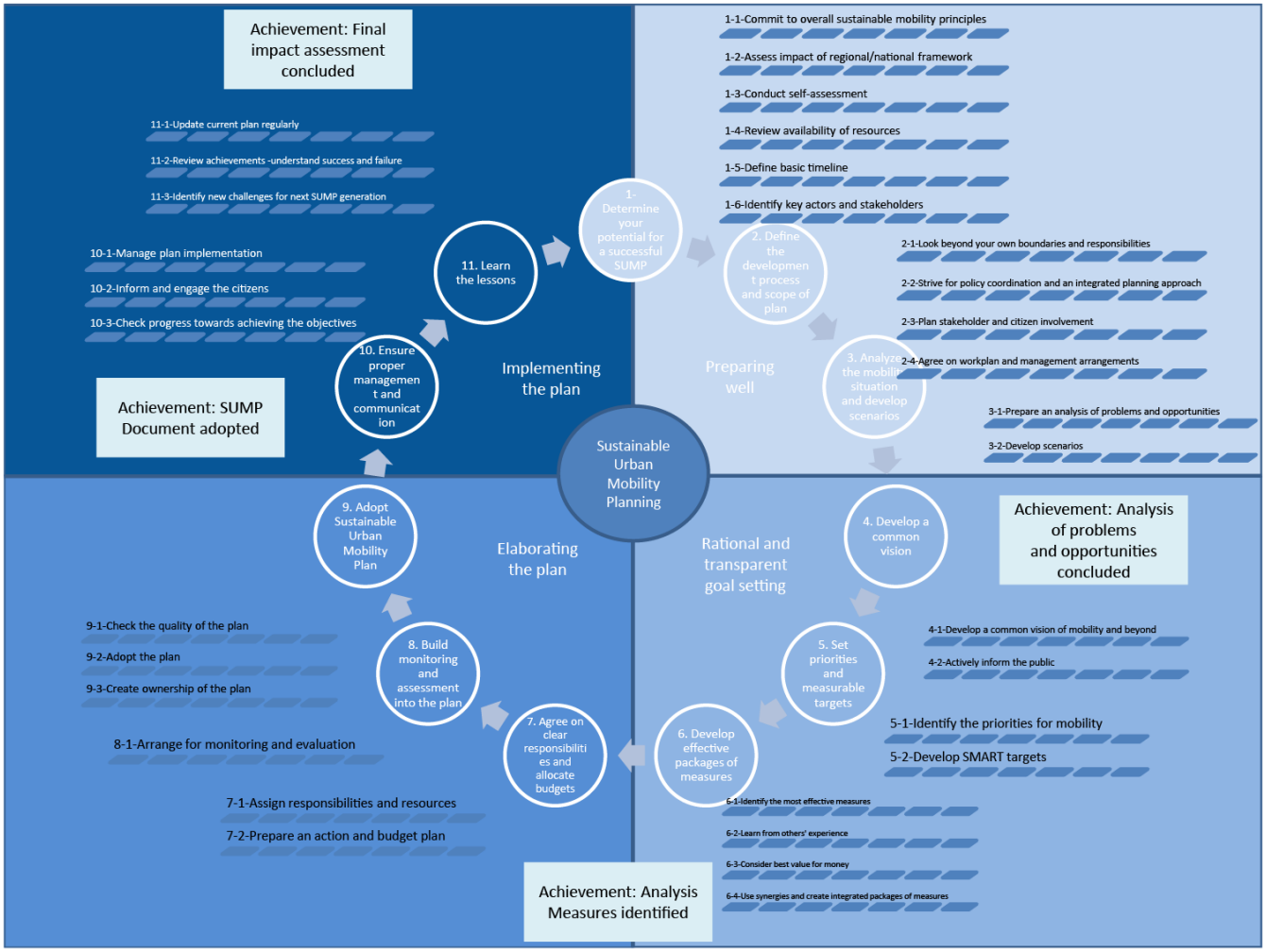

Figure 5. The planning process for sustainable urban mobility in Europe (Brunner & Forschung, 2019; European Union, 2017; Wefering et al., 2013)

4. Worldwide Approaches to Urban Mobility Planning and Lessons for Improving It

To persuade cities to develop urban mobility plans, national or regional policy frameworks are usually required, including a wide range of rules needed to provide guidelines. Generally, the urban mobility planning procedure involves developing a prevalent vision for transport development and mobility in a city or region. Besides, an urban mobility plan is often instrumental in achieving policy goals (Böhler-Baedeker et al., 2014).

4.1. Approaches of Different Cities in Urban Mobility Planning

4.1.1. Brazil's Approach

The national framework for urban mobility planning in Brazil, known as "Planos de Mobilidade Urbana (PMU)", was formulated in 2012. Accordingly, cities with a population of over 20,000 people would be needed to provide the PMU and should be submitted to the Ministry of the Interior to adopt national budgets to develop transportation plans. (Böhler-Baedeker et al., 2014). Based on the National Policy on urban mobility in Brazil, the urban mobility plan in the country should:1-Adopt solutions to dwindle the number of private vehicle trips and increase the share of soft modes, 2-Declining energy consumption and mitigating local pollution and greenhouse gases, and 3-Enhance safety by

focusing more on the issue for pedestrians, cyclists, children and the elderly.

4.1.2. France's Approach

The national policy on urban mobility in France was based on the compulsory provision of urban mobility plans aimed at eliminating the negative effects of traffic congestion. This plan (Plans de Deplacements Urbanis: PDUs) is a legally binding instrument for preparation, ratification, and implementation in 10 years (Böhler-Baedeker et al., 2014). It should be highlighted that the preparation of PDUs was made mandatory for cities of over 100,000 populations since 1996 (Merle, 2012). The process of creating PDUs took 2 and 4 years and from 2010 onward, this plan became a part of the framework for climate change (Böhler-Baedeker et al., 2014). Urban planning in France consists of three parts of regional coherence plan (SCoT), urban mobility plan (PDU), and urban development plan (PLU) (Merle, 2014). The measures outlined in PDU have been to alleviate private vehicle trips and increase the share of public transport and non-motorized transportation, such as mobility and transport demand management (Merle, 2012). The plan was based on the development of transport-oriented and aimed at boosting and modernizing the public transport fleet, giving priority to bus and Light Rail Transit, development of cycling and parking management (Böhler-Baedeker et al., 2014).

4.1.3. India's Approach

The urban mobility plan in India, launched in 2008, is known as a comprehensive mobility plan (CMP). Therefore, the Ministry of Urban Development (MoUD) of India, in cooperation with the Asian Development Bank, proposed a tool for CMP procurement (Ministry of Urban Development, 2014). Preparing this plan was required to request a budget for transportation projects under Jawaharlal Nehru National Urban Renewal Mission (JNNURM) (Ministry of Urban Development, 2014). CMP is an essential document proposing the development of various components of the urban transportation system (PADECO Co, 2008). CMP is a long-term plan for the appropriate mobility and accessibility of individuals and goods, which will build up safety, efficiency, and reliability along with the improving city's economic, social and environmental development (Ministry of Urban Development, 2014).

4.1.4. Mexico's Approach

The Urban Mobility plan in Mexico is developed by two sectors: 1- Mexico's National Infrastructure Found and 2- the Federal Mass Transit Support Program, which is known as the Plan Integral de Movilidad Urbana Sustentable (Böhler-Baedeker et al., 2014). These plans are also based on the modernization and enhancement of public transportation systems, the development of non-motorized transportation, and the provision of clean vehicles. Because Mexico has a critical and most concerning situation in traffic and air pollution among Latin American countries, distinct restrictions policy has been imposed on private vehicles in Mexico City (Jirón, 2013). The restrictions on the use of private cars and the diminution of vehicle dependency in Mexico are based on two principles (Dalkmann & Brannigan, 2007; ITDP Mexico, 2012) 1-Avoiding redundant journeys by the vehicle and mitigating average travel distance shifting into more effective transportation modes such as cycling and walking and improving public transportation, and 2-Improving efficiency and energy performance in motorized transportation to dwindle its negative effects. The main objective of the Mexican Urban Mobility plan (PMIUS) was to develop integrated mobility along with land-use strategies (Böhler-Baedeker et al., 2014).

4.2. Lessons to Improve Urban Mobility

4.2.1. Stockholm Experience

In Stockholm, it is envisaged that the number of inhabitants will increase by 25% and build 100,000 new homes in the city (Firth, 2012). Hence, the city's vision should be drawn in such a way that the city has the capacity to admit these people for life and work. To achieve the goals of the 2030 vision,

urban mobility strategies were applied. These strategies will provide policies to prioritize diverse actions to engender a safe, healthy, attractive, and environmentally friendly city. These policies include city operational planning, cooperation with other government agencies, and city residents' participation in project implementation (Firth, 2012). Stockholm's overall strategies for meeting the transport needs due to population growth have been based on Principles of urban planning, infrastructure planning, and traffic planning. These strategies comprise respectively: mixed and dense urban development to mitigate the need for travel, development of public transport, and transit network to increase traffic flow and enhance efficiency in existing infrastructure (Firth, 2012). Strategies show what is needed to do the city's vision. Hence, objectives are needed to realize the strategies. In this vein, four objectives were developed in the city of Stockholm as part of urban mobility strategies that embrace improvement of capacity, accessibility, attractiveness, and negative effects.

To attain the urban mobility strategies in Stockholm, an action plan for the period 2012-2016 was developed. This action plan includes a series of measures to achieve short-term objectives in urban mobility strategies and is separated into two parts: measures for the different transport modes and measures that can encourage sustainable accessibility (Firth, 2012). The municipality of Stockholm posited a road pricing system for entry into the city center in 2007. Tariffs for vehicles entering the central area also depended on the time of day and the magnitude of traffic congestion in the city center (Knutsson, 2010). Many drivers have bought low CO2 pollutant vehicles because they could enter the city center for free. The project has had a remarkable effect on improving urban mobility in Stockholm. Various studies have shown that between 2005 and 2008, traffic volumes dropped by virtually 15% to 20% (Knutsson, 2010).

4.2.2. London and Berlin Experience

Researches to improve urban mobility in London and Berlin revealed that attitudes can be identified as key factors for travel mode choice (Rode et al., 2015). Therefore, urban mobility can be divided into six distinct mobility attitude groups that were recognized in each metropolitan area (Rode et al., 2015): 1- traditional car-oriented: driving is the preferred mode and proper means of transport. Generally, this group fancy to live at the fringe or in the countryside, 2- pragmatic transit skeptics: this group is consists of individuals who opt for car use but show various tendencies concerning other modes, 3- green travel-oriented: individuals with lots of respect to the environment and mostly use public transport and positively rate public transport, 4- pragmatic transit-oriented: this group is comprised of individuals who positively assess various features of public transport. This group is different from green travel-oriented according to preserving the environment, 5- technology-focused individualists: this group consists of individuals who have the propensity to use private modes of travel, cycling, and using technology. They are not concern about the environment, and 6- innovative access-oriented: they are bowed to use modes of travel other than the car and enjoy trying technology to travel. The policy goals and options in terms of mobility attitude groups are shown in Table 2.

Table 2. Policy goals and options according to different attitude groups *(Rode et al., 2015)*

Mobility attitude group	Traditional car-oriented	Pragmatic transit skeptics	Green travel oriented	Pragmatic transit-oriented	Technology-focused individuals	Innovative access-oriented
Policy goals	• compensate for environmental impact	• reduce environmental impact	• maintain and expand cycling and public transport use	• maintain and further encourage cycling and	• reduce driving and car ownership	• encourage further use of alternative modes

	• reduce environmental impact • reduce driving and car ownership where possible	• reduce driving and car ownership where possible	• reduce car use and ownership further	public transport use • reduce car use and ownership further	• reduce environmental impact	• encourage further use of alternative modes
Policy options	• congestion charging • parking fees • low emission zones • tax benefits upon purchase of low emission vehicles	• free testing of electric cars and car-sharing schemes • promote flexible car-sharing schemes • tax benefits upon purchase of electric cars • congestion charging	• regular information on local travel and mobility options • promote mobility services to improve travel experience, particularly online services	• sustain positive public transport experience • affordable public transport • encourage technology use	• highlight autonomy and fun aspects of alternatives, including public transport modes • target through technology channels, smartphone travel apps, and electronic services	• promote mobility services to improve the travel experience, particularly online services • inform instantly about new options and services

4.2.3. Bremen Experience

In the city of Bremen, Several measures and options were taken to achieve the goals of the Sustainable urban mobility plan (Senate Department for Environment-Construction and Transport, 2015). Hence, sets of assorted scenarios were defined in the horizon year (2025). These scenarios include (Senate Department for Environment-Construction and Transport, 2015): 1- optimization of private motorized transport, 2- public transport first strategy, 3- efficient walking and cycling, 4- optimization of walking, cycling, and Public transport, and 5- high Mobility costs. To a quantitative comparison between different scenarios, the transport models of the city of Bremen were used. The analysis of model parameters based on target indicators (16 indicators) is the basis for comparing scenarios and selecting the best scenario.

4.2.4. Milan Experience

In the city of Milan, 58% of the trips exchange between Milan and the surrounding area, and 35% of the travels inside the city were carried out by private vehicles. The first debates on road pricing for access to the city center were raised by the Milan municipality between 2001 and 2006 until the congestion charging project to improve quality of life with the title of Area C was implemented in 2012 (Mattioli et al., 2012). Initially, this project was launched in 2008 for polluting vehicles, and a pollution charged was received for the access of polluting vehicles to the city center (Mattioli et al., 2012). A year following project launching, the outcomes are provided in two parts of urban and environmental mobility as follows (Berrini, 2016; Böhler-Baedeker et al., 2014):

Urban mobility results: 1-29.2% decline in traffic and a 26% diminution in crashes, 2-10% decrease in the occupancy of public spaces by cars, and 3-12% increase in surface public transit and 17% in underground transportation environmental results: 1-49% decline in polluting vehicles and a 6.1% increase in clean vehicles, and 2-Fewer emissions of pollutants: 8% decline in PM10, 18% reduction in NOx, a 35% decrease in CO2Following the implementation of the congestion charging Plan in 2012, the Milan urban mobility planning process commenced in 2013 and ended in 2015. The Milan urban mobility Plan was designed to address the city's major transportation challenges including traffic accidents, air pollution, and traffic congestion (Böhler-Baedeker et al., 2014). This plan is concentrated in nine categories (Böhler-Baedeker et al., 2014): 1- improved sustainable

mobility in the metropolitan area, 2- increasing the quality and performance of public transport, 3- providing integrated rail transport services, 4- improving access to newly developed areas, 5- Increasing safety, enhancing walking and creating environmental areas, 6- developing bike trips, 7- altering in parking policies, 8- providing smart mobility and 9- boosting urban goods logistics.

4.3. Analyzing Previous Findings on Different Approaches of the Urban Mobility Plan

Many urban mobility plans have an idealistic vision for increasing the share of public transport and non-motorized transportation. While the vision of an urban mobility plan in most developed cities focuses on the movement of people rather than vehicles, some of the mobility plan's measures emphasize the construction of road infrastructure and intersections, build parking lots, etc. For instance, the planning approach in some countries, such as Ukraine, continues to be based on the development of private transport infrastructure (Car-dependent mobility), and some other countries, such as Brazil, Mexico, and India, have a sustainable-oriented approach to urban mobility planning (Böhler-Baedeker et al., 2014). Consequently, it could be inferred that when cities are built on car mobility, they do not perform well. Simply put, car-based cities are cities that cause waste of human and environmental resources and affect the health of their citizens. In developing countries, automobile dependency is also affected by cultural and economic growth conditions, which is recognized as a symbol of personal freedom. Therefore, many developing countries consider motorization as a condition for development. The vision of the United Nations for the future of metropolises and densely populated cities is to create sustainable urban mobility and set up more sustainability in the daily travel of residents (Federal ministry for economic cooperation development, 2016). That is to say by 2030, bicycles, buses, rail systems, clean fuel vehicles, or walking will be the main modes of transportation in these cities.

A review of some recent researches reveals the importance of urban mobility on urban livability and how urban areas change from communities to metropolises (Louro et al., 2021). Some researches emphasize the impact of urban policies in attaining climate friendlier and safer urban mobility (Tiboni et al., 2021). Besides, smart urban mobility and planning are a keyword citing by many scholars in recent research (Lissandrello, 2021; Longo et al., 2021; Tregubov, 2020). This research proposed the assorted strategic policies to meliorate urban mobility based on suggested analysis criteria.

5. Tehran Urban Mobility Improvement: Approach, Strategies, and Alternatives Appraising

By investigating the alterations that have taken place in Tehran urban mobility and appraising the development of Tehran's spatial expansion and the growth of its urban road network in distinct eras, it can be inferred that particular attention has been paid to the development of the road network as the major guideline for the adopted mobility policy. In practice, the Tehran road network has evolved much faster than public transport infrastructure or non-motorized transport. Hence, the development approach of Tehran is based on a car-oriented and its urban mobility system is more designed to provide services to motor vehicles. In such a context, amendments in urban development and urban mobility planning approaches pretend indispensable. Accordingly, in this research, a new approach based on the human characteristics and its needs in terms of mobility, which is called Human-Oriented Urban Mobility (HOUM), is proposed versus the car-oriented urban mobility that is been adopted as the most significant policy approach in the city of Tehran (Khashaypoor, n.d.). HOUM is a system designed to respond to social needs, giving priority to human access and mobility. This approach is suggested as the most

overriding alteration in the policy approach in Tehran.

The outlined research methodology is pointed out in Figure 6 (Khashaypoor, n.d.). According to the proposed methodology, the first step is designating the policy approach based on mobility issues and lessons learned from successful cities' experiences. The next step is the determination of strategic policies. Put differently, to accomplish the policy approach, strategic policies are developed. Accordingly, following examining urban mobility drawbacks in Tehran, by considering the assorted views of technical experts and stakeholders according to the policy approach, strategic policies are suggested. . In this research, four strategic policies are proposed: 1- development of sustainable transportation against infrastructure-based development, 2- travel demand management in lieu of single response to trips demand, 3- quality in transportation services versus quantity in the transportation system, and 4- creating areas with the lowest level of emission and private vehicles in front of lacing restriction on private cars. In the third step, it is essential to measure the impact of strategic policies on urban mobility amelioration. By applying the model-based approach, it would be possible to measure the effects of implementing each strategic policy on improving the urban mobility of Tehran. Following this, it is imperative to gather various data and statistics, designate the analysis criteria, and also specify the alternatives. In the last step, it should be needed to opt for the superior alternative.

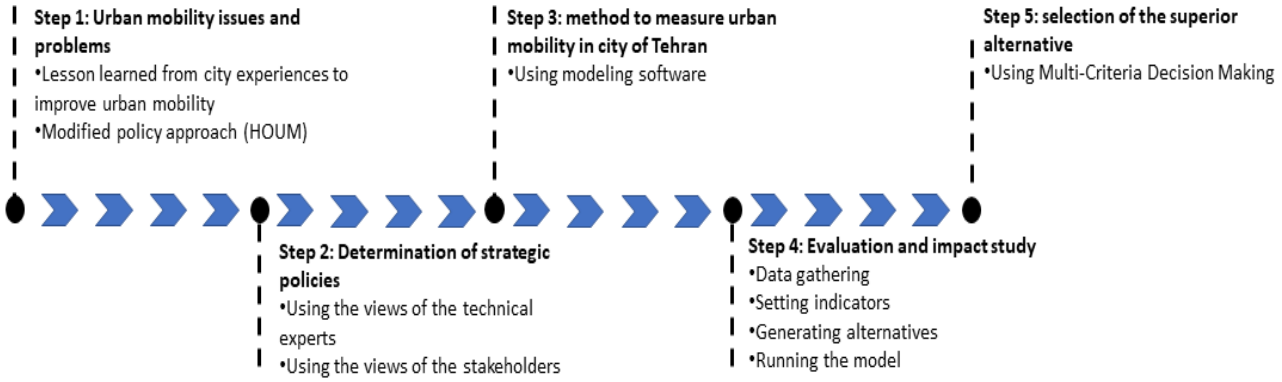

Figure 6. Conceptual framework of the research methodology

5.1. A Model-based Approach

The approach of many studies to appraise policy impacts is to use a model, that based on the characteristics of each model, a set of criteria are considered determining the overall effects of each alternative on the main sectors of each environment. Measuring the impact of alternatives on improving urban mobility in the Tehran central area based on quantified criteria is carried out using EMME/2 software. This tool is the macroscopic model with network-level and strategic in the sense. This software has been exploited in Tehran transport planning for more than two decades.

In this paper, the indicators are classified into three categories of urban mobility, environmental, and socio-economic index. For each of these indicators, analysis criteria are considered for the quantitative calculation of values. Hence, Five criteria are proposed which comprising transit volume, average speed, level of congestion, level of pollution, and total costs (cost of implementing and operating alternatives, cost of delay in routs, and cost of gasoline consumption in each alternative) (Khashaypoor, n.d.). As outlined before, based on the proposed modified approach (HOUM) as along with the pre-defined strategic policies, seven

alternatives are suggested (Khashaypoor, n.d.): A1- current condition (Do nothing), A2- Public transportation development in the city center, A3- development of walking and cycling in the city center, A4- implementing private vehicles restrictions to the city center, A5- congestion pricing for private vehicles entering the city center, A6- combination of alternative 2 and alternative 4, and A7- combination of alternative 3 and alternative 5. To model the alternatives, the characteristics of each alternative were first defined. In alternative A2, it has been attempted to make it easier for passengers access to the city center through public transport systems by making changes to the current condition. To develop cycling and walking in the central area of Tehran in alternative A3, cycling facilities such as bike stations or dedicated cycling routes, as well as pedestrian malls on some attractive routes in CBD have been proposed. In alternative A4, it is presumed that polluting vehicles are subject to this restriction and therefore are not allowed to enter the central area of Tehran. Also, in alternative A5, it is proposed that private vehicles must pay for entering the central area of Tehran. Drivers have to pay a congestion charge to enter CBD in this alternative. For instance, the traffic assignment map in terms of traffic volumes in the current condition network is depicted in Figure 7.

Figure 7. Results of Traffic assignment in EMME/2 Software in the do-nothing alternative

The features of household trips along with the socio-economic status of Tehran residents are the staple source of information on how people travel in the city of Tehran and how they reach the city center. Besides the household travel survey, a list of questions on urban mobility improvement objectives was asked from people traveling to Tehran city center. Therefore, the field survey and data collection procedure in the city of Tehran are comprised of two parts: 1- Tehran household travel survey, and 2- on-street questionnaire on urban mobility improvement objectives. In the process of both questionnaires designed for the city of Tehran, it has been endeavored to identify the features

mobility of Tehran inhabitant. Due to the extent of the household travel survey and its costs, Tehran Traffic and Transportation Organization have supported this sphere and carried out this crucial part.

5.2. Evaluation of Alternatives

According to 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 modeling was performed using the EMME/2 software. Appertaining to the definition of the various analysis criteria, the software outputs were provided based on these criteria. For instance, the percentage of the critical network (level of congestion) in the alternatives modeled is demonstrated in Figure 8.

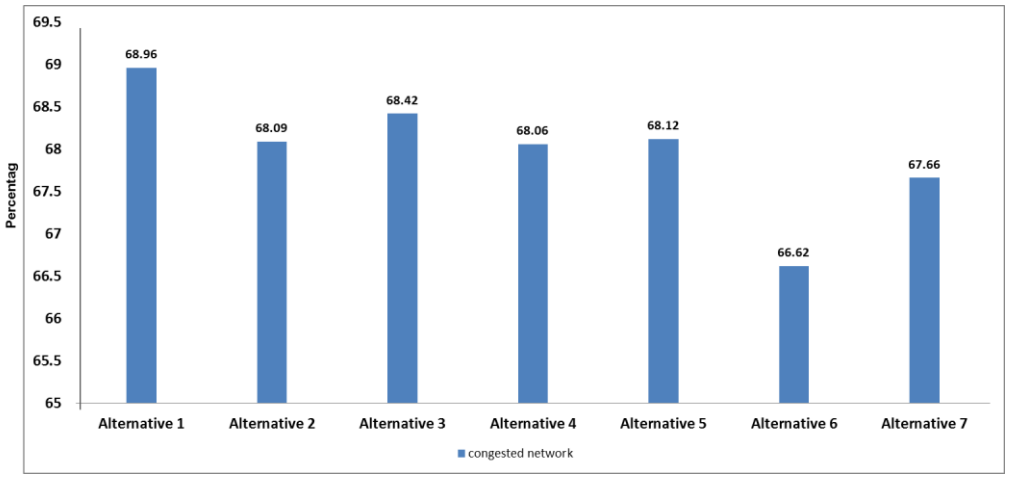

Figure 8. Percentage of the congested network in various alternatives based on modeling result

In the subsequent phase, aided by the decision-making process, it is required to opt for the superior alternative. In accordance with decision-making techniques and defined criteria, alternatives were appraised, and accordingly, a superior alternative is selected. Considering that five analysis criteria were used to appraise and opt for the best alternative, Multi-Criteria Decision Making (MCDM) methods were applied. MCDM methods play a key role in assessing and prioritizing the most suitable alternative among other alternatives based on a set of specified objectives and indicators. Hence, three methods of concordance analysis, AHP, and ANP were used in parallel. From this perspective, the Expert Choice and Super Decision software were applied to designate the best alternative using the AHP and ANP methods, respectively. According to the methods used, Alternative A7 (Mixed strategies) was the superior alternative (Khashaypoor, n.d.).

6. Conclusions and Suggestions

Urban mobility is a key factor in the booming of inhabitant quality of life which is considered a prerequisite for the economic upswing, trade, and health. This factor provides access to diverse parts of the city for different purposes and contributes to the possibility for residents to benefit from existing opportunities. However, mobility is not only a matter of developing transport infrastructure and services but also of overcoming the social, economic, political, and physical barriers to movement. Generally, due to the dominance of motorization, private vehicles are opting as the preferred means of mobility. Therefore, car-oriented cities are urban areas that are most likely to cause waste of human and environmental resources. World experience analysis depicts that car-oriented cities do not perform very efficiently; and that most cities around the world have based their approach and development plans on sustainable urban mobility: a paradigm shift, where people are placed first and before vehicles.

Tehran road network has been developed much faster than any sustainable transport system. Consequently, its urban mobility system is car-oriented. The most crucial drawback of Tehran's urban mobility is a drastic increase in the use of private vehicles that are affecting the central area and resulting in a density in this area and overriding environmental impacts. In this vein, a new policy approach was proposed in Tehran's urban mobility. Thus, a paradigm shift and selecting new approaches in Tehran urban mobility, proposing a conceptual framework for appraising the improvement in urban mobility, conducting a field survey, and also the use of the model-based approach, the superior strategy has been opted using MCDM methods. It can be concluded that mixed strategies (comprising the combination of infrastructure development alternatives and alternatives applying restrictions for private vehicles) are better solutions with higher priority to improve Tehran urban mobility, by about 1.9 percent in level of congestion in the entire CBD street network. Considering seven distinct alternatives, the proposed strategy to improve Tehran's urban mobility is to combine alternatives for developing soft modes in the city center and also congestion pricing for private vehicles entering CBD. Future research may pursue to explore policy options aimed at altering travelers' behavior rather than options targeting infrastructure development or restrictions on traffic flows.

7. References

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