

ORIGINAL RESEARCH PAPER

Prioritizing the guidelines and policies of the sustainable urban transportation

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ABSTRACT: In this research authors rely on the descriptive-analytical method to identify and introduce the indicators of the sustainable transportation on the first step, and then on the next step we will prioritize the mentioned indicators in the opinion of the urban experts in order to implement the sustainable transportation. Accordingly, after introducing the goals and indicators of the sustainable transportation, we will classify the guidelines for the fulfillment of those goals and improvement of those indicators in 7 main group and 34 subgroups. Using a questionnaire, we have asked the opinions of 15 urban experts who are related to the urban transportation issues and problems. The study has used analytical hierarchical process model to weight the obtained factors. The results of this research show that the most important factors in achieving the sustainable transportation are “land use” and “public transportation” respectively. Among the subsets of the indicators, the most important factors are the “service hierarchy and access to planning”, “paying attention to the traffic effects of the land uses on the main roads”, “integration of the land uses” and “efficient management of the land separating system” respectively. Consequently, in order to reduce the transportation problems of Shiraz City the urban planners have to pay especial attention to the organization of the land uses, to the promotion of the public transportation system both qualitatively and quantitatively, and to the promotion of the urban management in general.

KEYWORDS: Analytical hierarchical process; Shiraz; Sustainable transportation; Sustainable transportation guidelines; Sustainable Transportation Indicators (STI).

INTRODUCTION

In recent years the public attention to some subjects such as the quality of the environment, social equity and economic growth has led to the idea of the sustainable development. Although the theory of sustainable development was created in 1970s, but still after 30 years there is no comprehensive and agreed concept of the mentioned theory. A part of this disagreement is the result of the short age of this thought school while a considerable reason of this situation is the wide extent of the subject (Loo and Chow, 2006). However, one can refer to the most common concept of the sustainability as the

fulfillment of the current needs without threatening the needed resources of the future generations and to pay simultaneous attention to the present and future generations and the long-term effects of the present activities. Nowadays, the sustainable development is considered as a development that increases the quality standard of life, protects the environment, and cares about the local cultures and histories, social equity, as well as the economic development (Deakin, 2003).

The concept of sustainable transportation was formed gradually after the birth of the concept of sustainable development. Sustainable transportation is usually defined as the attempt to have transportation that -like the sustainable development in gen-

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eral- guarantee the needs and interests of the future generations while considering the environmental issues and economic benefits as well as the social equity within one generation and among coming generations. Apart from the need for the movement and transport, this concept regards the promotion of the health of the human and the environment, economic growth and social equity because the sustainable transportation pays attention to both the movement and access (Deakin, 2003; Zietsman and Rilett, 2002). Sustainable transportation includes the convergence of economic, social and environmental dimensions: (a) economic dimension includes the subjects such as being economic, efficiency, offering different options for the transportation, supporting the competitive active economy, increasing the free movement of the people and commodities, caring about the losses and damages of the car accidents, and caring about the preparation costs and expenses that the consumers have to pay; (b) social dimension includes the accesses and meeting the individual and social needs of the people safely with regard to the health of human and the individuals' quality of life, removing the social poverties and the effects of probable inequities and the probable disadvantages of the movement, mutual relation between the livability of the neighborhoods and transportation with regard to the equity within the generations and between the individuals; (c) environmental dimension includes the attention to the air and water pollution, reducing the production of greenhouse gases, using recycling energies, paying attention to the effects of transportation on the hydrology and reduction of the animals and local plants in transportation (Litman and Burwell, 2006; Boschmann and Kwan, 2008; Goldman & Gorham, 2006; Centre for Sustainable Transportation, 2002). In order to have a better understanding of the sustainable transportation we can compare it with the common transportation Table 1.

Nowadays, the transportation problems have come to be a big challenge for the governments. With regard to the important and permanent effects of the transportation on the economic, social and environmental dimensions of the sustainable development, the transportation is now a critical and crucial necessity for achieving the urban sustainability. Today's global attitude are moving mainly toward the systems of transportation that are effective and efficient so that the effectiveness and efficiency of the transportation is now one of the

preconditions of achieving the economic development; and the desirable movement of the travelers and commodities is now one of the requirements of the modern society (Rodenburg et al., 2002; Asian Development Bank, 2010). Yigitcanlar believe that the necessity of using sustainable transportation encompasses four main subjects: a) environmental pollutions, especially the air pollution that results from the consumption of fossil fuels; b) social problems resulting from the traffic load and rush; c) principle of safety with regard to the car accidents that lead to the mortalities; d) the necessity of relation between the transportation system and land uses and preventing the dispersion of the buildings. On the other hand, the Australian Institution of Engineers has introduced 7 reasons for making the rigid policies of sustainable transportation: improving the economy and environment, encountering the costs of the car traffic and its consequent mental problems, reducing the vagueness of pricing the transportation services, lack of resources and the necessity of protecting them, reducing the greenhouse gases, sustainability of the financial mechanisms and the needed costs for building and maintaining the infrastructures in order to minimize the destructive environmental effects of the current pattern of energy consumption (Yigitcanlar, et al., 2008; Institution of engineers, november, 1999).

Shiraz is one of the Iranian metropolises that face both general and particular problems of the urban transportation. The general problems include the air pollution, heavy traffic load, high time and financial expenses of traffic management, unequal accesses, social inequity, ignoring the side-walker citizens, etc. all of which show the lack of paying enough attention to the sustainable transportation policies. On the other hand, the particular problems of this city includes the narrow width of the pathways in the central areas of the city, high intensity of the buildings and the focusing on attractive land uses such as the commercial, administrative and medical centers without considering the enough parking lots for such centers, the disability of the structure and physical needs of servicing for the cars that lead to the heavy load of the car traffic. Moreover, the inefficiency of the public transportation and the failure of operationalizing the urban train has increased the people's willingness for using their personal cars and reduced the role of the public transportation in the urban travels. Consequently, since it seems that the

solution for most mentioned problems can be found in the sustainable transportation, it is necessary to realize the indicators and guidelines of the sustainable transportation. The main objective of this research is to introduce the concept and indicators of the sustainable transportation, to define the effective factors on it, and to offer some suggestions for implementing the sustainable transportation in Shiraz.

This study has been carried out in Shiraz of Fars Province of Iran during 2015- 2016.

MATERIALS AND METHODS

An overview of AHP

Multi-criteria decision making is a technic that uses several criteria for the possible assessment instead of relying on just one criterion (Asqarpur, 2011). In multi-criteria technics, the priorities, opinions and preferences of the decision makers and experts are studied through investigating the available options, evaluation criteria, goals and limitations

Table 1. Comparison of the movement-oriented approach of transportation with the access-oriented approach (Kennedy, *et al.*, 2005; Litman, 2003)

Common transportation (movement-oriented approach)	Sustainable transportation (access-oriented approach)
<ul style="list-style-type: none"> ■ Establishing and developing the roads ■ Establishing highways, freeways and ring roads ■ Developing the main roads ■ Planning the land uses after planning the transportation policies ■ Defining and measuring the transportation in terms of numbers of the travels by vehicles 	<ul style="list-style-type: none"> ■ Land use management ■ Emphasizing the intensity and intense development ■ Integration of the land uses ■ Designing the walking roads ■ Transportation villages ■ Transportation in used as a strategy for developing the neighborhoods as an effective element ■ Measuring the transportation in terms of accesses
<ul style="list-style-type: none"> ■ ITS, highways and intelligent machines ■ Online transportation system ■ GPS system for cars ■ Time informational system 	<ul style="list-style-type: none"> ■ Telecommunication advancements ■ Tele-communication ■ Tele-working ■ Tele-shopping
<ul style="list-style-type: none"> ■ Managing the transportation system ■ Using demand management only whenever it is not possible to increase the capacity of roads and parking lots ■ One-way roads ■ Removing the intersections by establishing new and multi-floor streets ■ Removing the parking lots of the street margins ■ Measuring the ramps 	<ul style="list-style-type: none"> ■ Managing the needs for transportation ■ Using the demand management everywhere and increasing the capacities whenever the demand management fails to be effective ■ Using the shared cars and bicycles ■ Optimal use of the parking lots ■ Managing the parking lots and their pricing
<ul style="list-style-type: none"> ■ Planning the public and private transportation in large scales ■ Railway heavy transportation and using the railways for movement ■ Regional pathways ■ Private pay-toll roads 	<ul style="list-style-type: none"> ■ Planning the public transportation in neighborhood scale ■ Light railing transportation and trams ■ Rental transport-based cars ■ Exclusive streets for walkers and bicycles
<p>Middle level of public participation Limited equity Considering the costs of the local air pollution as the additional costs</p>	<p>High level of public participation Wide extent of the equity while prioritizing non-drivers Considering the costs of the local and global air pollution, damages of the car accidents on the individuals or other users of the roads and other known effects as the additional costs</p>

(Bennui *et al.*, 2007). There are several systems for formulating the multi-criteria decision making. Analytical Hierarchical Process (AHP) is one of the most comprehensive designed systems for making decisions by the multiple criteria because this technic makes it possible to formulate the problem in a hierarchical form. This method makes it possible to analyze the sensitivity of the criteria and sub-criteria. Moreover, since this method is based on the pair comparisons, the judgments and its calculation can be done easily. In this method we can assess the compatibilities or incompatibilities, and this option is a very important advantage of AHP for multi-criteria decision making (Qodsipur, 2011; Bennui *et al.*, 2007). Considering the mentioned advantages of AHP, in this research we have used it as the tool for evaluating the priority of implementing the guidelines of sustainable transportation.

Proposed Methodology

This study follows a descriptive-analytical methodology, while it is an applied research in terms of its objectives. In this regard, we have used the descriptive method for studying the foundations and indicators of the urban sustainable transportation and analytical method for explaining the guidelines of the sustainable transportation and their prioritization for achieving the sustainable transportation in Shiraz. In this study we will review the theoretical literature of the sustainable transportation, its concept and goals, and then we will extract, collect and summarize the indicators of the sustainable transportation based on the mentioned theoretical literature. In the second part of the study, relying on the defined indicators, we will suggest some guidelines. Based on these guidelines we have formulated a AHP-based questionnaire by which we have collected the opinions of 15 experts of the urban transportation of Shiraz to weight and prioritize the suggested guidelines. Finally, we will identify the most important problems of the sustainable transportation of Shiraz to offer some guidelines for the implementation of those guidelines.

Selecting the Sustainable Transportation Goals

The goals of the sustainable transportation -like its concept- are relatively general and vague so that we can claim that the subject and goals of the sustainable transportation are still controversial. Litman and Burwell, (2006) have introduced 5 goals

for the sustainable transportation: environmental compatibility, human health, economic welfare, vertical and horizontal equity, and the social welfare. On the other hand, the European Conference of the Ministers of Transportation (ECMT, 2000) have recognized 9 goals for the implementation and fulfillment of the sustainable transportation including the promotion of the safety, creating the wealth, increasing the accesses, reducing the car traffic, reducing the fears of the pedestrians, protecting the environment, reducing the noise pollution, reducing the spread of the greenhouse gases, and promoting the air quality. Ramani have offered 5 goals for the sustainable transportation including the reduction of the car traffic, increasing the safety of people, increasing the economic opportunities, increasing the value of the investment in transportation projects, and improving the air quality. (Ramani, *et al.*, 2009).

A glance on the mentioned goals in the available literature shows that there is no agreement on the precise goals of the sustainable transportation. This lack of precision and clarity in the goals of the sustainable transportation is mainly the result of the lack of clarity of the sustainable transportation concept itself. For the sake of the objectives of this research, we first collected, classified and summarized the goals of the sustainable transportation. Then in order to define suitable indicators for these goals, we have defined some corresponding objectives in Fig.1.

Selecting the sustainable transportation indicators

Sustainability indicators are indeed some variables that can be measured to show the progress of the sustainability. Thus the first step in knowing the sustainability is to select its indicators. Although there are officially 21 indicators for the sustainable development, but to introduce the transportation indicators we need to match them with the goals of the sustainable transportation. Previous transportation criteria were not comprehensive and inclusive, and the planners used to use the indicators whose measuring was easy. For example, since the measurement of the access indicator is very hard, thus the planners relied on the indicators of car traffic and scale of the movement of people and commodities as their indicator, but these indicators couldn't provide proper information for the access. This is why the expert felt obliged to offer more complete and more comprehensive indicators for measuring



Fig. 1: The goals of the Sustainable transportation

the sustainability of the transportation (Litman and Burwell, 2006). In this research we first review the studies that have investigated such indicators that shows in Table 2.

There are lots of opinions on the effective indicators on the sustainable transportation. Kennedy, *et al.*, (2005) have introduced 6 main indicators including the access, health and safety, effectiveness on the competition and wealth creation, consumption of the national capitals, and production of the (local and global) contaminants. Haghshenas and Vaziri (2012) reviewed 17 researches on the indicators of the sustainable transportation and defined 23 indicators under environmental, economic and social groups among which they used 9 indicators to compare the sustainability of the transportation including the indicators of air pollution, energy consumption, costs of the transportation undertaken by the government, direct costs undertaken by the consumers, indirect costs imposed on the consumers, safety, access, and transportation diversity. Reisi, *et al.* (2014) used 9 indicators to assess the sustainability of transportation in Melbourne including the consumption of unrecoverable energies, spread of

the greenhouse gases (CHG) and other pollutants, the scale of using lands for transportation purposes, losses and damages of the car accidents, mortalities of the air pollution, costs of the car ownership, and costs of the car accidents. Some other researchers have focused on the social dimensions of the sustainable transportation. For example, Boschmann and Kwan (2008) have introduced three indicators –i.e. the social equity, social limitations, and quality of life- as the social indicators of the transportation. They suggested that we have pay attention to the location, scope of the research and the scale of transportation in order to fulfill the sustainability in transportation. On the other hand, Awasthti and Chaugab (2011) introduced 9 indicators for evaluating the sustainable transportation including the access, security, consumers’ satisfaction, traffic level, number of the users, noise pollution, air pollution, fuel consumption, and the relevant costs. Verma, *et al.* (2014) introduced the indicators of the sustainable transportation in relation to the distance of the travels and then weighted those indicators using AHP method to evaluate the transportation policies. Shiau (2012) referred to 10 sustainable transporta-

Table 2: Previous studies on the transportation indicators

NO.	Authors (Year)	References	Sustainable Transportation Index
1	Haghshenas and Vaziri (2012)	Urban sustainable transportation indicators for global comparison	23
2	Awasthi and Chauhan(2011)	Using AHP and DempstereShafer theory for evaluating sustainable transport solutions	9
3	Reisi <i>et al.</i> (2014)	Transport sustainability index: Melbourne case study	15
4	Verma <i>et al.</i> (2014)	Sustainability impact assessment of transportation policies: A case study for Bangalore city	7
5	Shiau(2012)	Evaluating sustainable transport strategies with incomplete information for Taipei City	10
6	Boschmann and Kwan(2008)	Toward Socially Sustainable Urban Transportation: Progress and Potentials	3
7	Litman and Burwell (2006)	Issues in sustainable transportation	23
8	Kennedy <i>et al.</i> (2005)	The Four Pillars of Sustainable Urban Transportation	6

tion indicators in five general groups (including the social, economic, environmental, energy, and financial classes) and the used AHP method to weight them based on the opinions of three groups, i.e. the academic experts, people-based institutions, and official authorities. Litman and Burwell (2006) explained the economic, social and environmental goals of the sustainable transportation and then introduced 23 corresponding indicators of the transportation.

Accordingly, the indicators of the sustainable transportation can be grouped in three main categories (i.e. the socially, economically, and environmentally). It is to be asserted that there is no consensus on the classification of the indicators. Some researchers classify the access under the economic indicators (Litman and Burwee, 2006) while the others put it under the social indicators (Haghshenas and Vaziri, 2012). Moreover, there are several controversies on the indicators themselves and their definition. This problem has caused the cost indicators (8 indicators) are defined under the economic indicators each of which aims to measure the financial burden that is carried by the people and government; on this problem has led to the multiplicity of the social indicators so that we can find several new indicators in every research, while this multiplicity can make us confused when we want to select the

suitable indicators. The summary of the studied researches of the literature are shown in Table 3.

In this step, we selected 23 indicators among those introduced in previous studies in order to come to guidelines for fulfilling the sustainable transportation. The main reason of selecting these indicators has been their relation or correspondence with the objectives or micro-goals of the sustainable transportation. Moreover, another important factor for selecting these indicators has been their inclusiveness and their close relationship with the urban management and planning rather than the number of their repetition in previous studies. Thus if an indicator has been repeated lower times in the literature but it is effective on the improvement of other indicators we have selected it to be inserted in our list of indicators. For example, although the indicators such as the promotion of the integration of land uses, intelligent growth, planning for non-motor vehicles and planning for non-drivers are seen only once in previous studies, but we have selected them because they are effective on the improvement of other indicators such as the reduction of air pollution, reduction of the noise pollution, and the reduction of the expenses of the families. Table 4 shows the selected indicators and their definitions. Table 5 explains the reason of selecting the mentioned indicators.

Table 4: Selected indicators of the research and their relevant definitions

Pillar	Indicator	Determinants	preference
Environmental	air pollution	Per emissions of CO ₂ and other climate change emissions	↓
	Other air pollution	Per capita emissions of CO, VOC, NO _x , particulates, etc.	↓
	Noise pollution	Population exposed to noise >55 dB (A)	↓
	Land Consumption	Land consumption for transportation infrastructure (private, public) per capita	↓
	Energy consumption	Transport energy use per capita	↓
Economical	commuting	Average commute travel time	↓
	land use mix	Number of job and commercial services within 30-minute travel distance of residents	↑
	smart growth	Implementation of policy that lead to more accessible, clustered, mixed, development	↑
	public transport	Access to public transport (population served by public transit)	↑
	Freight efficiency	Speed and affordability of freight and commercial transport	↑
	Mobility	Average level of congestion in the area under study	↑
	Consumer direct cost	Average daily user cost over GDP per capita	↓
	Consumer indirect cost	Average time spent in traffic	↓
	Affordability	Portion of expenditures devoted to transport by 20% lowest-income households	↑
	congestion levels	Average level of congestion	↓
	Transport diversity	Sum of transportation options divided per maximum of that option (per capita)	↑
Social	Safety	Fatality and injured of traffic accidents per capita	↑
	Health and fitness	Percentage of population that regularly walks and cycles	↑
	Community live-ability	Degree to which transport activities increase community liveability	↑
	fairness	Degree to which prices reflect full costs unless a subsidy is specifically justified	↑
	Transport for disabled	Quality of transport for disadvantaged, disabled, children	↑
	Transport for non-drivers	Quality of accessibility and transport services for non-drivers	↑
	Non-motorised transport	Degree to which on non-motorised transport are considered in transportation planning	↑

Table 5: Objectives (or micro-goals) of the sustainable transportation and their relevant indicators

Pillar	Goal	Objective	Indicator
Environmental	Improve the quality of environment	Reduce air pollution	Air pollution Other air pollution
		Reduce noise pollution	Energy consumption Noise pollution
		Reduce land consumption	Land Consumption
Economical	Enhance economical efficiency	Improve transport diversity	Transport diversity Non-motorised transport
		Improve road-based freight movement	Freight and Commercial efficiency
	Improve urban planning	Decreasing direct and indirect costs	Commuting Direct costs Indirect costs
		Increase the efficiency of city structure	Smart growth Non-motorised transport
		Increase the efficiency of land use	Land use mix Non-motorised transport
	Reduce congestion	Improve mobility	Commuting Mobility Public transport Congestion level
Social	Enhance safety and health	Reduce crash rates	Safety
		Increase people activity	Health and fitness Air pollution Other air pollution Energy consumption Non-motorised transport
	Enhance fairness and equity	Improve affordability	Affordability Fairness(pricing) Transport for disabled Transport for non-drivers
		Improve accessibility	Access to public transport Non-motorised transport Transport for disabled Smart growth
	Improve Social welfare	Enhancing the quality and vitality	Community liveability Non-motorised transport

RESULTS AND DISCUSSION

Selecting the sustainable transportation guidelines

Kennedy, *et al.* (2005) believes that the sustainable transportation has four main axes including the government (integrated planning for transportation and land uses), financial issues (sustainable, sufficient and justice-oriented financial mechanism), ur-

ban infrastructures (investment in important urban infrastructures) and neighborhood development. With regard to his introduced 10 indicators, Shiau (2012) have offered some planning guidelines based on the global codes and standards. His guidelines include the improvement of the access of dis-

able and old people, decreasing the distance of the travels, reducing the number of travels, reducing the use of personal cars, using the public transportation and electronic vehicle, and using clean and biomass fuels in order to achieve the goals of the sustainable transportation. Xenias and Whitmarch (2013) have offered some guidelines for promoting the public transportation, pricing the transportation services, promoting the facilities for walking and bicycling, using the new technologies and fuels in the automobiles, planning the land uses, using the government-responsible policies, public training for the citizens, etc. Using the AHP method, they have studied the priority of these guidelines from two different perspectives, i.e. the public people and the experts.

Moreover, the transportation policies of Europe that is known as the Common Transport Policy have been revised several times during 1992-2010 and have recommended several crucial strategies for the Europe and European economy. These strategies include the safety, protecting the environment, fair and effective pricing, efficiency, accessibility, competitiveness, and paying attention to the socio-economic issues. These policies follow three main approaches, i.e. the environmental, displacement, and socioeconomic approaches each of which has its own indicators: (a) environmental approach: level of the energy consumption, air pollution, water pollution, noise pollution, level of carbon dioxide; (b) displacement approach: increasing the physical access to the workplaces, medical centers, educational centers, etc.; (c) socioeconomic approach: optimal use of the resources with regard to the capital return, the access of all people to the transport, particularly to the public transportation system (Rodenburg, et al., 2002). Deakin (2003) has offered three general strategy for achieving the sustainable transportation: (a) technological changes of the fuel and motor vehicles (increasing the efficiency of the vehicles, using new technologies in the vehicles, and using new fuels); (b), improving the performance of the roads and cars (promoting the traffic stream, promoting the intelligent transport system, training the drivers, promoting and managing the transport system); (c) demand management (replacing the transportation modes, using telecommunication devices, pricing, management of the land uses). On the other hand, Shiftan, et al. (2003) classify the administrative factors of the sustainable transportation into 5 general

groups including the spatial pattern and land use, paying attention to the economic forces, using the technology, and paying attention to the social behaviors and willingness of the people. They believe that these factors have a mutual effect on each other.

The investigation of the mentioned guidelines and strategies shows that different experts have different and exclusive attitude to the sustainable transportation and consequently to the guidelines of achieving this concept. Some of them have focused on the urban planning as the guideline for reducing the distance and number of the urban travels (Shiau, 2012; Deakin, 2003), some have emphasized on the social issues (Shiftan et al., 2003) and some other believe that the economic dimension of the problem is the most important dimension of the subject (Litman and Burwell, 2006). Considering the selected indicators (as mentioned in section 2.3) and the tendency for increasing or decreasing these indicators, in this research we have selected some guidelines. It is to be noted that it is possible to consider several guidelines for improving a single indicator. Moreover, considering the

types of the indicators, we have selected the guidelines that are placed under the scope of the local government (municipality) tasks. Fig.2 shows the relation between the goals, indicators and guidelines.

Case study

As the most prominent city of southern Iran, Shiraz has been open to a considerable natural growth of population and hosting the immigrants in recent decades. Consequently this city has been faced to the increasing rate of urbanism and increasing need for the houses and services and the generation of the urban lands, so that its population has reached from 170,065 individuals (1956) to 1,418,585 citizens (2014) and the area of the city has increased along with its population growth so that its area has increased from 22.77 km² (1956) to 17889.1 km² (2014) But the question is whether the population and urban areas have been increased along with the improvement of Shiraz transportation based on the desirable standards, suitable guidelines and needed activities. The studies show that the increase of Shiraz population on one hand, and the limitation of the natural settings (capacity) of the city on the other hand have led to the linear growth of the city. Indeed Shiraz is surrounded by Baba Kouhi Mountains from the north, Sabzpoushan Mountains from the south, and

Maharlou deserts from the east. Maharlou deserts are connected to the underground waters whose water level is very high and thus the city cannot be developed eastward. Consequently, the best direction for the development of building and construction of the city is the west and northeast.

Hence the natural factors and the lack of proper management by the urban authorities are the main factors of intensity of traffic and movements

in some limited streets that connect the north and south of the city to each other and cause heavy car traffic there. The shortage of the main streets and roads that connect the east to the west, along with the tiny role of the bus services on the daily travels, failure of operationalizing the urban rail (metro services), the single-core nature of the city structure, marginalization, the extension of the neighborhoods in the margins of the city, etc. are the main

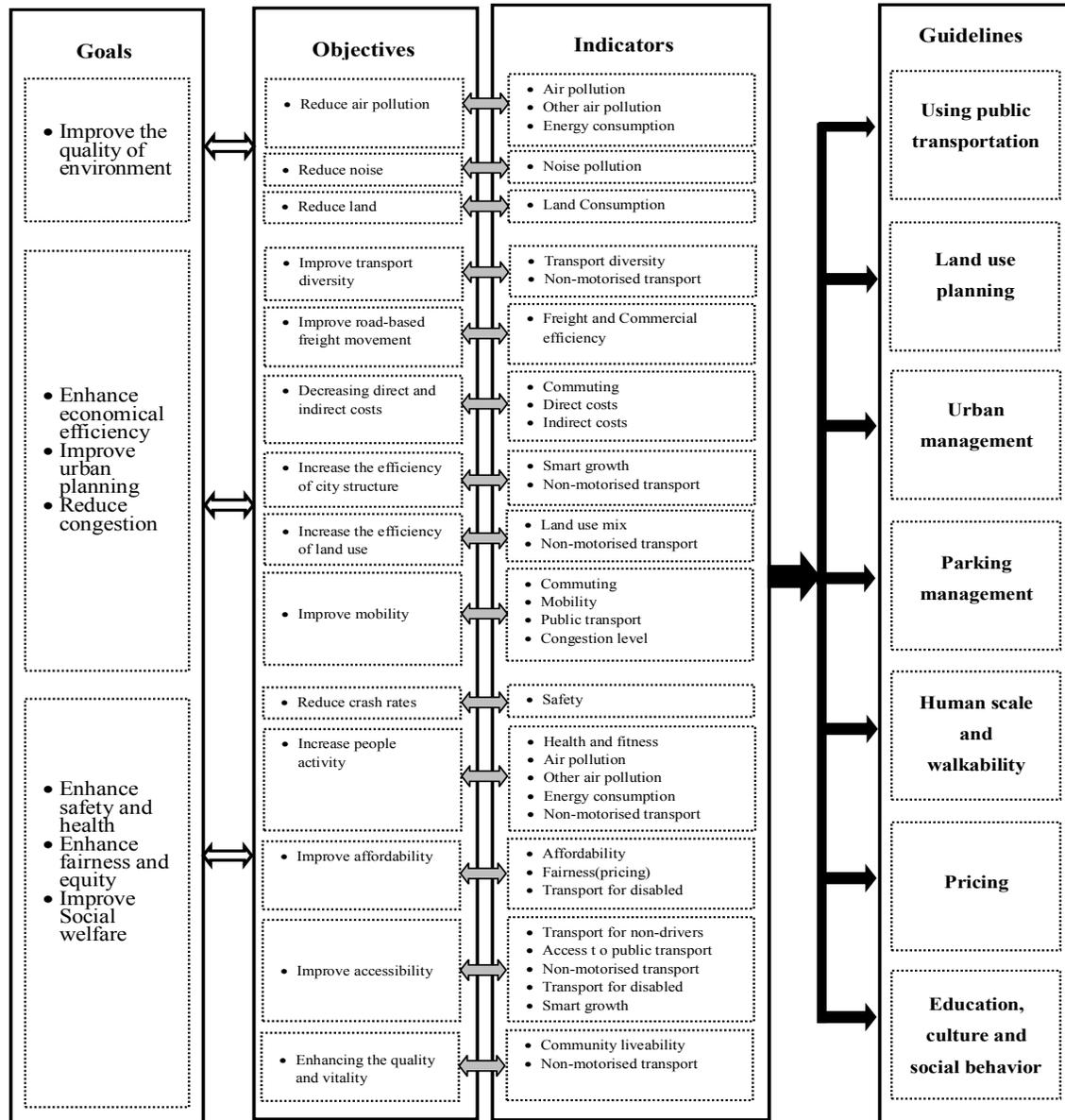


Fig. 2. Conceptual model of the research

problems and challenges of the transport in this Iranian metropolis. By and large, the most important problems of Shiraz transportation can be classified in the following categories: (a) the heavy traffic load of the city and the low level of the services (the increased demand for transport, lack of suitable solution for the heavy traffic of the city, and the low level of services, particularly at the rush hours of the day); (b) lack of coordination between the transportation system and the spatial land uses; (c) lack of coordination between the authorities and their disagreement on the suitable transportation system; (d) unsuitable public services such as the delays, lack of time schedule, shortage of the public transport vehicles in some regions of the city, and lack of using different public transport options; (5) destructive economic, social and environmental effects due to the urban transportation.

Selecting the experts

Considering the subject of this research that is related to the issues of the sustainable transportation, we have selected mainly those experts for completing the questionnaires who are working in transportation-related departments of Shiraz municipality. In this regard, we referred to 10 experts or managers of the relevant deputy or organization of transportation in Shiraz municipality. The educational level of these experts was bachelor degree (except two masters). Moreover, five MA students of urban planning were asked to complete the questionnaires. These 15 experts who were familiar with the transportation problems of Shiraz were used in this research.

Application of AHP

In this step of the research, based on the formulated objectives of the research and in order to determine the strategic priorities of the sustainable transportation, we focused on the main factors of the sustainable transportation and the solution for their application and inserted them in a questionnaire as the pair comparison and then we asked the experts of the urban transportation to complete the mentioned questionnaire. The questionnaire contained 7 guidelines including the guideline for public transportation, transportation and land uses, urban management, parking management, human-orientation and walking-orientation, pricing, and social behav-

iors and culture, along with the 34 subgroups.

- A) Public transportation: in this category, the following items were proposed: desirability and efficiency of the coverage of bus system, desirability of the walking to the bus stations, the connection between the bus and taxi lines, desirability of the social prestige of the bus, desirability of the location of the bus stations and terminals, diversity of the public transportation items, the management of the arrival times of buses to the stations, the number of the buses, and minimization of the travel distances.
- B) Transportation and land uses: in this category, five items were formulated as follow: the relationship between the land uses and the route of the bus lines, the traffic effects of the land uses on the main street, management of the land separating system, integration of the land uses, service hierarchy and accessibility in the urban plans.
- C) Urban management: the items of this category of sustainable transportation are as follow: the governmental support of the promotion of public transportation systems, managing the demands for travels, employing the experts in the organizations that are related to the urban issues, efficiency of the municipality regulations, providing electronic services by the public and private institutions, managing the traffic load, efficiency of the traffic police.
- D) Parking management: the solutions and guidelines of this category are as follow: desirability of the capacity of public parking lots, desirability of the location of parking lots, using the marginal parking lots in crowded land uses such as the commercial centers, medical centers, etc.
- E) Human-orientation and walking-orientation: 5 items were proposed for this category as follow: desirability of the location and number of the pedestrian bridge, desirability of the quality of sidewalks for the pedestrians, elder people, disable people and children, covering suitable pathways for walking and bicycling round the city, desirability of the facilities for the pedestrians (benches, canopy, etc.), efficiency of the municipality regulations and traffic police rules for reducing the speed of the cars.
- F) Pricing: the guidelines of this category are as follow: using incentive policies for encouraging the people to use the public transportations,

constraining policies for minimizing the use of personal cars in the city center.

- G) **Social behaviors and culture:** in this category, the following guidelines were proposed: public awareness about the environmental problems of cars, culture of respecting the traffic rules and respecting the right of the others, culture of planning the chain travels instead of single-purpose travels, making the people willing to use the electronic and internet services.

The results show that the most important factor for the experts has been the factor of “land use” that has obtained score 0.320. The next important factors were as follow respectively: “public transportation” (0.226), “urban management” (0.173), “human-orientation and walking-orientation” (0.102), “social behaviors and culture” (0.090), “parking management” (0.058), and “pricing” (0.030).

Then, in each of the mentioned factors of sustainable transportation, the criteria were compared and weighted in pair and the score of each guideline was calculated in each category to specify the most important guidelines:

- **Public transportation:** (1) desirable and efficient coverage of the bus system around the city (0.238), (2) diversity of the public transportation items (0.198), (3) desirable location of the bus stations and terminals (0.140), (4) suitable connection between the bus and taxi lines (0.124), (5) minimization of the travel distances (0.102), (6) Desirable distance to the bus stations (0.079), (7) management of the arrival times of buses to the stations (0.071), (8) promoting the social prestige of the bus (0.140).
- **Transportation and land uses:** (1) service hierarchy and accessibility in the urban plans (0.333), (2) the traffic effects of the land uses on the main street (0.218), (3) integration of the land uses (0.218), (4) management of the land separating system (0.170), (5) the relationship between the land uses and the route of the bus lines (0.061)
- **Urban management:** (1) employing the experts in the organizations that are related to the urban issues (0.235), (2) efficiency of the municipality regulations, governmental support of the promotion of public transportation systems (0.213), (3) managing the demands for travels (0.163), (4) efficiency of the traffic police (0.154), (5) efficiency of the electronic services by the public

and private institutions (0.104), (6) managing the traffic load (0.66).

- **Parking management:** (1) desirability of the location of parking lots (0.632) (2) using the marginal parking lots in crowded land uses such as the commercial centers, medical centers, etc. (0.216) (3) desirability of the capacity of public parking lots (0.151).
- **Human-orientation and walking-orientation:** (1) covering suitable pathways for walking and bicycling round the city (0.310), (2) efficiency of the municipality regulations and traffic police rules for reducing the speed of the cars (0.245), (3) desirability of the quality of sidewalks for the pedestrians, elder people, disable people and children (0.242), (4) desirability of the urban furniture for the pedestrians (0.114), (5) desirability of the location and number of the pedestrian bridge(0.089).
- **Pricing:** (1) using incentive policies for encouraging the people to use the public transportations (0.680), (2) constraining policies for minimizing the use of personal cars in the city center (0.320)
- **Social behaviors and culture:** (1) culture of respecting the traffic rules and respecting the right of the others (0.401), (2) making the people willing to use the electronic and internet services (0.273), (3) culture of planning the chain travels instead of single-purpose travels (0.229), (4) public awareness about the environmental problems of cars (0.097).

Finally, the weights of the factors were multiplied in the weight of the guidelines to obtain the final score of each factor. The results showed that the most important guideline is the “service hierarchy and accessibility in the urban plans” (0.107) and the less important ones are the “public awareness about the environmental problems of cars” (0.009), “desirability of the location of parking lots” (0.009) and “desirability of the capacity of public parking lots” (0.009), that it shows in [Table 6](#).

Based on the obtained scores of the “matrix of evaluating the guidelines of sustainable transportation using AHP model”, we can prioritize the suggested guidelines for the sustainable transportation in Shiraz and introduce 10 guidelines (out of total 34 guidelines) as the acceptable and most interesting guidelines that it shows in [Table 7](#).

Table 6: Matrix of evaluating the guidelines of sustainable transportation using AHP model

Guideline	Factor Weight	Priority	Subset of the guidelines	Weight of the guideline	Priority of the subset in relevant guideline	Final score	Final priority
Public transportation	0.226	2	<i>Desirable and efficient coverage of the bus system around the city</i>	.238	1	.054	3
			<i>Desirable distance to the bus stations</i>	.079	6	.018	15
			Suitable connection between the bus and taxi lines	.124	4	.028	9
			Promoting the social prestige of the bus	.049	8	.011	20
			Desirable location of the bus stations and terminals	.071	3	.032	8
			Management of the arrival times of buses to the stations	.140	2	.045	4
			Diversity of the public transportation items	.198	7	.016	16
			Minimization of the travel distances	.102	5	.023	12
Land uses	.32	1	The relationship between the land uses and the route of the bus lines ()	.061	4	.020	14
			The traffic effects of the land uses on the main street	.218	2	.070	2
			Management of the land separating system	.170	3	.054	3
			Integration of the land uses	.218	2	.070	2
			Service hierarchy and accessibility in the urban plans	.333	1	.107	1
			Governmental support of the promotion of public transportation systems	.163	3	.028	9
Urban management	.173	1	Managing the demands for travels	.154	4	.027	10
			Employing the experts in the organizations that are related to the urban issues	.235	1	.041	5
			Efficiency of the municipality regulations	.213	2	.037	6
			Efficiency of the electronic services by the public and private institutions	.085	6	.015	17
			Managing the traffic load	.066	7	.011	20
			Efficiency of the traffic police	.104	5	.018	15
Parking management	.058	6	Desirability of the capacity of public parking lots	.151	3	.009	22
			Desirability of the location of public parking lots	.632	1	.037	6
			Using the marginal parking lots in crowded land uses such as the commercial centers, medical centers, etc.	.216	2	.013	18

			Desirability of the location and number of the pedestrian bridge	.089	5	.009	22
			Desirability of the quality of sidewalks for the pedestrians, elder people, disable people and children	.242	3	.025	11
Human-orientation and walking-orientation	.102	4	Covering suitable pathways for walking and bicycling round the city	.310	1	.032	8
			Desirability of the urban furniture for the pedestrians (0)	.114	4	.012	19
			Efficiency of the municipality regulations and traffic police rules for reducing the speed of the cars	.245	2	.025	11
Pricing	.03	7	Using incentive policies for encouraging the people to use the public transportations	.680	1	.020	14
			Constraining policies for minimizing the use of personal cars in the city center	.320	2	.010	21
			Public awareness about the environmental problems of cars	.097	4	.009	22
Social behaviors and culture	.09	5	Culture of respecting the traffic rules and respecting the right of the others	.401	1	.036	7
			Culture of planning the chain travels instead of single-purpose travels	.229	3	.021	13
			Making the people willing to use the electronic and internet services	.273	2	.025	11

Table 7: Top 10 guidelines for the sustainable transportation in Shiraz based on the experts' opinions using AHP model

Guideline	Priority
Service hierarchy and accessibility in the urban plans	1
The traffic effects of the land uses such as the educational and medical centers Integration of the land uses	2
Management of the land separating system Desirable and efficient coverage of the bus system around the city	3
Diversity of the public transportation options	4
Employing the experts in the organizations that are related to the urban issues	5
Efficiency of the municipality regulations Desirability of the location of public parking lots	6
Culture of respecting the traffic rules and respecting the right of the others	7
Covering suitable pathways for walking and bicycling round the city Desirable location of the bus stations and terminals	8
Suitable connection between the bus and taxi lines Governmental support of the promotion of public transportation systems	9
Managing the demands for travels	10

CONCLUSION

Shiraz is a city surrounded by the natural constraints in a linear form. Thus the transportation planning for this city is vitally important. The north-south extension of the city has constrained it and has caused the city has a few limited crowded north-south streets with heavy car traffic. Currently, the main option for the public transportation in Shiraz is the bus system that is not efficient and qualified enough to meet the needs of the citizens, while the urban taxi services lack the exclusive lines for their movement and their organization is not suitable increasing the traffic problems. Moreover, the lack of suitable and safe infrastructures for the bicyclers and pedestrians has made the citizens don't welcome non-motor vehicles in Shiraz. The methodology of this research was descriptive-analytical aiming at studying and evaluating the situation of the indicators of sustainable transportation and to prioritize the suggested guidelines for the sustainable transportation in this city. Accordingly, a questionnaire was designed for collecting the needed data about the situation of transportation in Shiraz based on the available literature. After designing the questionnaire, we weighted and prioritized the guidelines using AHP model. The obtained results of the analyses showed that among the top ten guidelines of the application of sustainable transportation, three guidelines were related to the category of land uses. This finding shows the close relationship between and the effects of the land uses on the transportation. This is while the highest score was obtained for the hierarchy of services and accessibility in the planning. This guideline is especially important because its implementation leads to the fulfillment of other guidelines such as the management of the demands for travel, paying attention to the walking-orientation, increasing the accessibilities, achieving social equity, and reduction of the environmental pollutions. Although the guidelines of the land uses have obtained the highest scores, but among the prioritized guidelines we have to note that the guidelines of the urban management have had the highest contribution, while the most important guideline of this category belonged to the employment of experts in the urban management organizations. The scores and priorities of this area specifies the role of specialty in the urban authorities in making proper and effective policies for preventing the traffic problems by regulating ef-

ficient rules and promoting the public transportation system in order to manage the demands for urban travels. Moreover, among the top ten guidelines we have to pay especial attention to the guidelines that are related to the public transportation because they have a profound effect of the policies of this area on the sustainability of transportation. This solution requires the attention of the urban authorities to the public transportation and to promote this system both qualitatively and quantitatively. On the other hand, as shown in the relevant tables of scoring the guidelines, the least priority belongs to the policies of pricing, particularly the constraining policies. In other words, the constraining policies will not work properly and the people will keep using their personal cars unless other requirements of sustainable transportation (such as the land uses and public transportation) are efficient. Based on the obtained results of this research we can offer the following suggestions for applying and implementing the sustainable transportation in Shiraz:

- To organize the land uses, especially the crowded land uses in the current contexts of the city and to create cluster land uses
- To pay more attention to the hierarchy of services and accessibilities and marginal land uses of the streets in constructing new contexts and neighborhoods
- To prioritize the qualitative and quantitative promotion of the public transport system instead of widening the streets or building interchanges that requires huge amounts of money and budget. If the authorities prioritize the promotion of the public transport system, then the social and physical accessibilities will be increased, the pollutions will be reduced, and the safety and security of the pedestrians (including the children, elder people, disable people, etc.) will be supplied with regard to the human-oriented and walking-oriented objectives.
- To impose some rules for limiting the movement and park in the center of the city along with paying simultaneous attention to the promotion of an efficient public transport system, making the needed infrastructures for walking in the attractive land uses, reducing the traffic load of the crowded parts of the city, and establishing ring road round the city to reduce the car moving traffic to the internal streets of the city.

- Establishing dead-end streets in the residential areas of the city in order to reduce the car traffic and increasing the safety of citizens in these areas.
- Promoting the social behaviors and culture of the public through training the people about the traffic behaviors, environmental pollutions and their own role in reducing the urban travels.
- Using the intelligent systems for controlling the urban traffic, using geographical information system (GIS), etc.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interests regarding the publication of this manuscript.

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