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Research Paper

Sustainability Analysis of Urban Transportation Network Based on the Determination of the Relative Importance of Evaluation Criteria

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Abstract

There is rising agreement that transportation systems are perfectly capable of linking economic development, environmental integrity, and social quality of life. Meanwhile a wide range of research clearly shows that transportation systems are unsustainable in most of the cities and urban areas. In practice, there are numerous transportation systems which are able to pose serious threat to the environmental, social and economic aspects of future generations. Therefore, a truly sustainable urban transportation network is definitely one of the most pressing need of cities and urban centers, particularly in developing countries. Thus identifying the evaluation criteria and determining their importance are critical. While most researches have only focused on economic or environmental aspect of transportation systems, in this paper, by considering economic, social and environmental dimensions, the evaluation criteria for evaluating the sustainability of urban transportation network have been discerned. Furthermore, a framework based on a goal programming model for Best Worst Method (BWM) has been proposed to evaluate and prioritize sustainability dimensions and evaluation criteria. In order to demonstrate the utility of the proposed model, it is employed to a real-world case study of transportation in Yazd, one of the most important cities in Iran and the first Iranian historic city. The results of this study are applied to evaluate, prioritize and select real transportation projects. Moreover, it is demonstrated how the proposed framework could assist urban managers in analyzing sustainability of existing instances, formulating effective strategies, evaluating and selecting coherent policies or even constructing projects to accomplish sustainability goals.

Keywords: Sustainability, Sustainable transportation network design, urban transportation, Multi criteria decision making, Best worst method

1. Introduction

An overview of transportation systems obviously demonstrates that the conditions of people mobility in entire world is disappointing and certainly without a serious correction and preventive measures is able to provoke a major crisis. Transportation along with employment, housing and leisure is one of the four main functions of towns & cities. There are some noted features and characteristics for a perfectly satisfactory urban mobility system such as availability, accessibility, affordability, acceptability, safety to name but a few. Therefore, the transportation system has been perceived as the most essential factor to fulfill the economic and social needs of urban residents.

Since about 25% of the world's energy have consumed in urban and intercity transportation as a very significant criterion of urban sustainability. The positive effects of transportation on economic prosperity and development are quite obvious, however at the same time, bad management of the urban transportation system, definitely have irreparable negative effects on society, including: greenhouse gas emissions, mortalities and severe disabilities, considerable increasing stress to name but three. Researchers are constantly striving to improve the performance of transportation systems and achieve sustainable goals as much as possible by implementing new policies or utilizing new infrastructure.

The right choice of a new policy or project in urban transportation systems for the urban sustainability is the most challenging and complicated problems in designing a sustainable urban transportation network for researchers and decision makers which is largely because of the multiplicity of objectives and evaluation criteria and various limitations including: financial, technical and operational and also the plurality of stakeholders. For this purpose, it is necessary to identify the criteria for an urban transportation network stability analysis and to determine the importance of each criterion firstly. The relative importance of each criterion, as well as each sustainability dimensions, is able to improve received wisdom of managers / experts in their conscious decisions, a point that is the main focus of this study.

In the first step, by reviewing the literature, a list of indicators and evaluation criteria has been assembled. Then by using a goal programming model for Best Worst method (BWM), as a novel multi criteria decision making method, a framework for evaluating importance of criteria and prioritizing them, has been recommended. Using survey data from a sample of transportation experts/managers, academic experts and network users from different areas of Yazd (a city in Iran), the suggested framework has been employed to evaluate the criteria from three different points of view. Then a comprehensive analysis and some suggestions have been offered to significantly improve the performance of Yazd’s urban transportation network. Eventually, the results have been employed for evaluating, project prioritizing and selecting the real transportation projects in Yazd.

Focusing on urban transportation network of Yazd, and the users’, academic experts’ and transportation managers and experts’ point of view, in this article, we especially employ a goal programming model for BWM to answer the following research questions:

1. which criteria should be considered in evaluating the stability of urban transportation networks?
2. Which of the three dimensions is more important and what is the relative importance of each dimension?
3. Given the criteria in each dimension, how important is each criterion?

4. What is the relative importance of each criterion compared to other criteria and in different dimensions?
5. Is it possible to create a sustainable framework for urban transportation system and is it logically acceptable to improve the performance of an existing transportation network based on increased sustainability?
6. Based on the results of this study, which project should be selected and constructed as a real transportation project?
7. Are there any significant differences between users and transportation managers' viewpoint?
8.What are the practical and managerial results of this study?

First, in order to identify the criteria that can be analyzed in the economic, social and environmental dimensions, the literature related to the sustainable urban transportation network is surveyed, then using a target programming model for the best-worst BWM method and based on survey data, the relative importance (weight) of each dimension and criterion have been acquired.

This paper is generally organized in 9 sections: first section is related to the introduction and subject statement. A review of the relevant literature and current practices is provided in Section 2. Section 3 presents the proposed study method. The actual and operational case is discussed in Section 4. The data collection and setup are demonstrated in section 5. The results, relevant analysis and recommendations are shown in Section 6. Evaluation of candidate projects based on the results of the study has been used in Section 7. In section 8, a few practical suggestions about Sustainable development policy are put forward. Lastly, section 9 demonstrates an obvious conclusion.

2. Literature Review and Current Practices

Sustainability is a normative concept that stresses intergenerational equity and is commonly considered to have three dimensions: the environmental, economic and social dimension. The concept can be used to guide decisions at all scales: at the global, national and individual consumer level scale. Sustainability is a strategy to achieve development without compromising with the ability of our future generations to fulfill their needs.

In fact, urban sustainability and global sustainability are the same with identical concept. Accordingly, given the inherent complexity of cities and the various aspects of their impacts, the adoption of successful measures in line with the goals of sustainable development requires a comprehensive approach. Efforts to promote urban management and sustainable development is able to define as balancing environmental, economic and social issues. Which is firmly depend on a vast knowledge about saving and conserving energy resources along with improving the economic growth, social satisfaction and responsibility. In other words, Sustainability is the balance between the environment, equity, and economy. Weak sustainability, or sustainable development, presents the environmental, social, and economic themes with equal weighting and seeks to balance them. This image was developed based on the Brundtland Report and was widely disseminated. Strong sustainability, with a focus on systems, presents the three themes as nested and confers different sizes and weightings to them. This model was presented by [Giddings, Hopwood, and O'brien, 2002] and is a complete form of the definition of sustainability and sustainable development was presented in the Brontland Commission in 1987, which defined sustainability development as: "a development which tries to meet humans' present needs without compromising the ability of future generations to meet their own needs" [Brundtland et al. 1987]. Sustainability is defined in three primary dimensions: social, environmental, and economic. Both definitions simply reflect the fact that a truly sustainable system requires sustainability in all three dimensions. As shown in [Figure 1].

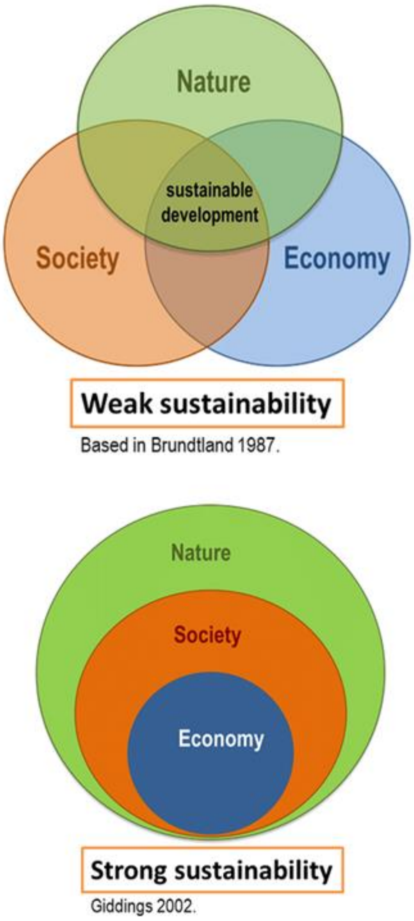

Figure 1. Weak and strong sustainability

A continuous improvement in 2018 by [Hu, 2018], developed a pyramid model of sustainability concept which generally signifies about the three aspects of the sustainability development such as environment, social and economic. The bottom-up approach of this pyramid generates a message of having stepwise decisions to achieve the goal of sustainability. This kind of pyramid model has became an integral part of the planning process for establishing a sustainable means of transport system. [Figure 2] depicts the pyramid model which is developed by [Hu, 2018] an important model for planning authorities. Considering the coherent and sustainable urban structure consisting of the citizen, urban management and urban districts, each components has undoubtedly a great role to achieve sustainability with their functions where the urban management is the noted one. thus, in the process of sustainable development, achieving a sustainable urban transportation network by considering the proper social, economic, and environmental impacts based on affective indicators is certainly possible which is able to directly affect people lifestyle, a point that should be actively pursued by urban transportation managers and policy makers.

Figure 2. Pyramid of sustainability

The Council of Transport Ministers of the European Union adopted a more expansive definition of sustainable transport in April of 2001. This approach, an adaptation of an earlier proposal by the Centre for Sustainable Transport (CST) in Toronto, sees sustainable transport as a system that:

- “Allows the basic access and development needs of individuals, companies and societies to be met safely and in a manner consistent with human and ecosystem health, and promises equity within and between successive generations.
- Is affordable, operates fairly and efficiently, offers choice of transport mode, and supports a competitive economy, as well as balanced regional development.
- Limits emissions and waste within the planet’s ability to absorb them, uses renewable resources at or below their rates of generation, and, uses non-renewable resources at or below the rates of

development of renewable substitutes while minimizing the impact on land and the generation of noise." [Rahman A et al. 2005].

Recently, numerous researchers have focused on the design, evaluation and development of sustainable urban transport networks.[Marek ogryzek and klimach, 2020] represented sustainable transport principles and general guides that can lead cities towards a more efficient transportation network. They also demonstrate good practice used in different urban areas, such as London and Copenhagen. Moreover, Vilnius was analyzed for its sustainable transportation instructions and mobility. All analyses and recommendations were based on using geographic information system (GIS) tools. They showed that pricing is a dominant tool to control the trip patterns in urban areas. [Mahmudi et al. 2019] considered economic, social and environmental dimensions; they evaluated the sustainability of Isfahan urban transportation network based on Best Worst Method. In this study the results have been applied to evaluate and select real transportation projects. [Sinha, 2003]. surveyed the relationship between urban public transportation and sustainability. He mentioned that for accomplishing a sustainable situation in urban TSs, use of private vehicles must be declined and the users must be encouraged to use public transportation systems. They just employed statistical methods to analyze historical data. They did not recommend mathematical model to make decision and did not consider major criteria such as accessibility and spatial equity, etc. [Basbas and Politis, 2008] analyzed the influences of different pricing strategies on the users' behavior, traffic volume, environmental impacts, etc., in the city center of Thessaloniki, Greece [see also Wann-Ming, 2019]. [Li, Zhao, and Suo, 2014] used Shannon Entropy and the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) and considered nine main criteria to evaluate sustainable development of highway transportation capacity in China [see also Zhang et al. 2018]. Their study explained that "rate of cement highway to administrative villages" was a paramount criterion for the sustainable development of highways. They just analyzed the performance of a highway transportation network, not an urban transportation network. Considering some restrictions and criteria in probability form, [Wang et al. 2015] highly developed a bi-level model to solve the sustainable urban transportation network design problem. Their numerical analysis demonstrated that travel time reliability seriously affects network reserve capacity and optimal design solution. Although they perceived emission as an environmental constraint, they did not consider numerous significant criteria and different perspectives in their modeling. [Szeto et al. 2015] suggested a multi-objective bi-level optimization model to design a sustainable road transportation network. They carefully considered all three sustainability dimensions and developed an artificial bee colony algorithm to solve the proposed model. [Cheshmehzangi and Thomas, 2016] prioritized different transportation systems in Mumbai to accomplish sustainable urban development. They proposed some short/long term suggestions to policy makers to improve the performance of existing TSs. Considering sustainability indicators; [de Almeida Guimarães and Leal Junior, 2017] evaluated eco-efficiency of urban passenger transportation system in Rio de Janeiro (Brazil) and suggested some decisive actions to improve the performance. Considering only service value and environmental impacts, they just evaluated the passenger transportation system, not the whole network. [Mansourianfar and Haghshenas, 2018] analyzed the impacts of different infrastructure projects on the sustainability of an urban transportation network. They considered nine construction scenarios, simulated the network under each scenario and then compared the results. . [Oses et al. 2018] developed a Multi-Criteria Decision Making (MCDM) method to thoroughly investigate sustainability of urban transportation networks by local governments. They only considered the mangers perspective and employed their proposed method for performance evaluation of urban transportation network of different metropolitan areas in Donostia-San Sebastian to recognize weaknesses in each area. [Areej Khairy Othman Alrawi, 2020] in this paper by following the integration policies, the possibility of achieving sustainable transportation in Karbala city studied. By analyzing the reality of the situation and the requirements of policies via SWOT strategic analysis, they reached a policy that is able to be adopted as a policy for sustainable transport. Most studies in the field of sustainability have been based on economic dimensions' criteria and some social and environmental criteria.

Based on the above literature, there have been several studies in the field of evaluation, analyze and design of sustainable transport networks, in many of which multi-objective evaluation methods have been considered to achieve optimal policies however, the identification of evaluation criteria in other dimensions of sustainability is not considered. furthermore, numerous studies have only considered a certain group of people's perspectives, including academics'/managers while users as the main beneficiaries of the urban transport network will certainly play a key role in determining the criteria and priorities. Therefore, in this study, in addition to considering managers' and academic experts' perspectives, users' perspectives are also included.

This study is one of the first studies which has concentrated on identifying, evaluating and prioritizing the evaluation criteria for evaluating the sustainability of an urban transportation network in all environmental, economic and social dimensions by employing the goal programming model for Best Worst Method (BWM). In this study, three different perspectives, including transportation experts as managers of the system, academic experts and users, have been considered. moreover, an attempt has been made to analyze the evaluation criteria and their relative importance in different urban areas based on the characteristics of each area separately. consequently, it is able to employ to make a fully comprehensive decision on upgrading or improving the performance of urban transportation network system.

The proposed procedure for this study is certainly able to be employ to analyze and evaluate the sustainability of a candidate project or to prioritize it in different urban transportation networks. Owing to various sustainable urban transportation networks' criteria which have been considered in numerous studies and reports, lastly, 38 of the most widely used criteria have been demonstrated in Table1.

3. Materials and Methods

The variety of evaluation criteria obviously demonstrates that the multi-criteria decision-making method (MCDM) should be employ to design a sustainable urban transportation network. A method that has been recently developed by many researchers in order to employ it as an ideal solution for many real-world problems. [Farmer Horabai et al., 2018]. As a remarkable and unique point of this study, BWM has been used as one of the latest developed MCDM methods, while the goal programming model for BWM has not been already employed in the sustainable urban transportation network design field.

Certainly, decision-making process becomes more complicated by considering the various evaluation criteria, largely because decision-makers are required to consider all the criteria to make a proper decision. Thus, there are different approaches to achieve the optimal solution in any (MCDM) problem, in all cases the weight of the criteria must be calculated. In the last decade, various methods have been proposed while the best-worst method (BWM) is one of the most popular one [Rezaei, 2015], which has been employed in different areas [Ahmad et al. 2017; Ahmadi, Kusi-Sarpong, and Rezaei, 2017; van de Kaa, Kamp, and Rezaei, 2017].

This method acquires the weights of criteria. The prime idea of BWM is using pairwise comparison of the best with other criteria and the worst with other criteria. Indeed, this idea leads to less pairwise comparison. The BWM provides an appropriate system to reflect DM preferences in final weights. However, for not fully-consistent comparison systems with more than three criteria, there may be multiple optimal solutions. Although multiple optimality may be desirable in some cases, in other cases, decision-makers prefer to have a unique solution.

We employ a novel model proposed by [Amiri and Amamat, 2020], which results in a unique solution. As the proposed model has fewer constraints in comparison with the previous models, we can mention that it involves fewer calculations. The main advantage of applying the proposed model is that we need only $2n - 2$ number of constraints while the previous models had $4n - 5$ number of constraints. This is a great improvement in terms of number of constraints. Compared to other methods, BWM has some advantages as follows:

- This method employs integer numbers for pairwise comparison, it is easy to use in any case.
- The results by this method will be completely reliable owing to the fully consistence of the pairwise comparison data gathered by BWM.
- This method is capable of applying to obtain the weight of the criteria. It is also able to be used with other methods to prioritize alternatives.
- The most obvious advantage of this method is the significant reduction in complexity and needed time for the decision-making process for experts and decision makers. Incidentally, this method requires less pairwise comparison data compared to others.

To obtain the weights of criteria using BWM, [Rezaei, 2016; Amiri and Amamat, 2020], recommended following steps:

Step 1. Determining a set of decision criteria, $C = \{c_1, c_2, \dots, c_n\}$

Step 2. Determining the best (e.g. most desirable, most important) and the worst (e.g. least desirable, least important) criteria.

Step 3. Determining the preferences of the best criteria over all the other criteria. The decision maker (DM) must specify his/her preference by an integer number between 1 and 9, which 1 shows equal preference and 9 shows maximum preference. The Best-to-Others vector would be: $A_{B=(a_{B1,}a_{B2,\dots\dots\dots,}a_{Bn).}}$ Which a_{Bj}shows the preference of the best criterion (B) over criterion (j).

Step 4. Determining the preferences of all the criteria over the worst criteria; the Others-to-Worst vector would be:$A_{w=(a_{1w},a_{2w,\dots\dots\dots,}a_{nw})^T}$ which a_{jw} shows the preference of criterion (j) over the worst criterion (W). DM must specify his/her preference by an integer number from 1 to 9. In step 3 and 4 it is clear that $a_{BB} = 1$, $a_{WW} = 1$

Step 5. Solving the model and obtaining the optimal criteria weight $W^* = (w_1^*, w_2^*, \dots, w_n^*))$, using following model (Equation (1)).

Table 1. Most widely used sustainability criteria of an urban transportation network

Dimension	Criteria	References
	Biodiversity and protected sectors	[Basbas and Politis, 2008; Joumard and Nicolas, 2010; Muqing Liu et al. 2015]
	GHG emissions	[Black et al. 2002; Yedla, Shrestha, and Anandarajah, 2005; Basbas and Politis, 2008; Joumard and Nicolas, 2010; Jeon et al. 2013; Haghshenas et al. 2015; Mitropoulos and Prevedouros, 2016; Li, Meng, and Yao, 2017; de Almeida Guimares and Leal Junior, 2017; Nanaki et al. , 2017; Oses et al. 2018; Mansourianfar and Haghshenas, 2018]
	Local air quality	[Black et al. 2002; Joumard and Nicolas, 2010 ; Sinha and Labi , 2011; Jeon et al. 2013; Oses et al. 2018]
	Noise pollution	[Black et al. 2002; Sinha and Labi, 2011; Jeon et al. 2013; Mitropoulos and Prevedouros, 2016; de Almeida Guimars and Leal Junior, 2017; Nadafianshahamabadi, Tayarani, and Rowangould, 2017; Oses et al. 2018; Mansourianfar and Haghshenas, 2018]
Environmental	Energy use	[Black et al. 2002; Joumard and Nicolas, 2010; Jeon et al.2013; Haghshenas et al. 2015; Mitropoulos and Prevedouros, 2016; de Almeida Guimares and Leal Junior, 2017; Mansourianfar and Haghshenas, 2018]
	Water pollution	[A. Dobranskyte-Niskota et al. 2009; de Almeida Guimares and Leal Junior [2017]
	Regional air quality (smog)	[Black et al. 2002; Joumard and Nicolas, 2010; Jeon et al. 2013]
	Water quality use and regime	[A. Dobranskyte-Niskota, et al. 2009; Joumard and Nicolas, 2010; Jeon et al. 2013]
	Natural and technological risks	[Joumard and Nicolas, 2010; Muqing Liu et al. 2015]
	Acoustic and light disturbance;	[Joumard and Nicolas, 2010]
	Site, landscape and man-made heritage	[A. Dobranskyte-Niskota et al. 2009; Joumard and Nicolas , 2010]
	Space/land consumption	[Joumard and Nicolas, 2010; Jeon et al. 2013; Haghshenas et al. 2015; de Almeida Guimares and Leal Junior, 2017; Lopez-Carreiro and Monzon, 2018; Mansourianfar and Haghshenas, 2018]
	Consumption of non-renewable materials	[Joumard and Nicolas, 2010; Jeon et al. 2013; de Almeida Guimares and Leal Junior, 2017; Mansourianfar and Haghshenas, 2018];
	Travel time	[Miandoabchi et al. 2013]; de Almeida Guimars and Leal Junior , 2017; Lu et al. 2018; Mansourianfar and Haghshenas, 2018; Marek Ogryzek, Daria Adamska-kmiec and Anna Klimach, 2020]
	Global surplus	[Joumard and Nicolas, 2010; Muqing Liu et al. 2015]
	Variation in surplus of the economic actors	[Joumard and Nicolas, 2010; United Nations Transport Trends and Economics Series , 2015]
Economic	Employment Evolution	[Basbas and Politis,2008; Joumard and Nicolas, 2010];
	Travel cost/ Mobility costs	[Joumard and Nicolas, 2010; Sinha and Labi, 2011; Haghshenas et al.2015; United Nations Transport Trends and Economics Series, 2015]
	Transportation cost for government	[Haghshenas et al. 2015; Ravindra Kumar, 2013; United Nations Transport Trends and Economics Series, 2015; A. Dobranskyte-Niskota et al. 2009]
	Indirect transportation	

Dimension	Criteria	References
	cost for user	[Haghshenas et al. 2015; Ravindra Kumar, 2013; United Nations Transport Trends and Economics Series, 2015]
	Economic efficiency	
	Affordability	[Basbas and Politis, 2008; Jeon et al. 2013]
		[Basbas and Politis, 2008; Jeon et al. 2013; Ravindra Kumar, 2013; United Nations Transport Trends and Economics Series, 2015]
	Economic development	[A. Dobranskyte-Niskota et al. 2009; Jeon et al. 2013; Ravindra Kumar, 2013]
Social	Accessibility to employment	[Joumard and Nicolas, 2010; Sinha and Labi, 2011; Jeon, Amekudzi, and Guensler, 2013; Haghshenas, Vaziri, and Gholamialam, 2015; de Almeida Guimares and Leal Junior, 2017]
	Accessibility to major public services	[Joumard and Nicolas, 2010; Sinha and Labi, 2011; Jeon et al. 2013; Haghshenas et al.et al. 2015; de Almeida Guimars and Leal Junior, 2017; Mansourianfar and Haghshenas, 2018; Marek Ogryzek, Daria Adamska-kmiec and Anna Klimach, 2020]
	Spatial equity	[Joumard and Nicolas, 2010; Jeon et al. , 2013; de Almeida Guimares and Leal Junior, 2017; Basbas and Politis, 2008]
	Satisfaction	[Hosseininasab et al. 2018; Mitropoulos and Prevedouros, 2016; Mansourianfar and Haghshenas, 2018]
	Community cohesion	[Sinha and Labi, 2011]
	Safety (accidents and etc.)	[Black, Paez, and Suthanaya, 2002; Basbas and Politis,2008; Joumard and Nicolas, 2010; Jeon et al. 2013; Haghshenas et al. 2015; Muqing Liu et al. 2015; Balasubramaniam et al. 2017; de Almeida Guimares and Leal Junior,2017; Mitropoulos and Prevedouros, 2016; Oses et al. 2018];
	Visual quality	[Sinha and Labi,2011; Marek Ogryzek, Daria Adamska-kmiec and Anna Klimach, 2020]
	Transportation variety	
	Social interaction	[Haghshenas et al. 2015; Ravindra Kumar, 2013]
	Archaeological resources	[Basbas and Politis, 2008; Sinha and Labi, 2011]
		[Sinha and Labi, 2011]
	Social equity	[Basbas and Politis, 2008; Jeon et al. 2013; Mansourianfar and Haghshenas, 2018]
	Reserve capacity	
	Robustness and reliability	[Yang and Wang, 2002; Miandoabchi and Farahani, 2011]
		[Van Geenhuizen and Rietveld, 2016]
	Traffic congestion	[Iniestra and Gutiérrez, 2009; Ravindra Kumar, 2013]
	Comfort of public transportation	[Oses et al. 2018; United Nations Transport Trends and Economics Series , 2015]

The proposed model use free variables $(y_j = y_j^+ - y_j^-$ and $z_j = z_j^+ - z_j^-)$ and eliminate absolute values in constraints. In the proposed nonlinear model, if $\frac{w_i}{w_j} = a_{ij}$, then a full system consistency exists. However, there is usually an inconsistency in real-world systems. Therefore, this amount of inconsistency is reflected to $y_j^+ - y_j^-$ for indicating the preference of the best item to other items and to $z_j^+ - z_j^-$ for indicating the preference of all items to the worst item. The objective function of the proposed model is also about minimizing total deviations. The proposed model is presented as Eq. (1).

$$minZ = \sum_j (y_j^+ + y_j^-) + \sum_j (z_j^+ + z_j^-)$$

$$s.t$$

$$\frac{w_B}{w_j} - a_{Bj} = y_j^+ - y_j^- , \quad for\ all\ j,$$

$$\frac{w_j}{w_W} - a_{jW} = z_j^+ - z_j^- , \quad for\ all\ j, \qquad (1)$$

$$\sum_j w_j = 1$$

$$w_j, y_j^+, y_j^-, z_j^+, z_j^- \geq 0 , \quad for\ all\ j.$$

In the proposed linear model, if $w_i = a_{ij}\, w_j$, then a full system consistency exists. Therefore, this amount of inconsistency is reflected to $y_j^+ - y_j^-$ and $z_j^+ - z_j^-$. The objective function of the proposed linear model is also about minimizing total deviations, thus the non-inear form (Eq. (1)), is able to be presented in linear form as follows [Amiri andAmamat, 2020]:

$$\mathrm{minZ} = \sum_j (y_j^+ + y_j^-) + \sum_j (z_j^+ + z_j^-)$$

$$\mathrm{s.t}$$

$$w_B - a_{Bj} w_j = y_j^+ - y_j^- , \quad \text{for all j},$$

$$w_j - a_{jW} w_W = z_j^+ - z_j^- , \quad \text{for all j}, \qquad (2)$$

$$\sum_j w_j = 1$$

$$w_j, y_j^+, y_j^-, z_j^+, z_j^- \geq 0 , \quad \text{for all j}.$$

The consistency ratio can be also obtained by Eqs. (3) and (4), suggested by [Rezaei, 2015].

$$\varepsilon = \max\{y_j^+ - y_j^-,\ z_j^+ - z_j^-\} \qquad (3)$$

$$Consistency\ Ratio\ (CR) = \frac{\varepsilon}{Consistency\ \ index} \qquad (4)$$

Table 2. Consistency Index

a_{BW}	1	2	3	4	5	6	7	8	9
Consistency Index	0.00	0.44	1.00	1.63	2.30	3.00	3.73	4.47	5.23

The lower value of ε, demonstrates the higher level of consistency and consequently higher level of reliability of the comparisons and results. The consistency index suggested by [Rezaei, 2015] is presented in Table 2. See more details about BWM in [Rezaei, 2015; Rezaei, 2016] and [Amiri and Amamat, 2020].

4. Case Study

Yazd is one of the major cities located in central region of Iran (see Figure 3). Yazd as a cultural identity center in Iran was inscribed as the first city of Iran in World Heritage Site at the 41st session of the UNESCO World Heritage Committee in July 2017 in Krakow, Poland [UNESCO, 2017] with an area of 195 hectares as The Historic City of Yazd. As shown in Figure 4, Yazd city has 3 main administrative divisions (areas) with high traffic volume in urban area. Yazd is the center of several small and major industries and known as an industrial city in Iran.

A large number of factories and companies have been located in different areas of the city (in north, south, west, east, and even inside the city) and all of them require an efficient urban transportation system to serve their consumers or to do their production and non-production activities. The quality indices of social and urban life such as spatial equity, satisfaction, community cohesion, etc. are deeply affected by the quality of services provided in the urban transportation system.

Yazd is a developing city with about 700 Thousand populations.Thus the Transportation Department of Municipality of Yazd is planning a lot of transportation projects such as new bus rapid transit (BRT) lines, etc. At the same time, Yazd is known as one of the most important and famous historical cities in the world which retains much of its past great glory. In Figure 5, the core zone of the World Heritage Site of the historic city of Yazd has an area of 195 hectares, which includes all the historical neighborhoods and the central core of the historic city and the old Mosque, the Bazaar, Pir district and it Tower.

Figure 3. Location of Yazd

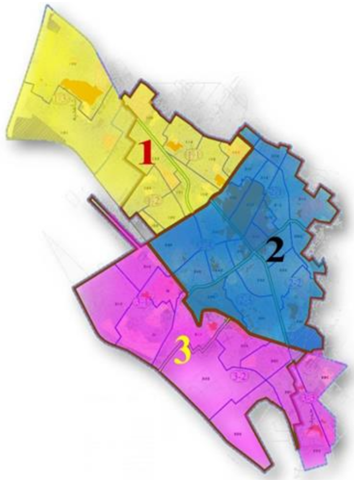

Figure 4. Map of 3 areas of Yazd

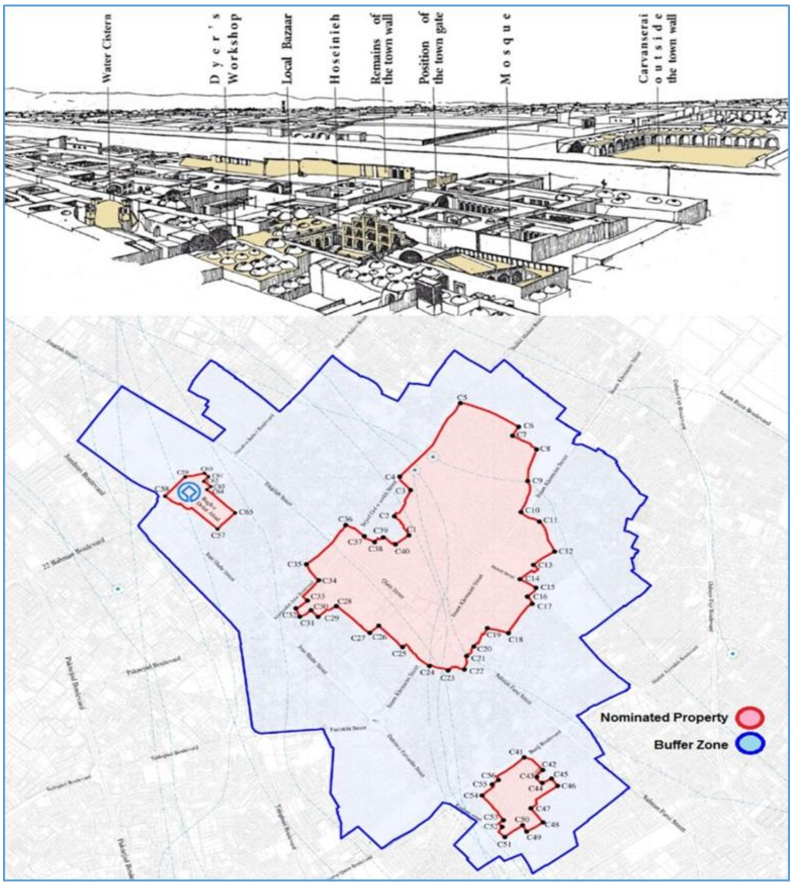

Figure 5. Map of historic city of Yazd

The buffer zone of the World Heritage Site has an area of 650 hectares, which includes the Qajar city, parts of the first Pahlavi urban development areas and some adjacent areas of its influence. The Historic City of Yazd encloses two other World Heritage Sites: The Persian Garden and the Persian Qanât, The Persian Qanât World Heritage Sites has two of its eleven world’s longest Qanâts in Yazd, Zarch and Hassan Abad-e Moshir, with a length more than 80 kilometers and a millenary history. Therefore, in addition to lots of technical and financial limitations, the government also should consider the man-made heritage, protected sectors and archaeological resources in their planning and evaluating candidate projects.

5. Data Collection and Setup

It is quite obvious that the multiplicity of selected criteria listed in Table 38 (including 10 economic criteria, 15 social criteria and 13 environmental criteria) will lead to many pairwise comparisons that will require more interview time and professional knowledge and understanding of the criteria and their effects. Since the users are not predominantly experts and also in many case they do not have sufficient knowledge about sustainability and its criteria. Thus it is necessary to employ fewer criteria that must be appropriate, comprehensive and more understandable for wide variety of users. In order to specify the final criteria of questionnaire forms, by taking into account repetitions, similarities, correlations, and data availability all the demonstrated criteria in Table 3 presented to academic and managers of Yazd urban transportation network, before designing the questionnaire. Eventually, based on the received feedbacks, 5 social, 3 economic and 5 environmental criteria considered for the questionnaire. Following the users' responses based on face-to-face interviews, the questionnaires completed in three urban areas. An example of the questionnaire and feedback details are notified in the supplementary file. Google forms were also used to collect responses from academics and managers/experts of transportation department of Yazd municipality. Google form links were sent to all the experts by email to receive their responses, while most of academics and managers were also interviewed. 27 students in nine groups, as interviewers, collected information in a completely random process. Each group of interviewers in one of the urban areas conducted the interview randomly, they also focused on users of public transportation system particularly. Furthermore, choosing people regardless considering gender, ability, age, pedestrian or driver, as well as choosing the different days of a week and different time period of a day, was a completely random process.

In the first step, based on Krejcie and Morgan sampling table [Krejcie and Morgan, 1970] and population of Yazd, 384 interviews were done over a period of 2 weeks. In order to collect acceptable data and have comments of all areas, interviews were done in all 3 areas. In this step, 30 responses were unusable. We considered 0.1 as the maximum acceptable CR. In the second step, 130 other interviews were done that 9 responses were unusable. Finally, 475 responses were gathered. Considering all the beneficiaries prospective is one of the main purposes of this study which really helps us to evaluate candidate projects or policies related to the urban transportation network. Despite the fact that users are the most important beneficiaries of an urban transportation network, any significant change and development of the network or urban services should be done in order to gain their benefits and satisfactions. Owing to an apparent lack of sufficient knowledge and comprehensive view of users on transportation networks, the experts of urban transportation networks’ prospective should be considered. On the other hand, comments of this group is capable of affecting by the construction costs and operational priorities of urban transportation projects, hence academic experts, with full knowledge of the urban transportation network and sustainability criteria, considered.

In academic experts' case, we interviewed 8 professors from Yazd universities including, 3 associate professors and 5 assistant professors. The selected academics were faculty of urban design, civil engineering and transportation engineering departments. All of them had a Ph.D. degree and some published papers in urban transportation and network design filed. With about 9 years work experience, they have taught at least one course relevant to transportation network design. Furthermore, they did not have any financial relationship with Yazd municipality. As the transportation experts, 5 general managers and 5 senior managers of transportation department of Yazd municipality (who were knowledgeable about urban transportation of Yazd, transportation systems design and management) were interviewed. Average work experience of the transportation department of Yazd municipality's experts was 18.2 years (Please observe the supplementary file for the respondents' profile and all data relevant to each area and each group).

6. Results and Discussions

The frequency of criterion/dimension selected as the best/worst from different perspectives demonstrates in Table 4. A3, B2 and C5 have been selected as the worst criterion in social, economic and environmental dimensions, prospectively. Therefore, transportation variety, economic efficiency and development and space/land consumption are not the main concerns in Yazd urban transportation network, compared to other criteria. The results clearly show that the consistency ratio of the comparisons of all dimensions and criteria are remarkably consistent. Among all calculations, the highest CR is 0.098.

Based on the results on Table 5a the issue about importance of dimensions is slightly different. The results show that both users and academic consider social stability as the most important dimension. Although from the transportation experts' point of view, economic dimension is more important than social dimension, comparing the weights of these dimensions demonstrates that this difference is not noteworthy. Thus, the transportation experts also are concerned about the social sustainability. The main point about environmental dimension is the best criteria, C3, which according to Table 5d is the most selected criterion as the best criterion and the most important criterion in environmental dimension for all groups WC3= 0.289. Considering the second rank of the studied environmental criterion for all groups particularly users, wc2 has the next priority WC2 users = 0.211. It means that all groups are totally convinced that due to energy Mismanagement and lack of using renewable materials the situation of air pollution and GHG emission are in critical condition. Thus, accomplishing a desirable level in these criteria will undoubtedly lead to higher level of sustainability.

Table 3. Selected evaluation criteria

Social criteria	Economic criteria	Environmental criteria
Accessibility to major public services(A1)	Travel time(B1)	Biodiversity and protected sectors(C1)
Safety (accidents and etc.) (A2)	Economic efficiency and development(B2)	GHG emissions(C2)
Transportation variety(A3)	Travel cost/ Mobility costs for user(B3)	Energy and non-renewable materials use(C3)
Traffic congestion(A4)		Site, landscape and man-made

Social criteria	Economic criteria	Environmental criteria
		heritage(C4)
Comfort of public transportation(A5)		Space/land consumption(C5)

Table 4. Frequency of selected criterion/dimension as the best/worst

B3		B2		B1		A5		A4		A3		A2		A1		Group
Worst	Best	Worst	Best	Worst	Best	Worst	Best	Worst	Best	Worst	Best	Worst	Best	Worst	Best	
137	218	172	123	166	134	44	111	79	82	270	42	42	72	40	168	**Users**
3	2	5	2	0	4	3	0	0	2	5	0	0	0	0	6	**A.E***
5	2	5	3	0	5	0	0	0	0	8	0	2	3	0	7	**T.E***
Environmental		**Economic**		**Social**		**C5**		**C4**		**C3**		**C2**		**C1**		**Group**
Worst	Best	Worst	Best	Worst	Best	Worst	Best	Worst	Best	Worst	Best	Worst	Best	Worst	Best	
166	118	144	210	165	147	168	37	121	87	61	133	53	140	72	78	**Users**
3	0	5	3	0	5	2	1	1	0	0	5	0	2	5	0	**A.E**
4	3	4	5	2	2	2	2	1	0	0	7	2	1	5	0	**T.E**

* Note: A.E. i.e. Academic Experts and T.E. i.e. Transportation Experts

Table 5a. The importance of sustainability dimensions

Group	Social			Economic			Environmental			ε	CR	S.D.
	W	R	S.D	W	R	S.D.	W	R	S.D			
Users	0.384	1	0.148	0.275	3	0.131	0.349	2	0.177	0.238	0.071	0.047
A.E.	0.506	1	0.183	0.265	2	0.253	0.229	3	0.073	0.230	0.056	0.059
T.E.	0.345	2	0. 156	0.384	1	0.219	0.270	3	0.151	0.123	0.039	0.020
F.W	0.386	1	0.149	0.308	2	0.135	0.283	3	0.174	0.236	0.070	0.047

Certainly, identifying the existing conditions, contributing and aggravating factors of air pollution is one of the most important measures in evaluating the performance of an existing urban transportation network. In the case of Yazd, the most important points to consider are:

- **Energy and non-renewable material use.**

  "Energy and non-renewable material use", is the main concern of all groups in environmental dimension.

  Yazd is known as one of polluted cities in Iran. Figure 6 shows the report of Yazd Department of Environment (YDE) about the air quality of Yazd during 2016-2020. Based on [YDE, 2020] report;

  Only 190 days were excellent from 2016 to 2020(about 10 Percent). Also based on a research conducting by Yazd Shahid Sadoughi University of Medical Sciences researchers in 2016, 442 cases (45.5%) of myocardial infarction have occurred in the days that the Yazd air quality has exceeded the standard [Askari shahi et al. 2018]. This fact is easily able to be recognized from Table 5d (WC3=0.289, RC3=1).

Some suggestions are able to be presented to deal with this concern: first, Continuous monitoring of air pollutants and allocating specific budget for activities related to reducing air pollution.

Considering that the city of Yazd is on the verge of one million populations and, moreover, Yazd has also known as one the industrial hub of the country, hence continuous monitoring of pollutants, particularly, the main causes of air pollution is essential to control and reduce its rate. Therefore, comprehensive environmental studies of Yazd and determining the polluting factors should be the government's overriding priorities.

Second, improving private cars. Most of cars in urban transportation networks in Iran are low quality products with more than 10 years' average age, this average is about 8 for the city of Yazd [Rahvar, 2020]. Third, offering subsidies. Government is expected to encourage users to sell their old cars and buy new ones to rejuvenate the entire private cars. Although, in the last three years for every 10 new vehicles which have entered the Yazd urban transportation network, 1 old vehicle has been removed on average [Rahvar, 2020].

• **Accessibility to major public services.** The results clearly demonstrate that accessibility to major public services is the first priority of social criteria from the perspective of all three groups, which is putting the great emphasis on this criterion in order to accomplish sustainable performance in urban transportation network of Yazd. This can be seen in Table 5b where WA1= 0.315 and rank of A1 is first among social criteria for all groups. Improving the affordable accessibility to major public services is one of the growing demands of users.

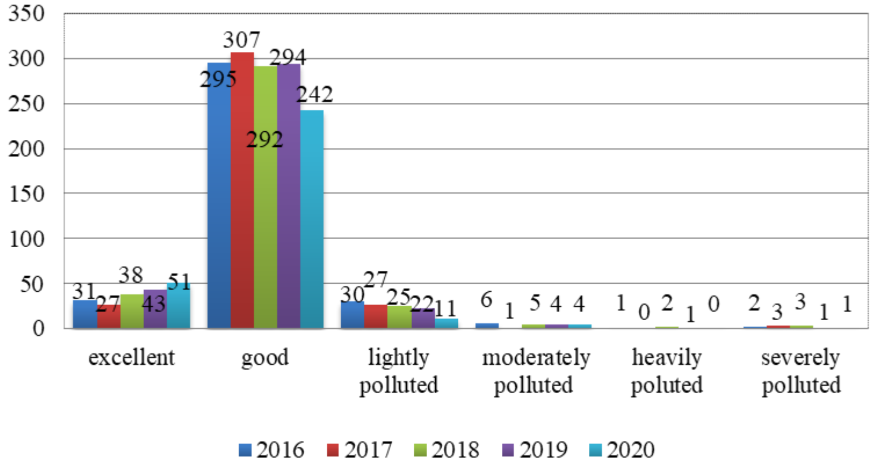

Figure 6. Air quality in Yazd from 2016 to 2020 (YDE, 2020)

Table 5b. The importance of each criterion in the social dimension

Group	A1			A2			A3			A4			A5			ε	CR	S.D.
	W	R	S.D	W	R	S.D	W	R	S.D	W	R	S.D	W	R	S.D			
Users	0.26	1	0.13	0.21	3	0.1	0.12	4	0.07	0.19	5	0.1	0.22	2	0.09	0.24	0.06	0.04
A.E.	0.37	1	0.14	0.13	4	0.05	0.06	5	0.04	0.27	2	0.17	0.17	3	0.05	0.15	0.03	0.01
T.E.	0.32	1	0.12	0.22	2	0.13	0.09	5	0.04	0.19	4	0.07	0.2	3	0.05	0.16	0.03	0.02
F.W	0.32	1	0.13	0.19	4	0.1	0.09	5	0.07	0.22	2	0.1	0.2	3	0.09	0.24	0.06	0.04

Table 5c. The importance each criterion in the economic dimension

Group	B1			B2			B3			ε	CR	S.D.
	W	R	S.D	W	R	S.D	W	R	S.D			
Users	0.297	3	0.179	0.308	2	0.150	0.395	1	0.174	0.320	0.086	0.058
A.E.	0.411	1	0.113	0.194	3	0.139	0.395	2	0.137	0.322	0.098	0.090
T.E.	0.465	1	0.153	0.269	2	0.143	0.266	3	0.162	0.194	0.053	0.022
F.W	0.391	1	0.177	0.257	3	0.150	0.352	2	0.173	0.317	0.086	0.058

Table 5d. The importance of each criterion in the environmental dimension

Group	C1			C2			C3			C4			C5			ε	CR	S.D.
	W	R	S.D	W	R	S.D	W	R	S.D	W	R	S.D	W	R	S.D			
Users	0.19	4	0.1	0.21	2	0.1	0.26	1	0.13	0.19	3	0.13	0.15	5	0.1	0.26	0.06	0.04
A.E.	0.13	5	0.09	0.19	3	0.09	0.3	1	0.12	0.18	4	0.04	0.2	2	0.17	0.26	0.05	0.03
T.E.	0.11	5	0.06	0.19	3	0.12	0.31	1	0.14	0.18	4	0.1	0.21	2	0.1	0.16	0.04	0.02
F.W	0.15	5	0.1	0.2	2	0.1	0.29	1	0.13	0.18	4	0.12	0.19	3	0.1	0.26	0.06	0.04

In [Table 5c], b3 is also the most important economic criteria in users' view as the most important beneficiaries of the public transportation system. Although based on the current coverage of bus routes network and an acceptable existing bus stop access coverage in Yazd as shown in Figure 7 as well as considering the existing transport mode usage in Yazd (see Figure 8), It should be noted that the people’s high demand for the public transportation system construction and development is concentrated mainly in BRT lines.

Careful examination of each dimension’s criteria and their relative importance from different perspectives will surprisingly provide the following remarkable results:

Weights and ranks of comfort of public transportation (A5) travel cost/mobility costs for user (B3) as high priority criteria, demonstrate a general consensus on a more convenient public transport system at low costs which could logically increase the proportion of acceptability and satisfaction of users in a public transportation system.

Figure 7. Bus stop access coverage in Yazd (Based on a 500m circular buffer around the stop)

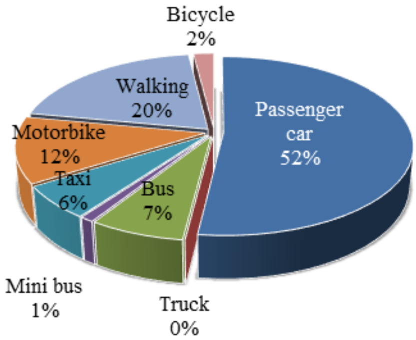

Figure 8. Transport mode usage in Yazd urban transportation network

In addition, effective management and coherence policies along with above-mentioned will definitely able to establish a sustainable transportation network. The relative importance of environmental criteria obviously demonstrates that there is no mutual agreement on C1, C4 and C5 while protected sectors and man-made heritage have a crucial importance among users. On the other hand, academics and transportation experts obviously consider C5 as a criterion which is able to lighten the economic burden of government. Thus in their view c5 has a second priority after C3. regarding environmental dimension, there are distinctive perspectives of users, academic experts and managers concerning two important environmental criteria, including C4 and C1.

C4 and C1 are two of the important environmental criteria for users (notably for users in area 2; since most of historic resources are located in this area, see supplementary file). Since, Yazd is known by these resources and the revenue from the tourism industry constitutes a major part of the income of the people of Yazd, particularly in that area. By contrast C1 and C4 are the least important environmental criteria for transportation experts and academic experts, hence managers of urban transportation network predominantly attempt to convince the users by new projects while most of historic places are located in downtown and very busy areas (see Figure 9), thus they found these resources as a serious obstacle to accomplish their goals.

Evaluating the next priorities, particularly in the social dimension, demonstrate that the safety is also one of the considerable criteria from transportation experts and users' perspective (especially for users in area 3; Due to the most connection with arterial streets and ring road). Considering number of car accidents in the urban transportation network, Yazd had the fourth rank among all cities of Iran in 2019 which more than 61 people are died in the accidents [Rahvar, 2020].

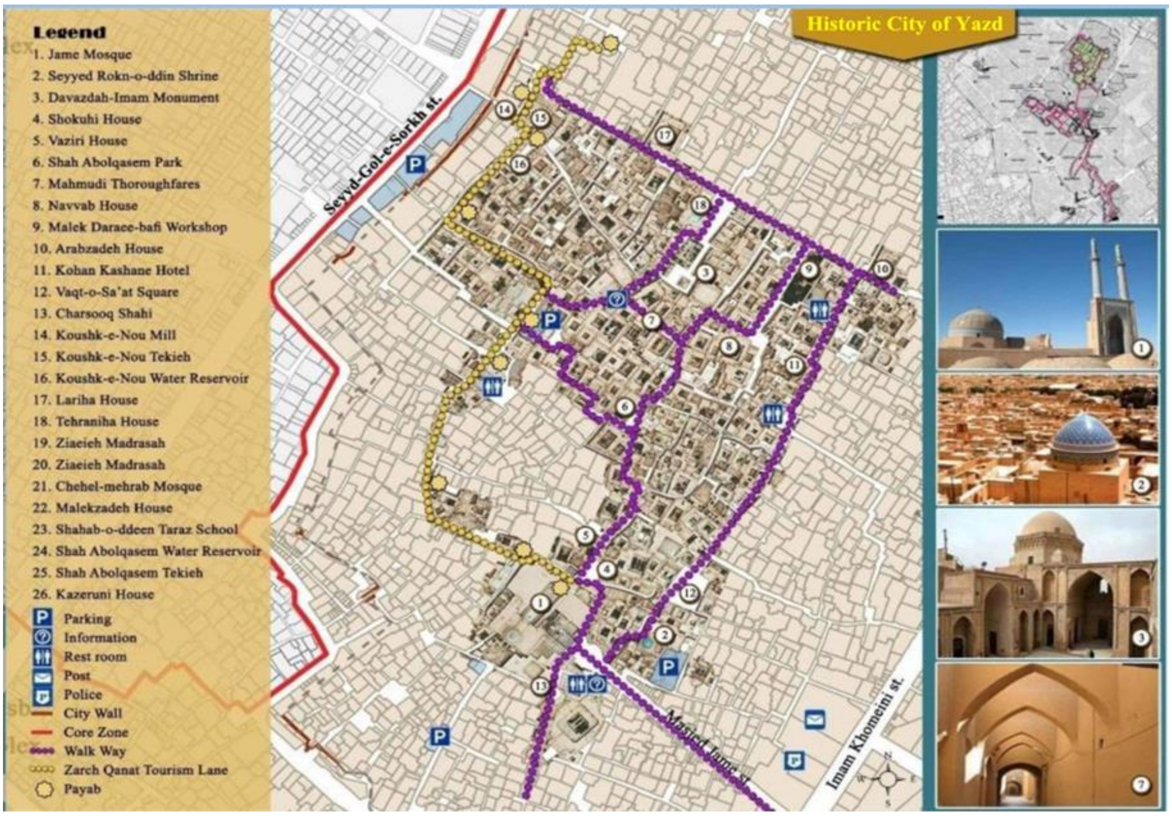

Figure 9. Location of some of important historical places and studied pathway within city of Yazd

Fortunately, owing to the installation of speed cameras on most of the urban streets and imposing severe traffic restrictions (about 10 hours a day) due to the Coronavirus, that number has declined by about 30 percent in 2020. There is no doubt that improving safety level of urban transportation network in Yazd will lead to higher level of sustainability. The new human-centered approach along with more vehicle restrictions and traffic calming policies could be highly effective including: reducing the width of urban lanes, notably in arterials and collectors in order to reduce speed, increasing warning signs, particularly at night, implementing traffic-calming measures and making the streets safer for vulnerable road users, such as cyclists, pedestrians and children by improving pedestrian accessibility and restricted car-use and perceived accessibility.

7. Evaluating Candidate Projects

Comprehensive transportation plan of Yazd (CTPY, 2019) has been propose various projects to accomplish its objectives by 2035, including bus rapid transit systems and their implementation (see Figure 10).

Figure 10. Candidate BRT lines for Yazd urban transportation network

This approach is based on the current network performance and principal objectives such as: reducing traffic congestion, increasing the public transportation usage, developing arterial networks, increasing accessibility and safety to name but a few. Nevertheless, due to numerous financial and technical constraints, the implementation of priorities and its possibility is also a widespread problem of urban management. Under certain circumstances and possibilities, a four-year time-period (2019-2022) as the short term planning horizon a nine-year time-period (2019–2027) as medium term horizon and 17-year time-period (2019–2035) as the evaluation horizon have specified in which traffic department of Yazd municipality identified 6 construction scenarios (see Table 6).

In this step, Trans CAD software is used to simulate the traffic situation for each proposed scenario and consequently the values of the indices are calculated for each scenario. The simple additive weighting method (SAWM) is used to calculate the rank of each scenario from users, academics experts and executives' perspective, as well as an overall rank (see Table 7). The results clearly show that the third scenario is the best scenario, while in the second scenario compared to other scenarios, the greatest improvement in energy and non-renewable materials use, mobility cost and accessibility to major public services are achieved. This study is illustrated the main point about effect of the number and type of evaluation criteria on ranking and selecting the best scenario. In other words, according to Table 8, by increasing the number of criteria, the results are converged to the final results. Further details of the indices' values for each scenario and rank of the scenarios in each area are provided in the supplementary file. For example, in our case study if we only consider A1 or B3 or C5, the selected strategies will be different, particularly considering A4 or c5, first strategy will be selected while considering all dimensions and criteria, strategy 1 will reach third rank. Although it is possible to evaluate and rank each scenario based on the weight of criteria in different urban areas, in this study we used the final weights of the criteria to rank each scenario. In order to review the feedback, the results were sent to transportation experts and managers. which are listed in the supplementary file. Based on the feedback opinions of 10 urban managers and transportation experts, approximately 75% of the results met their expectations.

Table 6. Description of the projects used in scenarios

Scenario	Projects Information
S1	BRT lines(1,6), 15 one way streets, downtown restrictions, Street widening(45000 square meters)
S2	BRT lines(4,8), 15 one way streets, downtown restrictions, Street widening(51000 square meters)
S3	BRT lines(2,5,6), 6 one way streets, Pedestrian street (1 km), downtown restrictions, Street widening(88000 square meters)
S4	BRT lines(4,7,8), 8 one way streets, Pedestrian street (1 km), downtown restrictions, Street

Scenario	Projects Information
	widening(92000 square meters)
S5	BRT lines(1,7,8), 8 one way streets, Pedestrian street (1 km), downtown restrictions, Street widening(87000 square meters)
S6	BRT lines(2,8), 8 one way streets, Pedestrian street (1 km), downtown restrictions, Street widening(46000 square meters)

Table 7. Rank of the scenarios from different perspectives

Group	S1		S2		S3		S4		S5		S6	
	SAW	R.	SAW	R.	SAW	R.	SAW	R.	SAW	R.	SAW	R.
Users	0.8113	3	0.6761	5	0.8480	1	0.8314	2	0.5779	6	0.7072	4
A. E.	0.8060	3	0.6705	5	0.8704	1	0.8221	2	0.5557	6	0.6987	4
T. E.	0.8216	2	0.6704	5	0.8621	1	0.8206	3	0.5595	6	0.6901	4
Final	0.8130	3	0.6723	5	0.8602	1	0.8247	2	0.5644	6	0.6987	4

Table 8. Rank of the scenarios considering different evaluation criteria

Scenario	considered criteria											All criteria
	A1	A4	B1	B3	C1	C2	C3	C5	A1,B3,C1	A4,B1,C5	A1,A4,B1,B3,C1,C2,C5	
1	3	1	2	2	3	1	2	1	4	1	2	3
2	3	4	5	5	2	3	5	3	5	4	5	5
3	1	3	1	1	5	2	1	5	1	2	1	1
4	2	5	3	3	4	1	3	6	3	5	4	2
5	4	6	6	6	6	4	6	4	6	6	6	6
6	2	5	4	4	1	5	4	2	2	3	3	4

8. Proposal to Shape Sustainable Development Policy

Highly effective management of Yazd urban transportation network as well as implementing sustainable development policy, would be attainable by following recommendations:

- The high priority of accessibility to major public services, travel time and energy and non-renewable materials use, as criteria of each dimension, clearly demonstrate that Yazd urban transportation network is required to dramatically improve. Hence as a short-term policy, BRT services must be developed in all areas of Yazd. (Lines 2, 5 and 6 based on the sub-projects of the third scenario) and subway lines must be constructed as a long-term policy.
- Considering the potential and distinguishing characteristics of Yazd (particularly, region 2-Figure 3), in order to improve accessibility, safety as well as reducing fuel consumption and mobility costs, as obvious examples of sustainable urban development, existing pedestrian and bicycle infrastructures must be significantly improved and also some new ones are required to be constructed. Moreover, refurbishment of the city center into a heritage realm in the authority of pedestrian is a high priority. Although the widespread patterns of physical growth have provided residents with a strong incentive to use private cars, Pedestrian realm of the city is a great opportunity for residents to reconnect to their history, environmental identity and cultural activities. In Historic City of Yazd inscription document of UNESCO World Heritage List, three pathways have been specified for walking tourists (see Figure 9). Moreover, based on Comprehensive Transportation Plan of Yazd [CTPY, 2019], according to the highest per capita bicycle ownership in this area (58 percent bicycle ownership in the area 2, shown in Figure 4), as well as considering Transport mode usage in Yazd urban trips (see Figure 8), thus

concentrating on pedestrianization and cycling in this area is quite justifiable. Therefore, considering that Yazd is a first Iranian historic city with the core zone of the World Heritage Site with an area of 195 hectares which includes all the historical neighborhoods with narrow streets, pedestrian and bike oriented strategies are required to be employed as a long-term practical solution.

9. Conclusions

Improving the performance of an urban transportation network, along with sustainable development is predominantly one of the major and growing concerns of urban managers and policy makers. Therefore, thoroughly determining the sustainability evaluation criteria and their relative importance from different perspectives could certainly be a strong support for urban managers to propose new projects and prioritizing them.

Consequently, to accomplish this goal, most important criteria for evaluating the sustainability of urban transportation network are identified in various dimensions based on survey data from users, academic experts and Yazd urban transportation managers and also employing goal programming model for BWM, ranks of dimensions/criteria and their importance (weight) were calculated. Largely because of considering all the sustainability evaluation criteria in economic, social and environmental dimensions for the purpose of evaluating, assessing performance, proposing projects and prioritizing urban scenarios, this study is definitely unique. Furthermore, for the first time, the goal programming model for BWM has been employed to evaluate the relative importance of criteria, prioritize and rank candidate transportation projects in a real application. Indeed, the proposed approach is able to be employed by other major cities to evaluate their sustainability. Likewise, the approach and results of this study would be extremely effective to make a conscious decision to develop infrastructures and improve sustainability of urban transportation network.

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