Cities 72 (2018) 149–159

Contents lists available at ScienceDirect

Cities

journal homepage: www.elsevier.com/locate/cities

Micro-scale sustainability assessment of infrastructure projects on urban transportation systems: Case study of Azadi district, Isfahan, Iran

Mohammad Hadi Mansourianfar[a,*], Hossein Haghshenas[b]

[a] *Transportation Engineering Faculty, University of Isfahan, Hezar jerib Avenue, Isfahan 81746, Iran*
[b] *Department of Transportation Engineering, Isfahan University of Technology, Isfahan 81746, Iran*

ARTICLE INFO

Keywords:
Sustainable transportation
Transport infrastructure
Indicator
Traffic simulation
MCDA
Isfahan

ABSTRACT

Sustainability assessment and sustainability indicators are familiar terms that have gained significant importance. Non-compliance between the sustainable development principles and transportation infrastructure projects is changing the appearance of historic cities from livable and vibrant atmosphere into the car-oriented condition and cause environmental and social problems. There exist numerous studies on measuring the sustainability of transportation at the country, state, city, and even traffic zone levels, but few have addressed the sustainability of micro-scale projects. The objective of this study is to assess the sustainability of infrastructure projects on urban transportation systems and evaluate their compliance with principles of sustainable development. According to made intensive field visits, run expert interviews, and development master plans relevant to the case study, nine scenarios are proposed to improve the traffic situation of Azadi district in Isfahan city. Obviously, a slight change in the urban streets network, would have a significant effect on traffic performance in larger area, therefore, all the proposed scenarios are modeled in Trans Cad 5.0 software environment to determine their influence area (IA) as the study area. Ten quantitative indicators in three dimensions (environmental, social, and economic) pertinent to the urban transportation are selected based on review of the related literature and available data in Isfahan. The IA and all proposed scenarios are simulated and calibrated in AIMSUN 8.0 environment and the indicators are quantified in a direct and indirect manner through AIMSUN outputs. A composite sustainability index (CSI) is applied for integrating the effects of selected indicators based on their rankings given by the experts regarding to the goals of Isfahan vision in 2025. The results indicate that public transportation development projects are the most compliant scenarios with the principles of urban sustainable development and the best options for the future development in Azadi district. This proposed framework, would assist policy-makers and traffic engineers in other cities to evaluate the sustainability of urban transportation infrastructure projects.

1. Introduction

One of the main features of the 'industrial revolution' was the rapid growth in industrial and economic sectors. Over time, industrial and economic developments took place at the cost of other livelihood aspects and led to major problems. Environmental and social consequences like the use of non-renewable natural resources, excessive land consumption, air pollution, and man-made diseases greatly affected human life. These problems changed the attitude of policymakers then and the new concept named 'sustainable development' was introduced by the Brundtland Commission. 'Development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs' and reflected environmental, social and economic aspects (Ahuti, 2015; Quaddus & Siddique, 2001; WCED, 1987).

Sustainable transportation as a derivative concept of sustainable development, with considering environmental, social and economic impacts of transportation, has a major contribution on achieving urban sustainable development. A transportation system will be entitled 'sustainable' when it would be able to provide economic development and meet the transportation needs of the society in a manner consistent with natural rules and human rights (Bueno, Vassallo, & Cheung, 2015; Litman & Burwell, 2006). The Center for Sustainable Transportation (CST), has developed a comprehensive definition of sustainable transportation system consisting of three major features (Gilbert, Irwin, Hollingworth, & Blais, 2003):

- Allows the basic access needs to be met safely and in a manner

* Corresponding author.
E-mail address: Hadimansourianfar@gmail.com (M.H. Mansourianfar).

http://dx.doi.org/10.1016/j.cities.2017.08.012
Received 26 March 2017; Received in revised form 14 June 2017; Accepted 14 August 2017

consistent with human and ecosystem health, with the observance equity within and between generations.
- Is affordable, operates efficiently, offers choice of transport modes, and supports a vibrant economy.
- Limits emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources, limits consumption of renewable resources to the sustainable level, reuses and recycles its components, and minimizes noise pollution and use of land.

By increasing the negative effects arising from the transportation activities, the importance of implementing sustainable urban transportation systems has become clear for planners and decision-makers (Haghshenas & Vaziri, 2012). The challenging issue in urban transportation is measurement of sustainability by developing and applying appropriate indicators that cover sustainability concept (Litman, 2012). Traditional indicators, which focus on vehicle mobility and travel time, are unable to assess which transportation system leads to sustainable results. But sustainability indicators divide complex concepts into small and interpretable units of information, so they can simply describe different aspects of the issue (Castillo & Pitfield, 2010). Some studies have proposed long lists of sustainable transportation indicators, Table 1.

Aggregating individual indicators into a composite index as a practical tool is commonly applied to compare and analyze various scenarios. Zheng et al. (2013) provided guidelines on developing performance measures for assessing transportation sustainability at the macro-scale. 22 variables in economic, social and environmental dimensions are developed, while some of them are difficult to be measured at the statewide level and are not practical. Based on the available data, a systematic tool for assessing sustainable transportation is introduced that named the Transportation Index for Sustainable Places (TISP). Jeon et al. (2013) in their study applied data from Atlanta Metropolitan Region, U.S and determined 15 performance measures based on sustainability issues and regional goals. They presented a CSI, by adopting the multiple criteria decision analysis (MCDA) method in order to assess transportation and land use alternatives at the planning stage. In a similar attempt, Reisi, Aye, Rajabifard, and Ngo (2014) developed a method for obtaining a composite transport sustainability index for statistical local areas (SLAs) in Melbourne, Australia. The main difference in this study and others is weighting system that considered different weight based on indicators importance. They applied principle component analysis/factor analysis (PCA/FA) for weighting indicators to resolve the subjectivity issue and provide an unbiased measure of transportation sustainability.

As mentioned, most of transportation sustainability assessments are defined in the planning phase at the country, state, and urban scale and less addressed to the micro-scale transport infrastructures. The innovative approach for project appraisal is a rating system that typically measures sustainability efforts in five categories: use of resources; energy; transport; water and waste (CEM, 2008). The rating systems adopted primarily in civil infrastructure field, but gradually have become applicable in the transportation sector (McVoy, Nelson, Krekeler, Kolb, & Gritsavage, 2010). Transportation sustainability rating systems (TSRSs) grade and score infrastructure projects depending on their sustainability performance through award levels (gold, silver and bronze). The prominent TSRSs include BE2ST-In-Highways, Envision, Green Leadership in Transportation and Environmental Sustainability (Green LITES), Green roads, Illinois Livable and Sustainable Transportation (I-LAST), Infrastructure Voluntary Evaluation Sustainability Tool (INVEST) (Bueno et al., 2015; Clevenger, Ozbek, & Simpson, 2013; Simpson, 2013). This approach is not perfect and some drawbacks are declared about it when dealing with the concept of sustainability. First, they are mostly focused on the environmental dimension related to construction processes and materials rather than operational phases. Second, they lack transparency in the definition of criteria and selection of weightings, which are not based on standardized methods of performance measurement (Lee, Edil, Benson, & Tinjum, 2011). And third, despite these approaches can be implemented at the planning, design and construction phases, European Union does not apply them to support decision-making process. The cost-benefit analysis (CBA) and MCDA are the most common appraisal tools in EU members to make decisions, while TSRSs are not applied to conduct a comparison among different alternatives in order to choose the best option (Bristow & Nellthorp, 2000).

Table 1
Sustainable transportation indicators in related studies (Haghshenas & Vaziri, 2012; Jeon, Amekudzi, & Guensler, 2013; Litman, 2008; Thompson et al., 2013; Zheng, Garrick, Atkinson-Palombo, McCahill, & Marshall, 2013).

Dimension	Indicator	Variable
Environmental	GHG emission	CO2 and ozone emissions per capita
	Air pollutants	VOC emissions
		CO emissions
		NOx emissions
	Energy consumption	Vehicle kilometer traveled
		Passenger kilometer traveled by public transport
		Fuel consumption
	Noise pollution	Traffic volume
	Land consumption for transport	Land use mix
		Land urbanized per population growth
		Length of railways and main road
		Length of cycling and walking pass
Social	Health	Pedestrian & bicycle mode share
		EPA Air Quality Index
	Traffic Safety	Fatality and injuries of traffic accident per capita
		Bicyclist & pedestrian fatalities per capita
	Accessibility to facilities and public transport	Railway and main road length
		Proportion of residents with public transit services within 500 m
		% of children walking to school
		% commuting to work via non-automobile means
		Access to activity centers and major services
		Access to health care center
	Social equity	Average income of population using transit relative to average state income
		Equity of exposure to noise
		Equity of exposure to emissions
	Satisfaction of citizens and variety and quality of transport options	Quality of transport for disadvantaged, disabled, children, non-driver
		Quality of pedestrian and bicycle environment
Economic	Affordability and household expenditure allocated to transport	% of household income spent on transportation
		Cost of parking
		Fuel price
		Point-to-point travel cost
	Promote economic development	Increased employment
		Land consumed by retail/service
	Mobility	Freeway/arterial congestion
		Total vehicle-miles traveled
	Economic efficiency	Total time spent in traffic
		User welfare changes

There exist very few studies where transportation infrastructures are assessed in three environmental, social and economic dimensions simultaneously at the local level from construction to operational phase. To fill these knowledge gaps, a new sustainability assessment framework is proposed for transportation infrastructures at the micro-scale in order to assist city authorities in selecting the most sustainable scenario for improving traffic condition in urban areas. These projects may appear as a point in the city map, while a slight change in the urban