Developing a Standardized Sustainable Transportation Indicators Set

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Abstract

The increasing interest in making transportation environmentally, economically and socially sustainable, leads to raise a requirement for sustainable transportation indicators as a suitable planning tool. This paper proposed a set of standardized, measurable, quantifiable, understandable and sensitive indicators that be as a valuable framework for the evaluation of performance of sustainable transportation. Additionally, this paper developed a standardized set of sustainable transportation indicators based on local travel behavior and transportation demands then to provide recommendations for further research. Standardized sustainable transportation indicators set had been developed by using a conceptual model which consists of four interdependent steps. Eight standardized sustainable transportation indicators were developed. Eventually, the buildup this set of standardized sustainable transportation indicators will provide powerful tools for policy making to the transportation decision-makers.

Key words :-Standardized, indicators, transportation, sustainable

الخلاصة

ان الاهتمام المتزايد في جعل النقل مستدام من الناحية البيئية ،الاقتصادية والاجتماعية تؤدي إلى رفع متطلبات مؤشرات النقل المستدامة كأداة للتخطيط المناسب. يقترح هذا البحث مجموعة من المؤشرات الموحدة، قابلة للقياس الكمي ومفهومة وحساسة التي قد تكون بمثابة إطار مفيد لتقييم أداء استدامة النقل. بالإضافة إلى ذلك، وضع هذا البحث مجموعة موحدة من مؤشرات النقل المستدامة القائمة على متطلبات واحتياجات سلوك السفر والنقل المحلية ثم قدم توصية لإجراء مزيد من البحوث. ثمانية مؤشرات للنقل المستدام قد تم تطويرها في هذا البحث باستخدام موديل مفاهيمي والذي يتكون من أربع خطوات مترابطة. اخيرا إن تراكم هذه المجموعة من مؤشرات النقل مستدامة وموحدة توفر أدوات قوية لصناع القرار لوضع سياسات النقل المستدام.

الكلمات المفتاحية: المعيار، المؤشرات ،النقل، الاستدامة.

1 Introduction

There is an increasing interest in the concepts of sustainability and sustainable transportation. Sustainability generally refers to a balance of economic, social and environmental goals. Moreover, sustainability reflects the essential human desire to improve and protect our world. It emphasizes the human activities integrated nature and the need for coordinated decisions among different jurisdictions, sectors and groups (Litman, 2012).

While a sustainable transportation "provides access to goods and services in an efficient way for all inhabitants of the urban area, protects the environment, cultural heritage and ecosystems for the present generation, and does not endanger the opportunities of future generations to reach at least the same welfare level as those living now, including the welfare they derive from their natural environment and cultural heritage" (May *et.al.*, 2001).

In the transportation context, Indicators were applied extensively to assessment of sustainability, such as Black *et.al.* 2002, Borken 2003, Jones *et.al.*, 2003, etc. However, there is currently no standardized set of sustainable transportation indicators. Therefore, there was an urgent need for transportation professional organizations to develop standardized indicator sets, with consistent definitions and collection methods, appropriate for comparing impacts and trends between different organizations and jurisdictions.

Because of the overabundance of indicators and the uncertainty surrounding their relevance to sustainability, successful sustainability assessment would depend on careful selection of indicators. Therefore, systematic frameworks or model is essential to select indicators. Consequently, a model is a standardized set of processes or

techniques since the standardization process assists to minimize the errors associated with the structure of the model.

From this overview, it can be concluded that there is a remarkable need for aggregation and development of standardized sustainable transportation indicators. Thus, based on the review of the literature and the data standardization methods, this research proposed a conceptual model to develop appropriate standardized sustainable transportation indicators.

The aim of this research is to develop a model to select and develop standardized sustainable transport indicators by capturing the key issues of transportation sustainability. As existing indicators are frequently not standardized, this research proposed a set of standardized indicators that offer a standardized approach to what is measured, and how that measurement is to be carried out.

Standardized indicators are qualitative or quantitative sets of measurements that provide a standardized set of methodologies. Moreover, standardized indicators allow cities to evaluate their performance and assess progress over time. They also help to guide policy, planning and management across multiple sectors and stakeholders.

2 Methodology

The methodology utilized in this research included development of a conceptual model and application of this simple conceptual model at a case study.

2.1 Conceptual model

The conceptual model consists of four interdependent steps as follows:

(A) review of the literature that helped in the identification of studies where sustainable transportation indicators in general are discussed;
(B) selection of initial sustainable transportation indicators set;
(C) developed and distributed a stakeholders interview to transportation issues;
(D) selection of final indicators set.

A. Review of the Literature

The rationale of this review of literature is to find out momentarily at studies around the world on the subject of development in addition to apply indicators of sustainable transportation. These check of what is being done elsewhere will offer a helpful start point from which the selection of sustainable transportation indicators will be addressed.

B. Selection of Initial Sustainable Transportation Indicators Set

The selection of the appropriate indicators to guide sustainable transport assessment presents challenges (Castillo and Pitfield, 2010). Selection of indicators for assessment of transportation is important in the decision making process. The selected indicators are helpful in emphasizing problems, identifying trends, contributing to priority-setting, policy formulation and evaluation and monitoring of process and in this way informing the public and decision-makers.

Indicator should be standardized for comparison, reasonable, understandable, measurable, possible to quantify, comprehensive, accessible, reflect different aspect of study, sensitive, independent, and clearly defined (Litman, 2009).

Also 10 criteria had introduced by Joumard and Gudmundsson for selection of indicator that had categorized into three major groups (Joumard and Gudmundsson, 2010):

- Operation: data availability, measurability, ethical concerns
- Representation: validity, sensitivity, reliability
- Policy application: transparency, target relevance, interpretability, action ability.

Moreover, selection of indicators which commonly used to assess the sustainability of transport and that appeared in the minimum three times from studies

C. Developed and Distributed a Stakeholders Interview to Transportation Issues

There is rising consensus that the subjects of transportation sustainability assessment ought to be included at the level of transportation planning to have any decision making policy effect. The addition of transport subjects into sets of sustainability indicator and build up transport indicators had been observed by many international programs. Stakeholders participate in the issues gathering by interview aiming to achieve a more sustainable transport.

D. Selection of Final Indicators Set

The selection of sustainability indicators for transportation could provide an important framework for the measurement and assessment of sustainability of transportation and for the development and improvement of the strategies to eliminate negative impacts from transport activities.

Selection the appropriate indicators to guide sustainable transport assessment presents challenges. Indicators were selected based on consensus derived from experts' workshop taking into account issues of sustainable transportation. To simplify information for easy assessment of sustainable transportation, a set of indicators highlighting and addressing key issues on sustainable transportation was proposed and represented. To take full advantage of their attractive qualities and their applicability, indicators must be carefully selected because unsuitably selected indicators will unavoidably cause ambiguous conclusions (Tam, 2002).

The most excellent pursuits for choosing indicators to evaluate transportation sustainability must consider a core set of criteria prepared by Litman (2007). This core set of criteria includes the following:

- Easiness to understand – indicators must be understandable and useful
- Accessibility and Transparency – indicators should be accessible to every one
- Comprehensiveness – indicators ought to reproduce a variety of social, economic, environmental impacts and a variety of transport actions
- Quality of data – high standards should be reflected by data collection practices on the way to make sure that data are reliable and precise
- Comparability – information gathering have to be standardized therefore the outcomes are suitable for comparison among a variety of groups, times and jurisdictions
- Cost effectiveness – indicators ought to be cost effective to gather
- Pure impacts - indicators have to make different among full amount of impacts and shifts these impacts to diverse positions and times
- Performance objectives – indicators ought to be appropriate for creating practical performance objectives

2.2 Case study application

A case study is suitable for validating a model developed earlier (Soy, 1997). It offers the scope to study real life situations by means of multiple sources of data (Yin, 1994). Based on the views that had been mentioned above and the fact that the issue of transportation sustainability arises in the real world, the proposed model has been applied in a case study.

3 Case Study

Urban passenger transport is essential for sustainable development and urban mobility; this research uses the city of Hilla, Iraq as a case study for the proposal of the applicability of the conceptual model to develop standardized sustainability transportation indicators.

The city of Hilla, Iraq has total population of 484,007 people. It is located on both sides of the Hilla river which is a branch of the Euphrates river in the position of the intersection of longitude (44.26) east and with latitude (32.29) north (Al Khatib,

1972). For proposing standardized sustainable transportation indicators, there were four steps as follows:

3.1 Review of the literature

It was necessary to examine the existing research and literature, in order to effectively aggregate sustainable transportation indicators. The first step of conceptual model is to conduct a literature review and summarize relevant sustainable transportation indicators at studies around the world. This step will provide a useful platform from which the initial selection of sustainable transportation indicators will be addressed.

Table 1 show Indicators which commonly used to assess the sustainability of transport that appeared in previous studies covering the categories environmental, economic and social. Moreover, Table 2 shows seventeen studies that recognize sustainable transportation indicators.

Table1 Sustainable transportation indicators applicable to urban passenger transport, Source: Haghshenas and Vaziri , 2012

Categories	Indicators	Author/year						
		Haghshenas and Vazrl (2012)	Litman (2009)	Litman (2011)	OECD (1999)	Kim and Han (2011)	Toth-Szabo et al.(2011)	Number of times it apparent from the studies
Environment	CO2 emissions, per capita	x	x	x	x	x	x	6
	Land consumption for transport infrastructure(road, parking, etc.)	x	x	x	x		x	5
	Per capita energy consumption, by fuel and mode	x	x	x	x			4
	Air and noise pollution exposure and health impacts	x	x	x	x	x	x	6
	Vehicle travel by mode (non motorized, automobile and public transport).		x	x	x	x		4
	Land use density (people and jobs per unit of land area)		x		x			2
Economic	Per capita congestion costs (Total time spent in traffic)	x	x	x		x	x	5
	Total transport expenditures (vehicles, parking, roads and transit services)		x					1
	Household expenditure allocated to transport (% budget)	x						1
	Expenditures on transportation for local government (annual , per GDP)	x						1
Social	Transport system diversity /transportation variety	x		x		x		3
	Quality of transport for disadvantaged people (disabled, low income, children, non-driver, etc.)	x	x	x				3
	Access to public transport (population served by public transit near around a train station, subway, bus stop)	x	x		x	x	x	5
	Fatality and injured of traffic accidents per capita or person/km	x	x	x	x	x	x	6
	Satisfaction of citizens and variety and quality of transport options (walking, cycling and public transport).	x	x	x			x	4
	Safety	x	x	x	x		x	5
	Health			x				1
	Gender equality/equity between societies and groups						x	1

Table 2 seventeen studies that recognized sustainable transportation indicators. Source: Haghshenas H, Vaziri M, 2012

No	References	Authors (year)	Urban SDI[a]	Urban STI[b]
1	Sustainable and cities: overcoming automobile dependence	Newman and Kenworth(1999)	40	22
2	Towards sustainable mobility indicators application to the Lyons conurbation	Nicolas et al. (2003)	-	18
3		Gillbert et al.(2003)	-	14
4	Sustainable transportation performance indicators (STPI)	Hezri and Hasan (2004)	30	3
5	Management framework for sustainable development indicators in the State of Selangor, Malaysia	Jeon and Amekudzi (2005)	-	30
6	Addressing sustainability in transportation system: definitions, indicators and metrics	Zegras (2006)	25	18
7		Savelson and Colman (2008)	-	14
8	Sustainable transport indicators and assessment methodologies Sustainable transportation in Halifax regional municipality.GPI(Genuine Progress Index) for Atlantic Canada	Moles et al.(2008)	40	11
9	Practical appraisal of sustainable development, methodology for sustainability measurement at settlement level	Litman (2008)	30	12
10	Sustainable transportation indicators Subcommittee of the	Appleton and Davies (2008)	-	12
11	Transportation Research Board SMART transportation ranking report (27 Canadian cities)	Li et al. (2009)	52	3
12	Measurement indicators and an evaluation approach for assessing	Litman (2009a)	-	35
13	urban stainable development (Chinas Jining city) Sustainable transportation indicator data quality and availability	Litman (2009b)	-	41
14	Well measured developing indicators for comprehensive and sustainable transport planning	Castillo and Pitfield (2009)	-	20
15	ELASTIC-a methodological framework for identifying and selecting sustainable transport indicators	Doody et al.(2009)	37	5
16	Evalution of the Q-method as a method of public participation in the selection of sustainable development indicators	Tanguay et al. (2010)	233	63
17	Measurement the sustainability of cities: an analysis of the use of local indicators(23study) The role of common local indicators in regional sustainability assessment	Mascarenhas etal. (2010)	55	5

[a] SDI: Sustainable Development Indicator.
[b] STI: Sustainable Transportation Indicator.

3.2 Sustainable transportation indicators initial selection

Bearing in mind that transportation is a main concern area for sustainability, selection of indicators for assessment of transportation sustainability possibly will play an significant role in the decision making progression. The selected indicators are helpful for pick out and emphasize problems, policy creating, recognizing trends, and assessing and monitoring of procedure. On the other hand, indicators have to be selected accurately in order that they clear no more than those subjects that are essential to sustainable transportation and related to the context.

In this step a pool of over 110 indicators, gathered from using Table 1 and Table 2 and other previous studies (Hak and Moldan, 2007; Hass *et.al*., 2002). Moreover, indicators that had more than three occurrence of use in different past studies were also collected. A long list of sustainable transportation indicators was selected. These indicators were selected and then a number of of them were redefined to meet the expectations of the following criteria: easily understandable, reasonable, measurable, possible to quantify, accessible, comprehensive, reflect various aspect of study, sensitive to changes over time, independent, standardized for comparison, clearly defined and capture long-term processes (Nourry, 2008; Litman, 2009; Li et al., 2009). Moreover, criteria introduced by Joumard et al., had also been taken into account for indicators selection. These criteria were categorized in 3 main groups as shown in Table 3 (Joumard and Gudmundsson, 2010):

Table 3 Groups of criteria that had been considered for indicators selection

Groups	Criteria
Representation	validity, reliability, sensitivity
Operation	measurability, data availability, ethical concerns
Policy application	transparency, interpretability, target relevance, action ability

3.3 Developed and distributed an stakeholders interview to transportation issues

Combination of transport problems and issues into indicator sets was observed aiming to achieve a more sustainable transportation.

Semi structured interview involved open-ended questions with stakeholders to investigate the most important issues and needs of transportation systems within the city of Hilla. 20 stakeholders were selected for participation in the interview.

3.4 Selection of final standardized indicators set

After the identification of transportation issues as well as long list of indicators and in proceeding towards the difficult work of developing the short lists of indicators, it was proposed to hold a workshop involving domain experts in addition to a group of scientists as well as senior advisors with a strong background in prospects studies along with utility infrastructure systems and representatives of stakeholders. The actual development would be strongly guided by the outcome of this workshop. The event had been announced publicly and had attended to the workshop **1.** All these groups were participated to achieve a brainstorming action to select indicators. The numbers of attendees are 10. The indicators were selected, evaluated, analyzed and revised based on consensus derived from attendees at the workshop. At the end of the workshop, issues were reviewed and formulation of indicators was done. This resulted in the production of 8 indicators. (Table 3 shows the standardized sustainable transportation indicators set for the case study). This process of sustainable transportation indicators selection possibly will provide a precious model for the assessment of transportation sustainability.

From a long list of indicators gathered thorough the previous steps, the most relevant indicators, 8 of them, are selected to form the indicator system. The indicator selection decision is made by the attendees of the workshop, The most relevant indicators for the transportation sustainability at case study of Hilla City, Iraq are selected by considering the transportation issues and the following core set of criteria which prepared by Litman (2007):

- **(**Comprehensiveness
- Data quality
- Comparability
- Easiness to understand
- Accessibility and Transparency

4 Results

The concluding set of the 8 most excellent performing and the majority suitable standardized sustainable transportation indicators set for the case study are show in Table 4. This set of 8 indicators that structure the transport sustainability outline for the case study and is the final production of the conceptual model. This group of 8 indicators exemplifies a part of a larger group of related indicators that systematically selected from initial extended list of indicators and within a technique that reproduces the issues that identified by the stakeholders interviewed.

Table 4 Final set of standardized sustainable transportation indicators for the case study

Standardized sustainable transportation indicators	
	Deaths and injuries from traffic accidents
	Availability of essential services locally
	Emissions of CO_2 from transport
	Transport energy consumption
	Emissions of air pollutants
	Public awareness of sustainable transportation issues
	Population exposed to noise
	Total time spent in traffic

5 Conclusions

Currently, there is no standardized set of sustainable transportation indicators. Thus there was urgent need for transportation organizations to develop standardized indicator sets, with gathering approach.

Developing standardized indicators set for assessment of transportation sustainability is becoming an essential task in many countries. The current research proposed a set of standardized transportation sustainability indicators of 8 indicators that may possibly provide an expensive model for the sustainability assessment of transportation performance. Furthermore this set will assist the policy strategies development to alleviate transport activities negative impacts.

This indicators set reflects the multidisciplinary nature of transportation. The current set of standardized indicators includes numerous sustainable transportation aspects, seeing that the subject of transport is extremely compound and linking several and a variety of aspects,

The proposed conceptual model should help decision-makers in transportation planning consider sustainable transportation issues by identifying better plans for readily available objectives.

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