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A balanced scorecard for performance evaluation of sustainable urban transport

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Abstract

Sustainability performance issues are increasingly crucial, especially in the urban transport sector. Urban transport sector's complex involvement with multiple attributes of society, environment and economy, multiple objectives targeted by multiple stakeholders as well as the continuous need to adapt, learn and innovate, traditionally it has been a very challenging task for transport policy makers and regulators to effectively measure and manage sustainability performance. Despite the immense need, an effective management of sustainability performance has not been adequately focussed in the literature. This paper develops an integrated framework for strategic performance evaluation of sustainable urban transport (SUT) using the Balanced Scorecard (BSC). Considering an integrated set of performance attributes of urban transport, including sustainability, stakeholder interest, process excellence, organization, learning and innovation, the BSC for SUT is developed through sequential methodological steps including the identification of performance attributes, integration of sustainability, development of perspectives and themes, integration of stakeholder interests and concerns, the choice of indicator properties, the choice of indicator development approach and the development of indicators. A performance measurement method is developed using a triangulation approach that quantitatively measures sustainability performance of urban transport. The BSC for SUT is demonstrated using the case of Singapore urban transport. An examination of the consistency of the performance obtained from BSC with the real-life in-depth review for all indicators indicates that an effective evaluation of sustainability performance in urban transport can be achievable using BSC. This paper concludes that through a balanced integration of essential parameters of sustainability along with their supporting drivers the BSC may establish an effective path in strategic performance evaluation of sustainable urban transport.

Keywords: Sustainable development, Sustainability, Balanced Scorecard, Performance measurement, Urban transport

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1. Introduction

Sustainability issues are increasingly crucial in the urban transport sector and this has led to increased attention and competitiveness to strive for sustainability goals. To achieve sustainability, it is imperative to develop an integrated framework capable of properly translating sustainability vision and mission to real life measurement and management for action. Such a framework may potentially help identify critical deficiencies from which appropriate sustainability strategies can be adopted for resource allocation and program prioritization. In the past, attempts appeared to focus on developing silo-indicators of social sustainability (e.g., Housley and Atkins, 2007) as well as environmental sustainability (e.g., OECD, 2002). Other sustainability studies have considered specific applications, such as smart technology deployment (e.g., Goldman and Gorham, 2006) or modal management (e.g., Buehler and Pucher, 2009). An integrated management framework for sustainability performance in urban transport has not been well addressed. The challenge is to develop a balanced measurement and management framework for sustainability in urban transport.

In recent years, performance measurement and management has been developed in organizations to enhance goals through increased competitiveness (Chan, 2004). The Balanced Scorecard (BSC) introduced by Kaplan and Norton (1992) is an improvement over the other prevailing indicator systems from several common points including: (a) a mechanism to provide a direct relationship between indicators and strategy, (b) a simplified set of indicators with a common framework helpful in strategic planning and management, and (c) a focus to measure strategic performance driven by mission and vision (e.g., Micheli and Kennerley, 2005; Vila et al., 2010; Voelker et. al, 2001). The BSC has received wide acceptance in public and private sectors (Voelker et. al, 2001) and has been implemented in education (e.g., Papenhausen and Einstein, 2006), health (e.g., Voelker et. al, 2001), tourism (e.g., Vila et al., 2010). It appears that this has not been employed in the transport sector and particularly in urban transport sustainability.

This paper attempts to develop a BSC as an integrated evaluation mechanism for strategic performance measurement of sustainability in urban transport. The sequential methodological steps in developing the BSC have been described in section 2 of this paper which include the identification of performance attributes, the integration of sustainability, the development of perspectives and themes, the integration of stakeholders, the choice of indicator properties and indicator development approach and the development of indicators. In section 3, a performance measurement method has been developed using a triangulation approach that quantitatively measures sustainability performance of urban transport. In section 4, the BSC for SUT has been demonstrated using the case of Singapore urban transport. Finally, section 5 discusses on the results and conclusions of this study.

2. Development of BSC for sustainable urban transport

This section describes the methodology adopted in developing the BSC for performance measurement of urban transport sustainability. In the public sector, while majority of the BSC studies (e.g., Chung et al., 2011; Gomes and Liddle, 2009) have considered the following common steps in developing BSC, i.e., (1) choice of

appropriate form, (2) development of perspectives and themes, (3) development of indicator set and (4) performance measurement and analysis; few have considered integration of stakeholders at varying extents (e.g., Chang et al., 2010) and few have considered integration of sustainability (e.g., Chai, 2009). However, there has been a lack of comprehensive BSC studies in public sector that adopts a systematic integration of both stakeholder and sustainability in the BSC. Urban transport being a major sustainability striving sector and involved with multiple levels of stakeholders seeking multiple goals, a critical understanding is required on the performance attributes of this sector prior to developing the BSC. Therefore we develop the BSC for sustainable urban transport, following the steps: (1) identification of performance attributes, (2) choice of appropriate form, (3) integration of sustainability, (4) development of perspectives and themes, (5) integration of stakeholders, (6) development of indicator set and (7) performance measurement and analysis.

2.1. Identification of performance attributes of SUT

In order to identify the performance attributes of sustainable urban transport, a rational approach is to start from material understanding of the definition of sustainable transport and its relevance in the urban context. Traditionally, the definition of sustainable transport has often been developed following the idea of sustainable development by Brundtland Commission (WCED, 1987), which defined 'sustainable development' as the "development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs", and consequently, most definitions for sustainable transport keep a focus on the three principal aspects of sustainable development – social equity, environmental protection and economic growth. Black (1996) defined sustainable transport as "satisfying current transport and mobility needs without compromising the ability of future generations to meet these needs". The European Council of Ministers of Transport (ECMT, 2001) has also defined sustainable transport on the basis of environmental, social and economic concerns.

Although definitions are available for sustainable transport, there has been a lack of comprehensive definition for sustainable urban transport. However the attributes of sustainable urban transport is generally understood as achieving social, environmental and economic sustainability goals in the context of urban high density growth, limited and constrained land area, increasingly intensive demand for quality transport services and higher level of commuter and citizen expectations and stakeholder concerns (Ahmed et al., 2008; Boschmann and Kwan, 2008; Buehler and Pucher, 2009). The sustainable urban transport is of greater interests to both national and urban authorities, mainly because, firstly, cities are the centers of national economic and industrial growth; secondly, cities being highly subject to rapid changes in technological innovations, livelihood patterns and living styles, the urban transport has to be rapidly adapted to meet the emerging needs; and thirdly, due to denser traffic movements, the impact of urban transport on the society, environment and economy are higher (Banister et al., 2007).

Traditionally, public sector BSCs have considered three major performance attributes: 'learning and innovation' (or input), 'internal process', and 'customer/ financial' (or outcome) (e.g., Chung et al., 2011; Gomes and Liddle, 2009; Wilson et al., 2003) for performance measurement. In recent years, there has been increased realization that the conventional attribute system may not adequately reflect the sustainability

goals and stakeholder interests, which are major aspects of public sector performance. Therefore, few studies have considered integration of 'stakeholders' at varying extents (e.g., Chang et al., 2010; Kollberg and Elg, 2011) and few have considered integration of 'sustainability' (e.g., Chai, 2009). However, there has been a lack of comprehensive BSC studies in public sector that adopts a systematic integration of both stakeholder and sustainability in the BSC.

Urban transport being a large public sector, continuously striving for sustainability goals as well as facing challenges in meeting multi-faced needs and interests of multiple stakeholders, the attributes 'sustainability' and 'stakeholder' can be even more relevant to this sector. Further to these, in order to achieve the objectives of sustainability as well as meeting stakeholder needs it is very important to adopt the traditional attributes of BSC, i.e., the 'internal process' and the 'input' (learning and innovation) attributes. Therefore, we consider these four performance attributes in developing the BSC for SUT.

2.2. Choice of appropriate form

Since public and private sectors are characterized with different motivations, the BSCs can be developed in either of two forms (Chai, 2009). In for-profit or private sector BSCs the outcome perspective is often the financial achievements (Kaplan and Norton, 1992), whereas, in non-profit or public sectors citizen satisfaction drives the mission and vision (Chai, 2009; Kaplan, 2001) and therefore both financial and user/citizen perspectives are considered as the outcome perspectives. Although at the micro level urban transport may involve private operators or suppliers it is essentially a domain for the public. A form for public sectors is chosen for performance measurement and management of urban transport sustainability, with required customization to suit the strategic objectives of sustainable urban transport, which are discussed in subsequent sections.

2.3. Integration of sustainability into BSC

A rational starting point aiming to incorporate sustainability into BSC for urban transport is to develop a conceptual understanding on the attributes of sustainability. Since Rio Earth Summit in 1992, the understanding of sustainability has developed further from the 'environmental' strategy to the integrated strategy encompassing the 'social', 'environmental' and 'economic' dimensions.

The initial BSC of Kaplan and Norton (1992), having four perspectives – *financial*, *customer*, *internal process* and *learning and innovation*, leaves high potential to integrate sustainability (Chai, 2009; Zingales and Hockerts, 2003). Sustainability is incorporated into BSC following one of the three possible approaches, depending on whether the application is private or public sector. The first approach adopts *sustainability* as an added perspective and used by Figge et al. (2002). The second approach integrates environmental and social aspects in the original perspectives, as discussed in Zingales and Hockerts (2003). Both of these approaches are mainly applied in private sectors, where the financial achievement is viewed as the key outcome and sustainability is often only an added objective. The third approach (Chai, 2009) adopts a broader attention to sustainability and is more suitable for the public sector. In this third approach, the social,

environmental and economic sustainability objectives are viewed as the outcome perspectives of BSC and the original BSC outcome perspectives are customized to suit mission and vision of public sectors in following ways: (1) the *customer* perspective is replaced by the *social* perspective, whose aim is serving the citizen and promoting social development instead of merely attracting customers from financial interest, (2) an *environmental* perspective is added, and (3) the *financial* perspective is replaced by *economic* perspective, to consider both financial measures as well as economic growth. Urban transport being a large public sector continuously seeking for social, environmental and economic sustainability outcomes, these sustainability dimensions need to be considered as the outcome perspectives in the BSC. Therefore, we adopted this third approach in this study.

2.4. Development of perspectives and themes

As discussed in the previous section, in order to integrate sustainability into BSC for SUT, the original BSC outcome perspectives are customized to suit mission and vision of sustainable urban transport, i.e., the *customer* perspective is replaced by the *social* perspective, an *environmental* perspective is added, and the *financial* perspective is replaced by the *economic* perspective. Accordingly, three key themes of sustainability - '*social*', '*environmental*' and '*economic*' is incorporated into *social*, *environmental* and *economic* perspectives of BSC, respectively.

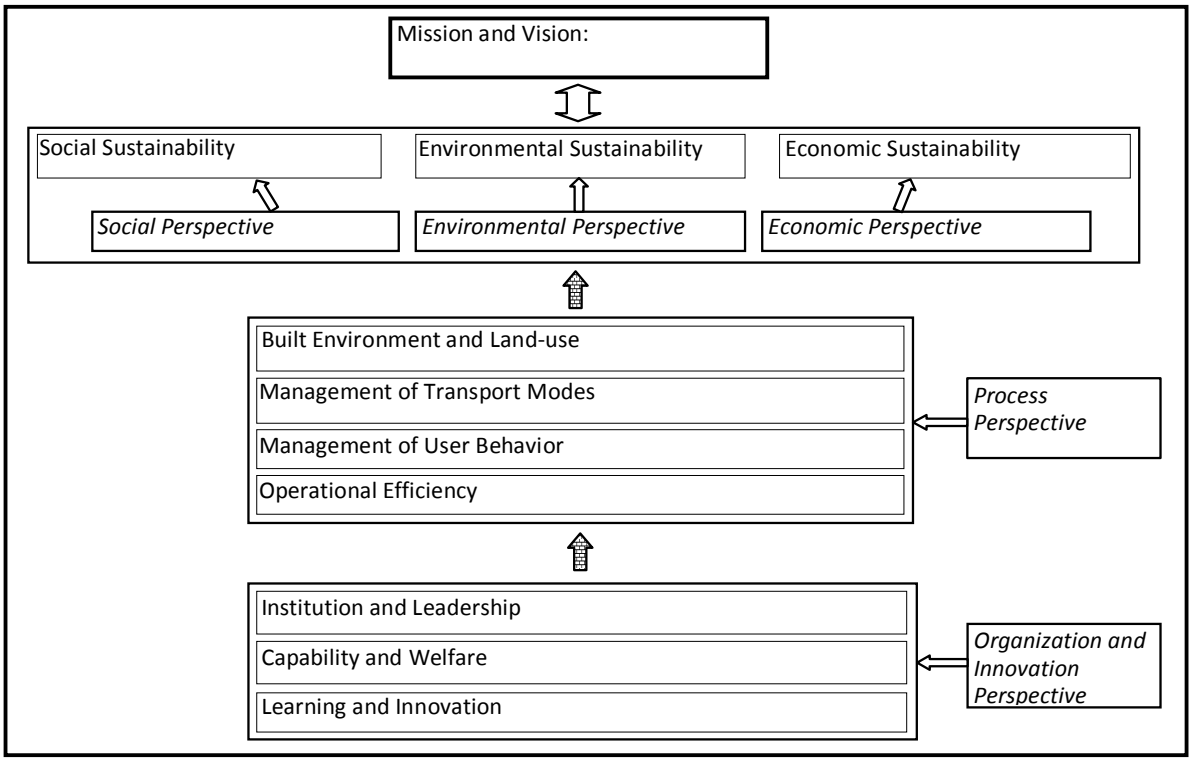

Figure 1. Proposed Framework of BSC for Sustainable Urban Transport

(*Note:* Following mission and vision on the top, *italic* texts denote perspectives and normal texts denote themes)

We customize the '*internal process'* perspective to the '*process'* perspective, because transport being a large-scale public sector, there has been significant involvement of this sector's process and activities to those of other sectors and stakeholders. In particular, urban transport process is greatly involved with all kinds of urban land-uses and associated public services; other ministries and their agencies including security, legislation, finance, environment, energy, commerce and education; and, supplier and partner stakeholders. In determining themes for the *internal process* perspectives, Kaplan (2001) recommends asking the basic question, i.e., "*To satisfy customers/citizens, at which internal processes we must excel?*" We customize this question for the *process* perspective of sustainable urban transport to: "*To achieve social, environmental and economic sustainability outcomes (thus satisfying citizen, government and other stakeholders), at which processes we must excel?*" Kaplan and Norton (2008) argue that, the choice of themes for the *internal process* perspective is more specific to sector/ organization, however, it should always be guided by the concept of the question as stated above. In the transport sector application, we used the well-known three-pronged 'infrastructure-mode-user' model (Rodrigue et al., 2009) that holistically address the process of transport system and we argue that a sound processing of these components is imperative to achieve sustainability in urban transport. In addition to these, the actual transport service is realized to achieve sustainability goals in the form of 'operation' that makes use of these three components: infrastructure, mode and user. We argue that, an efficient operation of transport services, which effectively makes use of infrastructure, modes and users, is imperative to achieve sustainability in urban transport. Therefore, we propose four themes, i.e., '*built environment and land-use*', '*management of transport modes*', '*management of user behavior*' and '*operational efficiency*' to be appropriate in answering the basic question developed above and incorporated into the *process* perspective.

Further, we customize the '*learning and innovation*' perspective to the '*organization and innovation*' perspective. Unlike a 'single-institution' private or public organization/sector, multiple institutions exist in the urban transport sector, because of its involvement with multiple aspects of the society, environment and economy. Therefore in order to achieve sustainability, there is a high need for an effective and efficient organization and integration of these institutions. In determining themes for the *learning and innovation* perspectives, Kaplan (2001) recommends asking the basic question, i.e., "*How can the organization/sector continue to learn and improve?*" Kaplan and Norton (2008) points out that, the *learning and innovation* perspective should aim to "*create a high-performance culture*", and they further specified that, this culture can be created through adoption of a three-pronged theme set that intends to: (1) "*develop leadership and an execution-driven culture",* (2) *"expand and build strategic skills, capabilities and expertise"*, and (3) "*enable and require continuous learning and sharing of knowledge"*. In the urban transport, in order to ensure adequate coverage, integration and efficiency of institutions associated with urban transport, we customize the intention of the first theme to "*develop leadership, institutionalization and an execution-driven culture".* Further, considering the need for employee welfare in order to enhance capability, we customize the intention of the second theme to "*expand and build strategic skills, capabilities, expertise and welfare".* Therefore, we found that the three themes, i.e., '*institution and leadership*', '*capability and welfare*' and '*learning and innovation*' are more appropriate in the urban transport context, and therefore incorporated

into the *organization and innovation* perspective. The proposed framework of BSC for sustainable urban transport is presented in Figure 1.

2.5. Integration of stakeholder concerns and interests into BSC

Identification of stakeholders in urban transport:

The major stakeholders in the public sectors include customers/ users (e.g., Somers, 2005; Voelker et al., 2001), local community (e.g., Chang et al., 2010; Wisniewski and Stewart, 2004), government/ shareholders/ funding authorities (e.g., Tencati et al., 2004), suppliers and partners (e.g., Chang, 2006), regulatory agencies (e.g., Wisniewski and Stewart, 2004), employees (e.g., Walker and Boyne, 2006) and media (e.g., Wisniewski and Stewart, 2004).

Despite being a sector involved with multiple stakeholders, there has been a lack of comprehensive studies in the transport sector regarding stakeholders. The major stakeholders as identified in previous studies include community/ users (Fouracre et al., 2006; Khayesi, 1999), politicians/ owners (Khayesi, 1999), regulators and other agencies (Fouracre et al., 2006; Khayesi, 1999), operators (Fouracre et al., 2006; Khayesi, 1999), employees (Khayesi, 1999) and researchers (Fouracre et al., 2006). Stakeholders which have not been adequately considered are the governments of other countries (they are also stakeholders primarily due to global environmental impacts of urban transport), suppliers, external process stakeholders, local and global sustainability pressure groups and the media.

Development of a 'balanced' approach for stakeholder categorization:

We adopt a balanced approach for stakeholder identification, which embraces a top-down identification of stakeholders from the policy level through the process to the impact level of urban transport system. In particular, we categorize the stakeholders into ten major groups, i.e., 1) government/ urban authority/ political parties/ financing authorities, 2) regulators, sub-agencies and external agencies, 3) managers and employees, 4) operators, 5) suppliers, 6) external process stakeholders, 7) researchers and innovators, 8) media, 9) users, citizens/ local community, and 10) global community. This approach of stakeholder categorization has several advantages. Firstly, it allows a more comprehensive and objective approach to stakeholder identification. Secondly, this approach helps understand and align stakeholders according to their involvement in the whole strategy map of BSC for achieving sustainability goals. Thirdly, being organized this approach has direct transferability to the strategic framework of BSC.

Integrating stakeholders into BSC themes and perspectives:

Several approaches are available to integrate stakeholders into the BSC. In the following sub-sections the limitations of these approaches are discussed, which helps identify the characteristics of a robust approach for stakeholder integration into BSC.

Table 1. Stakeholder Categorization and Incorporation into BSC

Stakeholder Group	Major Interests/ Concerns	BSC Theme	BSC Perspective
1) Government/ urban authority/ political parties/ financing authorities	Financial growth/ revenue; cost minimization; satisfied voters through sustainability outcome (social, environmental and economic sustainability)	Institution and Leadership	Organization and Learning
		Social Sustainability	Social
		Economic Sustainability	Economic
		Environmental Sustainability	Environmental
2) Regulators (e.g., principal transport authority); sub-agencies (e.g., public transport council) and external agencies (e.g., ministry of environment, traffic police, ministry of finance)	Institutional efficiency and integration; strategic alignment; effective investment; Social, environmental and economic sustainability	Institution and Leadership	Organization and Learning
		Social Sustainability	Social
		Economic Sustainability	Economic
		Environmental Sustainability	Environmental
3) Managers and employees	Financial benefits; skill development opportunities; motivation and rewards; other benefits including flexible work hour, health and children education	Capability and Welfare	Organization and Learning
4) Operators (infrastructural, modal, regulatory and enforcement)	Financial and other benefits; institutional integration; skill development; access to resources and information	Operational Efficiency	Process
5) Suppliers of products and services (e.g., infrastructural, vehicle and material manufacturers/suppliers; contractors; consultants)	Financial and other benefits; skill development; access to resources and information	Operational Efficiency	Process
6) External process stakeholders (e.g., utility line authorities, urban forestry and beautification authorities, social and public advertisement authorities, business entities)	Right of access, minimized disruption, proper integration	Built Environment and Land Use	Process
7) Researchers and innovators	Access to information; institutional and financial supports	Institution and Leadership	Organization and Learning
		Research and Innovation	Organization and Learning
8) Media	Access to information	Institution and Leadership	Organization and Learning
9) Users, citizens/ local community	Social, environmental and economic sustainability; Public participation opportunities	Social Sustainability	Social
		Economic Sustainability	Economic
		Environmental Sustainability	Environmental
		User Behavior Management	Process
		Learning and Innovation	Organization and Learning
10) Global community	Global environmental sustainability; Response to global feedback	Environmental Sustainability	Environmental
		Learning and Innovation	Organization and Learning

The *first* approach focuses on only financial and customer stakeholders, e.g., Gomes and Liddle (2009) in a non-profit third sector organization. The advantage of this approach is it represents a simplistic

incorporation of most focused stakeholders. However, this approach focuses on only outcome stakeholders with a rather narrow perspective, since financial and customer stakeholders are considered, instead of economic and community/social stakeholders, respectively, and environmental, process and input stakeholders remain potentially ignored. The *second* approach focuses on only customer and community stakeholders, as found in a several health-care organization studies (e.g., Chang et al., 2002). The advantage of this approach is that it is simplistic and intensively focuses on their key 'outcome' stakeholders: the customers and the community. However, by ignoring financial/ economic and environmental indicators, it may not exhaustively represent sustainability outcome of urban transport. Moreover, this approach may potentially ignore process and input related stakeholders, e.g., suppliers and employees. The *third* approach focuses on financial, customer and employee stakeholders, as found in public sector (e.g., Wilson et al., 2003), municipal governments (e.g., Chan, 2004), or mental health trust (e.g., Schmidt et al., 2006). The advantage of this approach is that it simplistically addresses most 'outcome' and 'input' stakeholders. However, this approach may potentially ignore economic, environmental or process related stakeholders. The *fourth* approach exhaustively addresses 'outcome' stakeholders (social, environmental and economic) and few 'input' indicators (e.g., Chai (2009) for public sector). This approach is advantageous, as it exhaustively addresses all 'outcome' stakeholders. However, this approach may potentially ignore several process related stakeholders, e.g., suppliers, operators etc. The *fifth* approach incorporates a separate perspective for stakeholders and addresses the interest of major stakeholders in this perspective (e.g., Voelker et al. (2001) in health-care, Papenhausen and Einstein (2006) in education, or Somers (2005) for social sector). This type of BSC is often known as 'Stakeholder BSC', whose core objective is to satisfy their stakeholders. This approach is advantageous, as it addresses all stakeholders in a single perspective. However, since this approach accumulates stakeholders from all levels of BSC strategic map (input, process, outcome) into a single perspective, it potentially ignores the strategic causal relationship of BSC and therefore cannot lead to "objectives or measures for *how* the balanced goals are to be achieved" and "is not an adequate foundation on which to build a management system" (Kaplan and Norton, 2001). The *sixth* approach adopts a rather random development of perspectives, without a clear strategic causal relationship and incorporates all stakeholders into these perspectives based on the thematic aims of these perspectives (e.g., Chang et al. (2010) in health sector). This approach also can be advantageous, as it addresses all stakeholders. However, since the stakeholders are incorporated into BSC through rather random perspectives without adequate strategic foundation, a robust management system cannot be built based on this approach.

The foregoing shows that, the incorporation of stakeholders into public sector BSC frameworks has gradually developed from a focus on specific 'outcome' stakeholders to a more comprehensive focus on all levels of stakeholders. However, there is still a lack in strategic alignment of stakeholders in the BSC. In order to ensure a robust strategic management through BSC, the stakeholder incorporation into BSC needs to be aligned with the strategic causal relationship among different levels of BSC indicators. Therefore, a more strategically compelling approach is to incorporate stakeholders' interests according to their 'strategic alignment' with the BSC perspectives. This approach can be even more relevant to urban transport, since this sector has significant involvement with stakeholders of all strategic levels of BSC (input, process, outcome) and often being a large public sector involved with multiple attributes of society, economy and environment,

a proper strategic management is required in order to improve performance of this sector. Therefore, we adopted this approach in our study.

The stakeholders of urban transport are tabulated in Table 1 according to their groups, interests/ concerns and potential involvement in the themes and perspectives of BSC.

2.6. Development of indicator set

This step discusses the methodology adopted in developing the indicator set for different perspectives and themes of the BSC. In developing the indicator set Mitchell (1996) proposes three key steps for sustainability indicator development, i.e., (1) choice of indicator properties, (2) choice of indicator development approach, and (3) determination of indicators. However, decision on the number of indicators being a key success attribute of BSC, we adopt the following four steps in developing the indicator set: (1) choice of indicator properties, (2) choice of number of indicators, (3) choice of indicator development approach, and (4) determination of indicators.

2.6.1. Choice of indicator properties

In developing indicator set for public sector BSC, researchers and practitioners often propose and use a simple set of indicators which is based on the strategic objectives of the sector, easily understandable to public as well as all levels of employees, easily applicable and does not require complex information that is often unavailable (Chang et al., 2010; Chung et al., 2011; Vila et al., 2010). The BSC literature has often criticized the traditional indicator developments, which does not transfer a clear strategic goal of the sector and requires high levels of complex information which is often hardly available, making them complex and difficult to use (Vila et al., 2010). Therefore, in developing the key performance indicators we chose the following indicator properties: (1) indicators should correspond to underline sustainability goals; (2) indicators should be driven from and cater for needs of the users and stakeholders; (3) indicators should be relevant, measurable (subjective or objective), sensitive and time-based (Mitchell, 1996); (4) indicators should embrace properties of causality, i.e., they should link together through the five perspectives of the BSC and be consistent with sustainability mission and vision of urban transport; and (5) indicators should ensure a 'balance', i.e., an assessment of all essential set of areas should be covered.

2.6.2. Choice of number of indicators

A small number of simple indicators has often been cited as one of the practical success factors of BSC, as compared to traditional indicator developments which end up developing a long list of often 'sophisticated' indicators, which are hard to convey to people and employees, difficult to gather sophisticated information, requires high level of time and resource and therefore, may create lack of enthusiasm in performance measurement (e.g., Chang et al., 2010; Vila et al., 2010; Wilson et al., 2003). BSC studies have often criticized the long-list nature of traditional indicator developments, as "for most of these indicators, the number of proposed indicators is very high, making them complex and difficult to use" (Vila et al., 2010). Butler et al.

(2011) argue that, the indicators should not be too many in number, as this may lead to distraction, may draw attention away from central strategy and make it difficult to use. In general, it is often argued that, making a long list of indicators reduces the practical applicability of the indicator development and in order to avoid this, it is often recommended to carefully develop a few number of simple 'area' indicators which significantly reflect the strategic objective of each of the BSC perspectives and themes. While Kaplan and Norton (1996) recommend 20-25 indicators for a typical BSC, a varied number of indicators appear in different BSC developments. In the public sector, the number of indicators has varied depending on the nature and strategic objective of public sector. There are evidences of developing a set of 15 indicators for the health sector (Kollberg and Elg, 2006), 23 indicators for a mental health trust (Schmidt et al., 2006), 17 indicators for a public IT sector (Chung et al., 2011), 44 indicators for tourism sector (Vila et al., 2010), 32 indicators for a non-profit third sector (Gomes and Liddle, 2009), 41 indicators for a municipal government (Chan, 2004) and 27 indicators for public building sector (Wilson et al., 2003). Considering that, the indicators have to be small in number and at the same time, they have to significantly represent the performance attributes of urban transport in each of the BSC perspectives and themes, we develop a set of 45 indicators for the BSC of sustainable urban transport.

2.6.3. Choice of indicator development approach

In determining the indicator set, there are mainly four approaches. The *first* involves expert consultation and interviews, as adopted in Gomes and Liddle (2009), and is mainly useful when the subject is related to a very specific area with a lack of adequate literature. The *second* approach involves review of literature, and is preferred when literature is available, but, cost of expert consultation is high (Mitchell, 1996). The *third* approach involves both synthesis of literature and expert consultation, as adopted by Chung et al. (2011), usually expert opinions complementing literature synthesis (Segnestam, 2002). The *fourth* approach develops performance indicators based on the strategic objectives of the BSC perspectives and themes and has been used in public sector (Chai, 2009; Papenhausen and Einstein, 2006; Wilson et al., 2003). In our study, in order to ensure a self-validating mechanism in the development of key performance indicators, we adopted an integrated approach that grasps the advantages of all the prevailing approaches. In particular, we determined the strategic objectives of each of the BSC perspectives and themes in the context of sustainable urban transport, and based on these objectives, we conducted a literature review on measures significantly contributing to achieve these objectives. As the next step, we developed the indicator set based on the understanding developed from the strategic objectives as well as the literature review and synthesis. Further, the developed set was consulted with experts for feedback and validation, and the final set was determined. This approach is relevant to urban transport for the following major reasons, i.e., *firstly*, urban transport, being a large public sector where the social, environmental and economic sustainability are vital, and multi-facing stakeholders exist at multiple levels, the need for determination of clear strategic goals is very important; *secondly,* literature is available; and *thirdly*, the cost of expert consultation is not high. The perspectives and themes of the BSC, along with consideration for stakeholder integration, guided the literature review. In choosing experts, four basic preferences were considered, i.e., experts must have comprehensive knowledge, experience, willingness and sufficient time. In our study the experts comprise a

selected international panel in the area of urban transport sustainability. A total of 4 experts responded to our invitation to participate. All of the experts have detailed knowledge and substantial years of practical experience in the urban transport as academics, government officials, professionals and consultants.

2.6.4. Determination of indicators

The set of indicators for each of the BSC perspectives and themes was initially developed based on the strategic objectives of the perspectives and themes, with an integration of stakeholders and a comprehensive literature review on which measures can significantly contribute to these objectives. The developed indicator set was further consulted with experts for feedback and validation purpose. The indicator set was finalized through a two-round 'Delphi' process. The proposed perspectives, themes and indicators of BSC of SUT are presented in Table 2. In Table 2, the indicators with an asterisk (*) denotes an indicator with major user-experience. The following sub-sections briefly describe the indicators of BSC.

Social perspective:

In the literature a wide range of definitions appear regarding the social sustainability. McKenzie (2004) has provided a comprehensive definition of social sustainability: "*Social sustainability occurs when the formal and informal processes, systems, structures and relationships actively support the capacity of current and future generations to create healthy and livable communities. Socially sustainable communities are equitable, diverse, connected and democratic and provide a good quality of life.*" In the public sector BSC studies, indicators for social sustainability have been identified and used in the context of the sector in concern. These indicators include accessibility (e.g., Urrutia and Eriksen (2005) for health care); affordability (e.g., Chai, 2009); quality service (e.g., Schmidt et al. (2006) for health; Wilson et al. (2003) for public sector); safety (e.g., Chang et al., 2010); security (e.g., Chang et al., 2010); and equity (e.g., Vila et al. (2010) for tourism; Wilson et al. (2003) for public sector).

In sustainable urban transport, the *social* perspective aims to ensure social satisfaction and development through provision of equitable transport services. Unlike many other public sectors, one important social sustainability indicator of urban transport is the employment growth, because transport accessibility, services and network have a significant role on creation of job opportunities. From a stakeholder point of view, the major stakeholders to social sustainability of urban transport are, firstly, the users and citizens/ local community, who constantly look for socially sustainable transport services and attributes, and secondly, the government/ urban authority/ political parties or financing bodies, who are interested in a socially sustainable urban transport in order to make satisfied voters or to enhance the social outcome dimension of their investment. The indicators of the social perspective need to reflect the interests of these stakeholders.

The social sustainability aspect of urban transport has been discussed in several studies including those by Housley and Atkins (2007), Ahmed et al. (2008) and Boschmann and Kwan (2008). All of these studies have highlighted accessibility, affordability, comfort, safety, security, equity and employment growth as prime indicators for social sustainability which are further used in several sustainable transport

development projects at national and international levels including those by Texas Department of Transport (Ramani et al., 2009) and Non-Agricultural Market Access (NAMA) countries (Mohanty, 2011).

Environmental perspective:

World Bank (2008) defines environmental sustainability as "*ensuring that the overall productivity of accumulated human and physical capital resulting from development actions more than compensates for the direct or indirect loss or degradation of the environment*". In the public sector BSC studies, indicators for environmental sustainability have been identified and used in relation to context of the sector in concern. These indicators majorly include carbon emission (e.g., Chai (2009) for public sector); energy consumption and waste management (e.g., Vila et al. (2010) for tourism).

The *environmental* perspective of sustainable urban transport aims to ensure a livable and ecologically sustainable environment for current and future generations. Unlike many other sectors, who are mainly concerned with carbon emission, energy consumption and waste management, two important environmental sustainability indicators of urban transport are the air pollution and the noise impact. From a stakeholder point of view, the major stakeholders of environmental sustainability are firstly, the users and citizens/ local community, who constantly look for environmentally sustainable transport; secondly, the global community, who are affected by the greenhouse gases and other atmospheric emissions from transport; and thirdly, the government/ urban authority/ political parties or financing bodies, who are concerned about the environmental sustainability of urban transport in order to gain satisfied voters or to enhance the environmental outcome dimension of the investment. The indicators of the environmental perspective need to reflect the interests of these stakeholders.

Earlier studies including those by Nijkamp (1994) and Greene and Wegener (1997) provide comprehensive discussion on the local and global environmental impacts of transport. These studies address global environment, local environment, noise, energy and waste as principal environmental indicators which have been used by international organizations including Organization for Economic Co-operation and Development (OECD, 2002) to formulate guidelines for Environmentally Sustainable Transport (EST) as well as by several national bodies (e.g., Mohanty, 2011) to develop strategic plans for EST.

Economic perspective:

Compared to social and environmental sustainability dimensions, there has been little attempt in the literature to define the concept of economic sustainability. However, it is often understood as an 'economic system' in which "*society's well-being would be maximized and poverty eradicated through the optimal and efficient use of natural resources*" (UNDESA, 2002). Miller (1994) defines 'sustainable economy' as an "*economic system in which the number of people and the quantity of goods are maintained at some constant level*". Unlike many private sector BSC studies, which use financial measures rather than economic sustainability, in the public sector BSC, the *economic* perspective has often been argued to consider both financial and economic growth measures (e.g., Chai, 2009). While financial measure is reflected through the use of the indicator 'revenue/ profit' (e.g., Schmidt et al. (2006) and Voelker et al. (2001) for health sector),

the economic growth measures are often sector specific. Among others, the savings of external cost has often been reflected as an economic growth indicator (e.g., Wilson et al. (2003) for public sector; Papenhausen and Einstein (2006) for education).

In the urban transport, the objective of the *economic* perspective is to ensure a vibrant economic growth along with enhanced revenue in order to maintain financial viability of urban transport and support social and environmental sustainability initiatives. From a stakeholder point of view, the major stakeholders of economic sustainability are, firstly, the users and citizens/ local community, who look for an efficient transport system that helps them grow economically as part of national development; secondly, the government/ urban authority or political parties who are concerned about the economic growth from urban transport in order to maintain national or local progress which will lead to satisfied voters; and thirdly, the financing bodies, who looks for financial returns as well as economic growth through the investment. The indicators of the economic perspective need to reflect the interests of these stakeholders.

Compared to social and environmental sustainability, there have been little attempt in the urban transport literature to develop key indicators for economic sustainability. However, urban transport being a public sector seeking for economic growth and financial enhancement, the indicators for economic perspective can be derived considering both the financial and economic growth aspects of urban transport. The financial aspect has two indicators: revenue enhancement and effective investment. While we use the revenue enhancement as an indicator in the *economic* perspective, we argue that, in the urban transport context, the effective investment acts more as a principal input to sustainable development as part of organizational capability, rather than as an indicator of economic sustainability. Therefore we use effective investment as an indicator of the *organization and learning* perspective. In deriving the indicators for economic growth, one similarity of urban transport with other public sectors exists in reducing the external costs. Further, a comprehensive review of the literature discussing economic aspect of the urban transport literature reveals that, an economically sustainable transport can be viewed through enhanced mobility that supports movement of people and goods most efficiently and desirably, that supports industrial and business growth and other economic sectors as well as that minimizes congestion through a proper travel demand management along with financial and technological measures (e.g., Buehler and Pucher, 2009; Greene and Wegener, 1997, Hayashi et al., 2004). Therefore, in addition to 'revenue enhancement' and 'external cost savings', two indicators are proposed, i.e., 'mobility and economic growth', which maps and measures the contribution of urban transport in enhancing economic growth through enhanced mobility, and 'congestion and travel demand management', which maps how effectively this sector has been able to reduce congestion and manage travel demand.

Process perspective:

Strategically, the purpose of the *process* perspective is to ensure efficient internal operations that will lead to the achievement of the sector's strategic goals (outcome perspectives) while satisfying internal and external stakeholders involved in the process. Unlike social, environmental and economic sustainability perspectives,

where a range of similarity exists between the indicators of urban transport and other public sectors, the indicators of the process perspective are dominantly sector specific.

In the urban transport, the *process* perspective has four major themes: *'built environment and land use'*, '*management of transport modes'*, '*user behavior management*' and '*operational efficiency*'. The major stakeholders of the *process* perspective are, firstly, the operators (infrastructural, modal, regulatory and enforcement), who are interested in the financial and other benefits; institutional integration, skill development, and access to resources and information; secondly, the suppliers of products and services (e.g., infrastructural, vehicle and material manufacturers/ suppliers; contractors; consultants), who look for financial and other benefits, skill development, and access to resources and information; and thirdly, the external process stakeholders, whose interests involve right of access, minimized disruption and proper operational coordination. The indicators of the process perspective need to reflect the interests of these stakeholders. In urban transport, the interests of the external process stakeholders (e.g., utility line authorities, urban forestry and beautification authorities, social and public advertisement authorities, business entities) are involved with the process of the theme *'built environment and land use*' and those of the operators and suppliers relate to the *'operational efficiency'* theme.

The objective of the theme '*built environment and land use'* is to ensure an effective infrastructural system that supports the process of urban transport to achieve sustainability goals. The indicators of the theme '*built-environment and land use*' have been addressed in the urban transport literature, rather from a scattered approach. Some studies (e.g., Greene and Wegener, 1997; Jolley, 2004; Ahmed et al., 2008) have pointed out two major measures, i.e., land-use and transport integration, and infrastructure management, for a sustainable infrastructural development. However, most of these studies, being conducted in the national context, have placed inadequate focus on the parking management, which is mainly an urban feature. A few other studies (e.g., Goldman and Gorham, 2006) have pointed out the need for parking management in the urban context. On the whole, there has been a lack of integrated approach to develop key indicators for the 'built environment and land use' theme. Further, there have been little studies which discuss the stakeholder interests of this theme. In particular, the indicator 'land use and transport integration' has often been interpreted and understood only from the travel demand management, accessibility and connectivity points of view, and little focus has been attempted to realize the involvement and interests of external process stakeholders (e.g., utility line authorities, urban forestry and beautification authorities, social and public advertisement authorities, business entities) in this indicator. Based on the theme's strategic objective, sustainability and stakeholder integration and a critical understanding developed from the literature review, three key indicators are proposed, i.e., land use and transport integration, management of transport infrastructure and management of parking facilities, for this theme.

The theme '*management of transport modes*' intends to ensure effective management of urban transport modes which supports the process of urban transport in achieving sustainability goals. The theme 'management of transport mode' has been focused in the urban transport literature only from a scattered approach, and there has been a lack of integrated study. While most of the studies (e.g., Banister et al., 2007; Ahmed et al., 2008) restrict themselves within the discussion of traditional indicators, i.e., promotion of public transport, control over private vehicles and promotion of non-motorized transport, some studies (e.g.,

Mohanty, 2011) have focused on efficiency of commercial goods transport. Among others, few studies have focused on the indicator 'promotion of green transport' (e.g., Kohler et al., 2009) and very few on 'promotion of vehicle sharing practices' (e.g., Goldman and Gorham, 2006). Further, there has been a lack of adequate focus on 'integration among passenger modes', which would consider the integration among different passenger modes regarding physical facilities, time-synchronization, ticketing, fare structure and fare collection system, as well as ease of transfer and efficiency of mixed traffic operations; and is a very important modal indicator of urban transport. On the whole, the comprehensive literature review and synthesis reveals that, indicators of the national level transport have been more discussed, while those of the urban transport have received little and rather isolated focus, probably due to inadequate integrated studies devoted to urban context. Based on the theme's strategic objective and a critical understanding developed from the literature review, seven key indicators are proposed, i.e., promotion of public transport, control over private vehicles, promotion of non-motorized transport, integration among passenger modes, efficiency of commercial goods transport, promotion of green vehicles, and promotion of vehicle sharing practices, for this theme.

The objective of the theme *'user behavior management'* is to ensure a sustainable user behavior and attitude in the process of urban transport which is supportive to achieve sustainability goals. Compared to the sustainability (outcome) themes, the theme 'user behavior management' has received poor focus in the urban transport literature and there is a lack of integrated study regarding this theme. However, the aspects of this theme have been discussed in scattered manner. In particular, few studies (e.g., Banister et al., 2007; Vergragt and Brown, 2007) have focused on the indicator 'awareness and education', and very few (e.g., Goldman and Gorham, 2006) on the indicator 'legislation and enforcement'. We argue that, the intention of the indicator 'awareness and education' is to create long-term transition in the user's mindset, which is very important to achieve long-term sustainability. Therefore, we retitle it to 'awareness, education and transition'. On the whole, based on the strategic thirst of the theme and a review of the available literature, we propose two key indicators, i.e., awareness, education and transition, and legislation and enforcement, for this theme.

The theme '*operational efficiency*' intends to ensure an effective operation of urban transport process, which is supportive to achieve sustainability goals. The operational efficiency of urban transport can be achieved through the use of smart technologies in different dimensions of operation as well as meeting the needs of the stakeholders involved in the operational process. In the urban transport literature, the theme 'operational efficiency' has been discussed rather following a scattered approach, and there has been a lack of integrated study. While few studies (e.g., Kohler et al., 2009; Vergragt and Brown, 2007) highlight smart infrastructure and vehicle technologies as measures for efficient operation in general; some others (e.g., Jolley, 2004; Mohanty, 2011) discuss on specific smart operations, including smart road pricing, smart fare collection and advanced traveler information. Very few studies (e.g., Goldman and Gorham, 2006) address smart congestion and incident management as a measure for sustainable urban transport. Goods transport being an important feature of urban transport operation, we retitle the indicator 'advanced traveler information' to 'advanced traveler and goods information'. Further, there has been a lack of studies to address the interests of stakeholders involved in the operational process. These stakeholders include

operators and suppliers of products and services. Therefore, based on the theme's strategic objective and stakeholder integration and a critical understanding developed from the literature review, eight key indicators are proposed, i.e., smart infrastructure technologies, smart vehicle technologies, smart road pricing, smart fare collection, advanced traveler and goods information, smart congestion and incident management, operator capability and welfare and supplier capability and welfare, for this theme.

Organization and innovation perspective:

The strategic purpose of the *organisation and innovation* perspective is to ensure an effective institutionalization with enhanced skills and capability and continuous learning through feedback, research and innovation activities (as input) that will support the process (or output) of urban transport in order to achieve the sustainability goals (as outcome). *Organization and innovation* is often understood as an innovative perspective in the concept of BSC, since traditional scattered indicator system mostly focus on the outcome indicators, while very few addresses the process indicators, and the input indicators of this perspective are often ignored in the traditional indicator systems.

In the urban transport, the *organisation and innovation* perspective has three major themes, i.e., *'institution and leadership'*, '*capability and welfare'*, and '*learning and innovation'*. The major stakeholders of the *organisation and innovation* perspective are, firstly, regulators (e.g., principal transport authority); sub-agencies (e.g., public transport council) and external agencies (e.g., ministry of environment, traffic police, ministry of finance), who seek for an efficient and integrated institutionalization and effective investment; secondly, managers and employees, who are interested in the financial benefits, skill development opportunities, motivation and rewards, and other benefits including flexible work hour, health and children education; thirdly, the sustainability pressure groups at local and global level, who want that the urban transport will be sufficiently responsive to public feedback and global environmental concerns; fourthly, the media, which seeks for information access; and fifthly, the researchers and innovators, whose interests involve access to information and institutional and financial supports. The indicators of the *organisation and innovation* perspective need to reflect the interests of these stakeholders. In urban transport, the interests of the regulators, sub-agencies, external agencies and media are met through indicators of the theme *'institution and leadership'*; those of the managers and employees are considered in the theme '*capability and welfare'*; and those of the local and global sustainability pressure groups, researchers and innovators are met through indicators of the theme '*learning and innovation'*.

The objective of the theme *'institution and leadership'* is to enhance the organizational capability through an effective institutional system and leadership culture. In other public sectors, the theme *'institution and leadership'* have often been understood as the *'institution'* theme, probably because most of the other public sectors are comparatively less sensitive to leadership and political stability, as it is in the urban transport, which often involves cost intensive and long-duration mega projects of transport infrastructure. Therefore, in other public sector BSC studies, the indicators of the *'institution'* theme have less focused on the leadership and political attribute. The major indicators used in other public sectors regarding this theme include 'institutionalization' (e.g., Chai (2009) for public sector), 'investment' (e.g., Urrutia and Eriksen (2005) for

heath sector) and 'information system' (e.g., Chung et al. (2011) for public IT sector; Gomes and Liddle (2009) for non-profit third sector).

Table 2. Perspectives, Themes and Indicators of the Balanced Scorecard

Perspectives	Themes	Indicators
I. Social	Social Sustainability	a) Accessibility, connectivity and travel time* b) Affordability* c) Level of service and comfort* d) Safety enhancement* e) Security enhancement* f) Social equity, culture and coherence* g) Employment growth*
II. Environmental	Environmental Sustainability	a) Impact on global environment b) Impact on local air quality and ecology* c) Impact on local noise level* d) Sustainable energy consumption e) Sustainable waste management
III. Economic	Economic sustainability	a) Revenue enhancement b) External cost savings c) Mobility and economic growth d) Congestion and travel demand management*
IV. Process	1. Built Environment and Land-use	a) Land-use and transport integration b) Management of transport infrastructure* c) Management of parking facilities*
	2. Management of Transport Modes	a) Promotion of public transport* b) Control over private vehicles c) Facilitation of non-motorized transport* d) Integration among passenger modes* e) Efficiency of commercial goods transport f) Promotion of green vehicles g) Promotion of vehicle sharing practices*
	3. Management of User Behavior	a) Awareness, education and transition* b) Legislation and enforcement*
	4. Operational Efficiency	a) Smart infrastructure technologies b) Smart vehicle technologies c) Smart road pricing d) Smart fare collection* e) Advanced traveler and goods information* f) Smart congestion and incident management* g) Operator capability h) Supplier capability
V. Organization and Innovation	1. Institution and Leadership	a) Institutional coverage and integration b) Leadership and political dynamics c) Effective investment d) Information and performance management
	2. Capability and Welfare	a) Skill development and training b) Employee welfare
	3. Learning and Innovation	a) Local and global feedback* b) Innovations and good practices c) Research and development

(Note: An asterisk (*) denotes an indicator with major user-experience)

In urban transport, while several studies have indicated the need for institutionalization (e.g., ADB, 2010) and investment (e.g., Ahmed et al., 2008; Buehler and Pucher, 2009), there have been little focus on a comprehensive indicator development regarding this theme and the leadership and political attribute has often received inadequate attention. Further, we argue that, performance measurement and management should be a part of institutional culture, which have been often ignored in most public sector studies including urban transport. Therefore, we propose the following indicators of this theme: (1) we customize the traditionally used indicator 'institutionalization' to 'institutional coverage and integration', since urban transport sector being involved with multi-directional institutions, a proper integration among the institutions is imperative; (2) we propose the indicator 'leadership and political dynamics' in order to consider the impact of leadership and political stability; (3) we customize the indicator 'investment' to 'effective investment', since urban transport investments often being large-scale, the loss due to an improper or wrong investment can be catastrophic; and (4) we customize the indicator 'information system' to 'information and performance management', to consider the regular performance measurement and management through the effective use of information.

The theme *'capability and welfare'* intends to improve the organizational capability through enhancement of the contributing capacity and interest of its employees. In several public sector BSC studies, the objective of this theme is met through two major indicators, i.e., 'employee capability' (e.g., Chai (2009) for public sector; Chung et al. (2011) for public IT sector) and 'employee welfare' (e.g., Schmidt et al. (2006) for health sector).

In the urban transport literature, there has been a lack of studies focussing on the employee capability and welfare theme. In order to enhance the organizational performance of urban transport the need for proper skill development and training as well as welfare of the employees are imperative. Therefore, we propose two indicators, i.e., 'skill development and training' and 'employee welfare', for this theme.

The objective of the theme *'learning and innovation'* is to enhance the organizational capability through an effective learning and innovation culture. In other public sectors, three major indicators have been used, often in scattered manner, i.e., 'public participation' (e.g., Chai (2009) for public sector), 'innovation' (e.g., Chan (2004) for municipal governments) and 'research and development' (e.g., Wilson et al. (2003) for public building sector; Urrutia and Eriksen (2005) for health sector).

In urban transport, while few studies have indicated the need for public participation (e.g., Banister et al., 2007; Ahmed et al., 2008) as a component of social equity, there has been a lack of studies focussing on the innovation and research aspect of managing sustainable urban transport. We argue that, urban transport being a sector which is subject to rapid changes due to several factors including technological innovation, economic dynamics and increased demand from citizens for quality services, the need for innovation and research in this sector can be even more that other sectors, which are comparatively static in nature. Further, while other public sectors often use the indicator 'innovation', we argue that, in urban transport, in addition to 'innovation', there is a need for learning from global best practices. This is even more necessary for developing countries which are often challenged with severe problems including congestion, air and noise pollution, uncontrolled private modes, poor quality public transport services, and, consequently, high level of

citizen dissatisfaction, but lacks adequate resource for innovation. In addition to these, we argue that, in the urban transport context, the indicator 'public participation' does not adequately reflect the user/ community feedback system. Since the external impact of the transport are shared by both the local community (in the form of congestion, accidents, air and noise pollution and carbon emission) as well as global community (mainly in the form of global climatic and ecological crisis due to high levels of carbon emission and energy consumption), the feedback should be taken from both local and global community. We propose the following indicators of this theme: (1) we customize the traditionally used indicator 'public participation' to 'public and global feedback'. Notably, we place this indicator in the current theme, rather than the *'social sustainability'* theme, because we argue that, this indicator has a more objective role in the current theme as part of 'input' to sustainable urban transport, rather than as an 'outcome' in the *'social sustainability'* theme; (2) we customize the traditionally used indicator 'innovation' to 'innovation and good practices'; and, (3) we propose the indicator 'research and development'.

3. Measurement of indicator performance

The measurement of indicator performance involves two common steps, as used by Chang et al. (2010) and Newell et al. (2011), i.e., (i) determining score for individual indicator, and (ii) using individual indicator scores to obtain aggregated scores for the themes and perspectives as well as to obtain an overall BSC score.

In scoring performance of individual indicators, especially in the public sector, a 'triangulation' method that adopts more than two approaches in scoring, mainly involving review of literature, field survey and expert interviews, and determines final score through averaging scores from these approaches, is often used. This approach has been used in other public sectors (e.g., Bolton, 2003; Palme and Tillman, 2008) due to its inherent capability of 'cross examination' or 'cross validation', which increases confidence in obtained scores (Gomes, 2006). We used this triangulation method for the urban transport sector as there is abundance of literature, the cost of expert consultation is not high and user surveys are not very difficult. For all cases, performance scores can be obtained using a suitable scale. A 5-point Likert scale ranging from 1 (very poor) to 5 (excellent) is often used in public sector BSC studies (e.g., Chung et al., 2011; Newell et al., 2011). Considering the simplicity of use and public understanding, we adopt this 5-point Likert scale for urban transport.

For obtaining aggregated scores, the weighted average method provides a common foundation in many multi-criteria evaluation mechanisms including BSC (Valiris et al., 2005). We adopt this weighted average method in urban transport. In particular, the aggregated score for a theme, perspective or the BSC is determined through the weighted average of the indicators for that theme, perspective or the BSC, respectively. In obtaining 'weights' or 'importance scores', researchers (e.g., Valiris et al., 2005) often propose the expert feedback approach, since they may potentially have better level of understanding on the subject of concern. We adopt this approach in urban transport. We choose the criterion for obtaining importance scores for each indicator as its relative importance towards achievement of sustainable transport in the particular urban case in concern. A 5-point Likert scale ranging from 1 (least important) to 5 (most important) is used, considering the simplicity of use and public understanding. The final importance score is determined

through averaging importance scores obtained from experts. The equations for determining aggregated scores from individual scores are presented in the following equations.

Score of a theme *h*,

$$S_h = \frac{\sum_{i=1}^{I}(S_{i,h} \times Y_{i,h})}{\sum_{i=1}^{I} Y_{i,h}},\ S_h \in [1,5] \quad (1)$$

Score of a perspective *v*,

$$S_v = \frac{\sum_{i=1}^{I}(S_{i,v} \times Y_{i,v})}{\sum_{i=1}^{I} Y_{i,v}},\ S_v \in [1,5] \quad (2)$$

Overall score of BSC,

$$S_{Over.} = \frac{\sum_{i=1}^{I}(S_i \times Y_i)}{\sum_{i=1}^{I} Y_i},\ S_{Over.} \in [1,5] \quad (3)$$

where,

S_i = Score of indicator *i;* $S_i \in [1,5]$, 1 and 5 being, respectively, the minimum and maximum point on the 5-point Likert scale.

Y_i = Importance of indicator *i;* $Y_i \in [1,5]$, 1 and 5 being, respectively, the minimum and maximum point on the 5-point Likert scale.

S_h = Score of theme *h;* $S_h \in [1,5]$

S_v = Score of perspective *v;* $S_v \in [1,5]$

$S_{Over.}$ = Overall score*;* $S_{Over.} \in [1,5]$

4. Demonstration of BSC for sustainable urban transport

This section demonstrates the BSC for SUT using the case of Singapore urban transport. Singapore's urban transport has been recognized as a global landmark due to its consistent success in maintaining an excessively high level of traffic through its smart operation that ensures a smooth traffic flow on its urban streets. While Singapore's success and achievements in land transport sector have been a role-model to follow for other global cities there are challenging areas without a proper addressing of which may hinder betterment of its sustainability in the long run. Therefore while on the one hand it is necessary to record the successful aspects and learn their root underlying factors it is also essential, on the other hand, to identify the major critical and challenging areas which may stand against its long term sustainability. In order to address these two key issues it is necessary to make a holistic evaluation of the sustainability performance of Singapore urban transport.

4.1. Study design

The approach for measurement of indicator performance as well as the performances of the BSC themes, perspectives and overall BSC performance has been discussed in earlier section. In order to obtain performance scores for the indicators of BSC, the triangulation method adopted involves three sources of scoring, which comprises: (1) review of literatures, (2) guided questionnaire surveys and (3) expert judgements. In all cases, score was given to each of the indicators on a five-point Likert scale represented by: 1: Very poor, 2: Poor, 3: Moderate, 4: Good, 5: Excellent.

Review of literature: The comprehensive review of literature includes the review of the government policies and strategies as documented in master plans and policy books as well as government policy announcements; news articles and published information from relevant organization's web portals. The score was determined for each of the indicators based on subjective knowledge and understanding from literature review.

Field interview: Out of the 45 indicators in the BSC 22 are related to major commuter experience which are denoted by an asterisk (*) symbol in Table 2. The field interviews were conducted on these 22 indicators. A total of 135 interviewees (commuters) were interviewed out of which 54 interviews were in written questionnaire format, 24 were in a mix of written questionnaire and guided verbal questionnaire and 57 interviews were in fully guided verbal questionnaire format. The interviewees were chosen based on the four criteria: knowledge, experience, sufficient time and willingness to participate. The interviewees were of active age range, physically and economically, of 24-52 years. The travellers were interviewed at 10 locations of Singapore out of which 3 were in CBD. Score from field interview was determined for each of the 22 indicators by averaging the scores obtained from the total number of interviews.

Expert judgement: A team of three experts consisting of professionals and academicians in the field of urban transport sustainability were interviewed for expert opinion and judgements. The experts were chosen based on four criteria, i.e., knowledge, experience, willingness and sufficient time. All of the experts hold academic background and substantial research and professional experience in transportation sustainability and have detailed understanding on Singapore's urban transport. Score from expert feedback was determined for each of the indicators by averaging the scores obtained from the experts.

The overall score for each indicator related to major user experience was determined by averaging scores obtained from all of the three abovementioned approaches. For other indicators the overall score was determined by averaging scores obtained from literature review and expert judgement. For obtaining aggregated scores, the weighted average method was used. In particular, the aggregated score for a theme, perspective or the BSC is determined through the weighted average of the indicators for that theme, perspective or the BSC, respectively. A team of three experts were consulted for providing 'importance' weight to each indicator. The experts were chosen based on the criteria that they must have detailed knowledge, experience, willingness and sufficient time. The importance score for an indicator was put by experts based on their perceived understanding of the indicator's relative importance towards achieving sustainable urban transport in Singapore. A 5-point Likert scale ranging from 1 (least important) to 5 (most

important) was used. The final 'importance' weight was determined through averaging importance scores obtained from experts.

4.2. Results and discussion

This section discusses the results of the Balanced Scorecard for sustainable urban transport in Singapore. The performance scores for each indicator as obtained from review of literature, field interview and expert judgement as well as overall score for each theme and perspective has been presented in Table 3. From Table 3, it is noticeable that scores obtained from literature review and expert judgement are generally consistent; however, users have generally tended to underrate the performance as compared to both literature review and expert judgement. This may reflect that users are keen for even more efficient and sustainable transport system. From Table 3, it is also noticeable that there are significant differences in performance among different indicators, themes and perspectives. From Figure 2, it is noticeable that, among 10 themes of BSC eight have performed 'good' and the remaining two have performed 'excellent'. The 'excellent' performing themes are 'built environment and land use' and 'management of user behaviour'. All of the five perspectives have performed 'good'. The overall sustainability performance of Singapore urban transport as 'good' (score: 4.20). The consistency of the performance obtained from literature review, field interview and expert judgment indicates the validity of the obtained results. The following sub-sections discuss important findings of this case study.

4.2.1. Social perspective

The overall performance of the social perspective is 'good' (score: 4.11). Among the indicators the 'security enhancement' has shown the highest performance 'excellent' (score: 4.75). This is mainly due to Singapore's aggressive approach towards technological advancement in a wide range of security measures as well as its proactive approach towards managing potential security hazards. All other indicators have performed 'good'. The 'employment growth' indicator has the worst performance (score: 3.51). This is mainly due to the incapability of creating adequate distant job centres other than CBD which has resulted in a spatial mismatch and at the same time has led to increased traffic load in the CBD. Although 'accessibility, connectivity and travel time' indicator has performed 'good' (score: 4.05), the frequency and waiting time of buses is still high but accessibility and connectivity aspects are relatively better. Among other indicators the 'affordability', 'level of service and comfort', 'safety enhancement' and 'social equity, culture and coherence' have scored 4.25, 3.66, 4.30 and 4.26, respectively.

4.2.2. Environmental perspective

Overall performance of this perspective is 'good' (score: 3.50). However it shows the worst performance among all five perspectives. This has been mainly due the 'poor' performance of 'impact on global environment' (score: 2.40) and 'sustainable energy consumption' (score: 2.45) indicators, respectively. The CO_2 emission per capita in Singapore is 9.2 ton, which is excessively high compared to the global standard

making Singapore top fourth carbon emitting country in the world (per capita calculation) and transport sector is the second largest carbon emitting sector of this city-state.

Table 3. Balanced Scorecard for Sustainable Urban Transport in Singapore

Persp.	Theme	Indicator	Imp. (AD)	Score				Theme Over.	Persp. Over
				Indicator					
				LR	FI (CoV)	EJ (AD)	Over. (AD)		
Social	Social sustainability	Accessibility, connectivity and travel time*	4.86 (0.05)	4.1	3.9 (0.12)	4.2 (0.20)	4.05 (0.13)	4.11	4.11
		Affordability*	4.67 (0.04)	4.5	3.7 (0.12)	4.5 (0.16)	4.25 (0.34)		
		Level of service and comfort*	4.91 (0.04)	3.8	3.3 (0.14)	3.9 (0.20)	3.66 (0.25)		
		Safety enhancement*	4.92 (0.02)	4.4	4.1 (0.10)	4.4 (0.16)	4.30 (0.13)		
		Security enhancement*	4.59 (0.04)	4.8	4.7 (0.11)	4.8 (0.11)	4.75 (0.06)		
		Social equity, culture and coherence*	4.52 (0.05)	4.3	4.2 (0.10)	4.3 (0.20)	4.26 (0.05)		
		Employment growth*	4.81 (0.03)	3.5	3.4 (0.14)	3.6 (0.13)	3.51 (0.06)		
Environ.	Environmental sustainability	Impact on global environment	4.76 (0.04)	2.3	n.a.	2.5 (0.20)	2.40 (0.10)	3.50	3.50
		Impact on local air quality and ecology*	4.91 (0.04)	4.5	4.2 (0.10)	4.6 (0.16)	4.43 (0.16)		
		Impact on local noise level*	4.89 (0.03)	3.8	3.3 (0.14)	4.0 (0.11)	3.70 (0.27)		
		Sustainable energy consumption	4.87 (0.06)	2.4	n.a.	2.5 (0.11)	2.45 (0.05)		
		Sustainable waste management	4.53 (0.04)	4.5	n.a.	4.6 (0.22)	4.55 (0.05)		
Econ.	Economic sustainability	Revenue enhancement	4.62 (0.04)	4.6	n.a.	4.8 (0.18)	4.70 (0.10)	4.36	4.36
		External cost savings	4.71 (0.05)	3.7	n.a.	3.8 (0.11)	3.75 (0.05)		
		Mobility and economic growth	4.89 (0.04)	4.7	n.a.	4.8 (0.11)	4.75 (0.05)		
		Congestion and travel demand management*	4.92 (0.02)	4.3	4.2 (0.11)	4.3 (0.11)	4.25 (0.06)		
Process	Built environment and land-use	Land-use and transport integration	4.87 (0.03)	4.2	n.a.	4.3 (0.07)	4.25 (0.05)	4.51	4.35
		Management of transport infrastructure*	4.86 (0.04)	4.7	4.7 (0.09)	4.8 (0.11)	4.74 (0.04)		
		Management of parking facilities*	4.85 (0.03)	4.6	4.3 (0.13)	4.7 (0.13)	4.52 (0.17)		
	Management of transport modes	Promotion of public transport*	4.92 (0.04)	4.2	3.9 (0.11)	4.3 (0.13)	4.14 (0.15)	4.10	
		Control over private vehicles	4.89 (0.02)	4.8	n.a.	4.8 (0.11)	4.80 (0.00)		
		Promotion of non-motorized transport*	4.51 (0.04)	3.7	3.5 (0.14)	3.8 (0.18)	3.66 (0.13)		
		Integration among passenger modes*	4.74 (0.04)	4.3	4.1 (0.10)	4.5 (0.04)	4.30 (0.13)		
		Efficiency of commercial goods transport	4.90 (0.03)	4.5	n.a.	4.5 (0.13)	4.50 (0.00)		
		Promotion of green vehicles	4.78 (0.04)	3.9	n.a.	3.7 (0.13)	3.80 (0.10)		
		Promotion of vehicle sharing practices*	4.61 (0.04)	3.5	3.4 (0.14)	3.5 (0.13)	3.45 (0.06)		
	Management of user behavior	Awareness, education and transition*	4.54 (0.03)	4.4	4.3 (0.11)	4.6 (0.16)	4.43 (0.12)	4.53	
		Legislation and enforcement*	4.53 (0.04)	4.6	4.6 (0.11)	4.7 (0.09)	4.63 (0.05)		
	Operational efficiency	Smart infrastructure technologies	4.82 (0.04)	4.8	n.a.	4.9 (0.07)	4.85 (0.05)	4.46	
		Smart vehicle technologies	4.83 (0.04)	4.7	n.a.	4.6 (0.20)	4.65 (0.05)		
		Smart road pricing	4.85 (0.03)	4.9	n.a.	4.9 (0.09)	4.90 (0.00)		
		Smart fare collection*	4.88 (0.04)	4.6	4.5 (0.11)	4.6 (0.13)	4.58 (0.03)		
		Advanced traveller and goods information*	4.85 (0.03)	4.6	4.5 (0.11)	4.7 (0.11)	4.60 (0.07)		
		Smart congestion and incident management*	4.92 (0.03)	3.8	3.5 (0.14)	3.9 (0.07)	3.75 (0.14)		
		Operator capability	4.91 (0.04)	4.2	n.a.	4.3 (0.11)	4.25 (0.05)		
		Supplier capability	4.75 (0.03)	4.1	n.a.	4.1 (0.18)	4.10 (0.00)		
Organization and Innovation	Institution and leadership	Institutional coverage and integration	4.85 (0.03)	4.7	n.a.	4.8 (0.04)	4.75 (0.05)	4.24	4.22
		Leadership and political dynamics	4.85 (0.03)	4.5	n.a.	4.6 (0.07)	4.55 (0.05)		
		Effective investment	4.82 (0.04)	4.1	n.a.	4.3 (0.11)	4.20 (0.10)		
		Information and performance management	4.86 (0.03)	3.4	n.a.	3.5 (0.18)	3.45 (0.05)		
	Capability and welfare	Skill development and training	4.73 (0.06)	4.4	n.a.	4.4 (0.13)	4.40 (0.00)	4.43	
		Employee welfare	4.81 (0.03)	4.5	n.a.	4.4 (0.07)	4.45 (0.05)		
	Learning and innovation	Local and global feedback*	4.56 (0.06)	3.1	2.7 (0.17)	3.5 (0.13)	3.11 (0.26)	4.06	
		Innovations and good practices	4.84 (0.04)	4.7	n.a.	4.6 (0.18)	4.65 (0.05)		
		Research and development	4.82 (0.03)	4.3	n.a.	4.4 (0.09)	4.35 (0.05)		

Note: *1. An asterisk (*) denotes an indicator with major user-experience*

2. LR: literature review, FI: field interview, EJ: expert judgment

3. AD: average deviation, CoV: coefficient of variation

The energy consumption per capita in Singapore is also consistently high compared to other global mega cities. The indicator 'sustainable waste management' has performed 'excellent' (score: 4.55). Regarding the indicator 'impact on local noise level' (score: 3.70) there is a need to reduce the noise level near road-sides and MRT stations. The indicator 'impact on local air quality and ecology' which has performed 'good' (score: 4.43). This indicates that Singapore has a good level of local air quality.

4.2.3. Economic perspective

The overall performance of this perspective is 'good' (score: 4.36). Among the indicators the 'revenue enhancement' and the 'mobility and economic growth' have performed 'excellent', with scores 4.70 and 4.75, respectively. The other two indicators 'external cost savings' and 'congestion and travel demand management' have performed 'good', scoring 3.75 and 4.25, respectively. Key notable points regarding indication of results of this theme are that, the travel demand is increasing and congestion exists during peak hours. The public transport modal share has also slightly fallen.

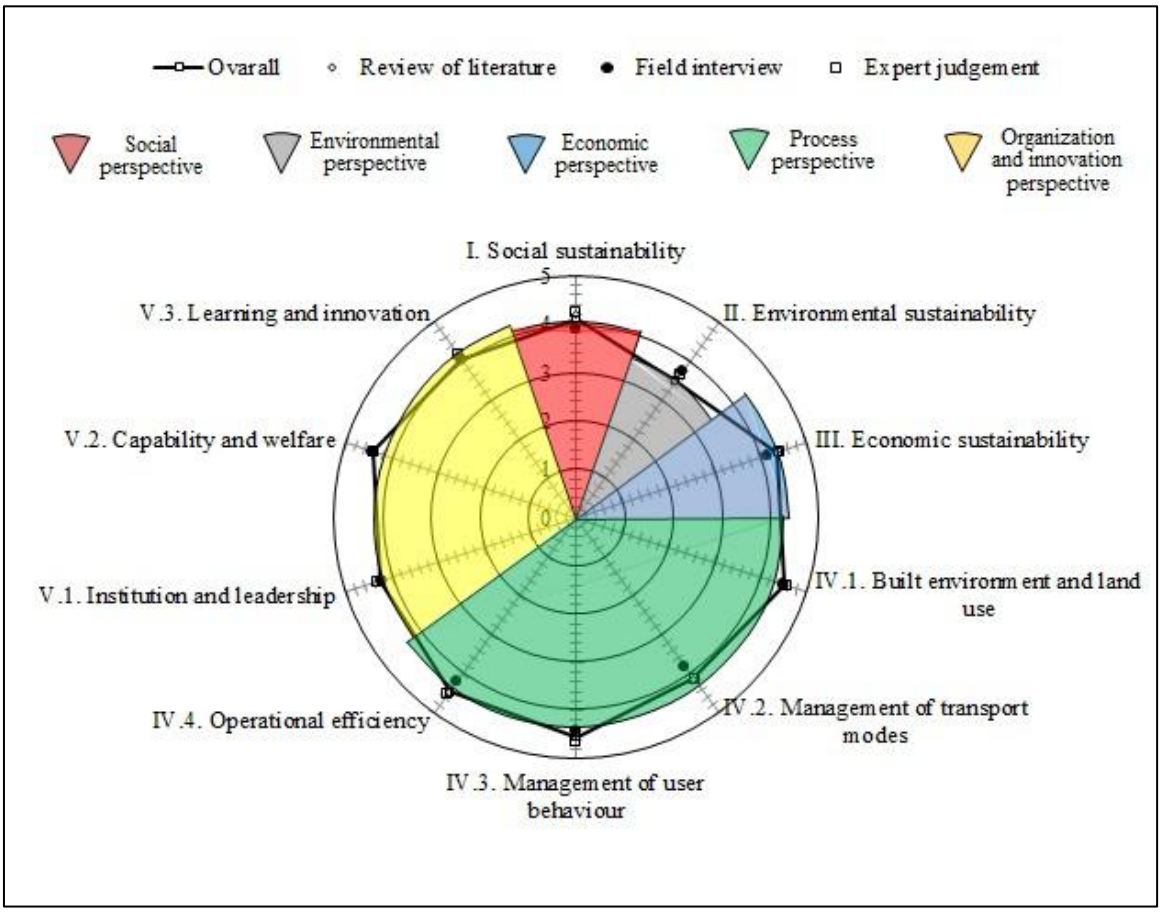

Figure 2. Scores of BSC themes and perspectives

4.2.4. Process perspective

The overall performance of this perspective is 'good' (score: 4.35). The overall performance of the theme *'built environment and land-use'* is 'excellent' (score: 4.51). Among indicators the best performing is the 'management of transport infrastructure' which has performed 'excellent' (score: 4.74), which denotes that Singapore has an excellent level of land transport infrastructure. The 'management of parking facilities' has also performed 'excellent' (score: 4.52). The 'land-use and transport integration' has scored 'good' (score: 4.25). The key notable points regarding this indicator are that, more distant business centres need to be developed through the connection of more integrated MRT networks and facilitating more improved and dispersed bus transport facilities. There is also a need to reduce the transfer time among passenger modes through more improved and integrated land-use planning. The theme '*management of transport modes*' has performed 'good' (score: 4.10). Among indicators of this theme the best performing is the 'control over private vehicles' which has performed 'excellent' (score: 4.80). This is due to city state's innovative and aggressive approaches in restricting car population; most notable of such approaches are VQS and ERP. 'Promotion of public transport' has scored 'good' (score: 4.14). The areas need to be improved about this indicator are the service quality of public buses, improving waiting time and to deliver more dispersed services. The indicator 'efficiency of commercial goods transport' has also performed 'excellent', scoring 4.50. All other indicators 'promotion of non-motorized transport', 'integration among passenger modes', 'promotion of green vehicles' and 'promotion of car sharing practices' have performed 'good', scoring 3.66, 4.30, 3.80 and 3.45, respectively. In 'promotion of non-motorized transport' there is still lack of smooth bikeways and connectivity for this mode to be considered as an alternative mode of transport to commuters. The lack of dedicated bike lanes is also notable. Regarding 'integration among passenger modes' high transfer and waiting time for non-first boarding(s) are areas that need to be improved. Regarding 'promotion of green vehicles' it is notable that, although there are a variety of initiatives undertaken to promote green vehicles the population of these vehicles in Singapore is still low. Finally, the 'promotion of car sharing practices' needs to be more widely practiced and there is lack of HOV lanes. The theme '*management of user behaviour'* has performed 'excellent' (score: 4.53). Among two indicators, the 'skill development and training' has performed 'good', scoring 4.43, and the 'legislation and enforcement' has performed 'excellent', scoring 4.63. Finally, the overall performance of the theme *'operational efficiency'* is 'good' (score: 4.46). Out of the eight indicators under this theme five have performed 'excellent' and three have performed 'good'. Among the 'excellent' performing indicators the 'smart infrastructure technologies', 'smart vehicle technologies', 'smart road pricing', 'smart fare collection' and 'advanced traveller and goods information' have scored 4.85, 4.65, 4.90, 4.58 and 4.60, respectively. Singapore is the pioneer in deployment of technology in road pricing, which has been successful in controlling private vehicles. In addition, Singapore is a global landmark in the deployment of world-class cutting-edge technologies in infrastructure facilities. The indicator 'smart congestion and incident management' has performed 'good' (score: 3.75). The relative lower score of this indicator compared to other indicators is mainly due to presence of congestion, especially in the peak hours as well as several incidents. The indicators 'operator capability' and 'supplier capability' have performed 'good' with scores 4.25 and 4.10, respectively.

4.2.5. Organization and innovation perspective

The overall performance of this perspective is 'good' (score: 4.22). The theme *'institution and leadership'* has performed 'good' (score: 4.24). The indicators 'institutional coverage and integration' and 'leadership and political dynamics' have performed 'excellent', scoring 4.75 and 4.55, respectively. This has been mainly due to an excellent level of institutional integration and positive political influence in the urban transport sector of Singapore. The other indicators 'effective investment' and 'information and performance management' have performed 'good', scoring 4.20 and 3.45, respectively. The theme *'capability and welfare'* has performed 'good' (score: 4.43). Both of the indicators 'skill development and training' and 'employee welfare' have performed 'good', scoring 4.40 and 4.45, respectively. Finally, the overall performance of the theme *'learning and innovation'* is 'good' (score: 4.06). The indicator 'innovation and good practices' has performed 'excellent' (score: 4.65). Singapore has been best benefitted from the technological advancement through both innovating as well as learning from the global benchmarking practices. Singapore's ERP is the world's first electronic congestion charging system and the idea of VQS is also innovative and successful. The indicator 'local and global feedback' has performed 'moderate', scoring 3.11. The indicator 'research and development' has performed 'good' (score: 4.35) which implies that a good level of research and studies are on-going in the field of urban transport sustainability.

5. Conclusions

This study developed an integrated mechanism for strategic performance evaluation of sustainable urban transport which is crucial to the progress and competitiveness for achieving sustainability goals in this sector. The BSC for sustainable urban transport offers an integrated mechanism by considering all pillars of sustainability in urban transport along with their performance drivers. The BSC for SUT transfers the sustainability mission and vision into a balanced set of performance indicators that meet diverse needs of stakeholders in this sector. A performance measurement mechanism was developed using a triangulation approach that quantitatively measures sustainability performance of urban transport. The BSC for SUT has been demonstrated using Singapore urban transport as a case study. Results show that, there are significant differences in performance among the BSC indicators and themes, which fall in the score range of 2.4-4.9, on a 1-5 scale. The overall sustainability performance of Singapore's urban transport is good with an overall score of 4.2. The major areas of strength for which Singapore's urban transport has been transformed into a global icon include an effective institutional structure, a world-class land transport infrastructure system, deployment of cutting-edge technologies, strict control over ownership and usage of private vehicles, stringent legislation and enforcement, and innovative approaches towards problem solving. On the other hand, the poor and moderate performing critical areas include the energy consumption, carbon emission, vehicle sharing practices and public participation. Further, areas that are marginally good and still need further improvement include improvement of the level of service, congestion management, employment growth, improvement of public and non-motorized transport, reduction of noise level, integration of land-use and transport, and promotion of green vehicles. The consistency of the performance obtained from literature review, field interview and expert judgment indicates the validity of the obtained results. The BSC developed

in this study, through offering an integrated mechanism for performance evaluation, reduces the dependency of transport policies on arbitrary measures of performance. The results help policy makers easily identify areas of higher and lower performance, based on which corrective measures can be undertaken. With all these advantages coupled with the ease of usage, it can be concluded that, the application of BSC may help establish an effective path in strategic performance evaluation of sustainable urban transport.

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