Sustainable Transportation Indicators

A Recommended Research Program For Developing Sustainable Transportation Indicators and Data

10 November 2008

By the

Sustainable Transportation Indicators Subcommittee of the Transportation Research Board (ADD40 [1])

Subcommittee Chair *Todd Litman* (litman@vtpi.org)

Summary

This paper, developed through a cooperative effort by the Transportation Research Board's *Sustainable Transportation Indicators Subcommittee* (ADD40 [1]), identifies indicators that can be used for sustainable transportation evaluation. The paper discusses sustainable transportation definitions and concepts, describes factors to consider when selecting indictors, exemplify specific sustainable transportation indicators, discusses issues of data quality, and provides recommendation on further research and development in the field. We hope these recommendations will be endorsed by TRB and other professional organizations, leading to the development and application of suitable sustainable transportation indictor sets in the USA and worldwide.

Paper 09-3403
2009 Transportation Research Board Annual Meeting
Words: 4,500 + 3 table = 5,250

Introduction

Planning activities rely on *indicators* (standardized information suitable for analysis) for guidance, just as people rely on senses such as sight, hearing and touch. Indicators let us analyze trends and model impacts. Which indicators are selected and how data are collected and analyzed is important. An option may seem to be appropriate and desirable if evaluated by one set of indicators but unsustainable if evaluated by others. Indicators are important tools for making decisions and measuring progress.

Decision-making increasingly incorporates sustainability concepts, such as consideration of long-term economic, social and environmental impacts. As a result, there is growing demand for suitable planning tools, such as sustainable transportation indicators. Such indicators help determine how individual, short-term decisions affect long-term, strategic goals. Such indicators must be carefully selected to reflect diverse impacts and perspectives, while being feasible to collect and analyze.

These are important considerations for transportation professional organizations, such as the Transportation Research Board (TRB). Many of TRB's research activities can support sustainable transportation planning, and sustainability concepts can help guide TRB policies and programs. For example, research programs related to strategic planning, infrastructure design, and facility operations can incorporate sustainability analysis and support sustainability objectives.

TRB can contribute to developing such tools by helping to standardize sustainable transportation indicators and related data collection practices. This will allow more comprehensive and integrated analysis, and allow decision-makers to understand how specific policies and planning decisions affect sustainability goals. This paper is a step in this direction, based on extensive effort by the TRB Sustainable Transportation Indicators Subcommittee (ADD40 [1]). It:

- Discusses sustainable transport definitions and issues.
- Describes factors to consider when selecting indicators.
- Identifies a wide range of possible sustainable transportation indicators.
- Rates selected indicators for possible inclusion in a "standard" set of sustainable transportation indicators.
- Discusses issues of data collection practices and data quality.

This is consistent with efforts by TRB and other professional organizations to improve transportation data quality – it expands these efforts to consider additional types of information needed for sustainable transport planning. Although previous studies have described sustainable transport indicators, this report goes beyond that by evaluating potential indicators. We ask TRB committees and other stakeholders to further evaluate and comment on this proposed list based on their perspectives and knowledge with the goal that recommendations for sustainable transportation indicators and data collection practices can be adopted by TRB and other professional organizations.

Defining Sustainable Transportation

At its most basic, *sustainability* reflects a concern for indirect and long-term impacts. The concepts of *sustainability* and *sustainable development* originally focused on certain long-term environmental concerns, such as natural resource depletion and ecological degradation (including climate change), but have expanded to include other issues. Most current definitions recognize three main categories of sustainable development issues: economic, social and environmental (or ecological),[1] and some incorporate other issues such as governance and fiscal sustainability (CST, 2005; Litman, 2007).

Sustainability is a simple concept with complex implications (Litman and Burwell, 2006). It reflects a *paradigm shift*, a fundamental change in the way problems are defined and solutions evaluated. It maintains a distinction between *growth* (increased quantity) and *development* (increased quality). It focuses on social welfare outcomes, such as human health and education attainment, rather than on material wealth, and questions common economic indicators such as Gross Domestic Product (GDP) that measure the quantity but not the quality of market activities. Because sustainability strives to protect natural resources and ecological systems, it emphasizes a *conservation ethic*, and so favors policies that minimize consumption of resources such as air, water and land.

Sustainability can be evaluated based on a *weak* standard, which allows natural capital (natural environmental resources and ecological systems) to be replaced by human capital (industrial productive capability), or a *strong* standard, which rejects such substitutions. For example, weak sustainability allows wild fish stocks to be depleted if aquaculture can provide equal or greater fish production, while strong sustainability requires preserving wild fish stocks in order to protect their ecological functions. Strong sustainability shifts the burden of proof to favor ecological preservation over industrial growth.

A *weak* sustainability standard allows transport to increase environmental impacts if required for economic development, or if negative impacts can be offset by other sectors, such as pollution reductions by heavy industries. A *strong* sustainability standard places more emphasis on impact reductions within the transport sector, and so places more emphasis on reducing motor vehicle impacts.

Transportation has significant economic, social and environmental impacts, and so is an important factor in sustainability. Sustainability supports a paradigm shift occurring in transport planning. Previously, transport was evaluated primarily in terms of *mobility* (physical movement), but increasingly it is evaluated in terms of *accessibility* (people's ability to obtain desired goods and services). Many factors affect accessibility, including mobility, land use factors (such as the location of activities) and mobility substitutes (such as telecommunications and delivery services). Accessibility-based planning expands the range of solutions that can be applied to transport problems; for example, congestion can be reduced by improving land use accessibility or telecommunications, in addition to accommodating more vehicle traffic.

---

[1] *Environmental* is a general term referring to the conditions in which something occurs. *Ecological* refers specifically to the natural environment and natural systems (air, earth, water, wildlife, etc.).

Several definitions of *sustainable transportation* have been proposed (CST, 2005; Litman, 2007). Of them, we recommend the definition selected by the European Council of Ministers of Transport (ECMT, 2004),[2] because it has a broad scope and recognizes specific transportation issues. According to this definition, a sustainable transport system:

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

Key Definitions (based on Gudmundsson, 2001)

Baseline (or *benchmark*) – existing, projected or reference conditions if change is not implemented.

Goal – what you ultimately want to achieve.

Index – a group of indicators aggregated into a single value.

Indicator – a variable selected and defined to measure progress toward an objective.

Indicator data – values used in indicators.

Indicator framework – conceptual structure linking indicators to a theory, purpose or planning process.

Indicator set – a group of indicators selected to measure comprehensive progress toward goals.

Indicator system – a process for defining indicators, collecting and analyzing data and applying results.

Indicator type – nature of data used by indicator (qualitative or quantitative, absolute or relative).

Objective – a desirable change defined in a planning process, often intended to address a problem.

Target – A specified, realistic, measurable objective.

[2] Originally developed by the Canadian Centre for Sustainable Transportation (http://cst.uwinnipeg.ca).

Principles for Selecting Sustainable Transport Indicators

Indicators are variables selected and defined to measure progress toward an objective. Indicators can reflect various levels of analysis, as illustrated in Table 1. For example, indicators may reflect the decision-making process (the quality of planning), responses (travel patterns), physical impacts (emission and accident rates), effects these have on people and the environment (injuries and deaths, and ecological damages), and their economic impacts (costs to society due to crashes and environmental degradation). A sustainability index can include indicators that reflect various levels of analysis, but it is important to take their relationships into account in evaluation to avoid double-counting. For example, reductions in vehicle-mile emission rates can reduce ambient emissions and human health damages; it may be useful to track each of these factors, but it would be wrong to add them up as if they reflect different types of impacts.

Table 1 **Levels of Analysis**

Level	Examples
External Trends ➜	Changes in population, income, economic activity, political pressures, etc.
Decision-Making Process ➜	Planning process, pricing policies, stakeholder involvement, etc.
Policies ➜	Facility design and operations, transport services, prices, user information, etc.
Response ➜	Travel activity (VMT, mode choice, etc.), pollution emissions, crashes, land development patterns, etc.
Cumulative Impacts ➜	Changes in ambient pollution, traffic risk levels, overall accessibility, transportation costs, etc.
Human and Environmental Effects ➜	Changes in pollution exposure, health, traffic injuries and fatalities, ecological productivity, etc.
Economic Impacts ➜	Property damages, medical expenses, productivity losses, mitigation and compensation costs.
Performance Evaluation	Ability to achieve specified targets.

This table shows how indicators can measure various levels of impacts, from the planning process to travel behavior, impacts on people and the environment, and economic effects.

The following principles can help select sustainable transportation indicators:

1. Comprehensive and Balanced

For comprehensive and balanced analysis, indicator sets should include indicators from each of the major categories of issues, such as those listed in Table 2. For example, it is important to have indicators of transport cost efficiency (economic), equity and livability (social), and pollution emissions (environmental). These are examples of sustainable transportation issues, but the table is not intended to be comprehensive. Some indicators reflect multiple impact categories; for example, traffic accidents impose economic costs from damages and reduced productivity, and social costs from pain and reduced quality of life. Fuel consumption can be a useful indicator because it reflects energy consumption, pollution emissions, climate change, and total vehicle travel, and to a lesser extent mileage-related impacts such as congestion and crash rates. On the other hand it provides limited information about actual damage to the environment.

Table 2 **Sustainable Transportation Issues** (Litman and Burwell, 2006)

Economic	Social	Environmental
Accessibility quality	Equity / fairness	Air pollution
Traffic congestion	Impacts on mobility disadvantaged	Climate change
Infrastructure costs	Affordability	Noise pollution
Consumer costs	Human health impacts	Water pollution
Mobility barriers	Community cohesion	Hydrologic impacts
Accident damages	Community livability	Habitat and ecological degradation
DNRR	Aesthetics	DNRR

This table lists various impacts which should be reflected, as much as feasible, in sustainable transportation indicator sets. (DNRR=Depletion of Non-Renewable Resources)

Because sustainability is concerned with impacts that occur in distant locations and times, assessment generally requires *lifecycle analysis,* which considers all impacts over the entire life of a product or activity, including resources used (and therefore pollution produced) during production and disposal, also called *embodied* resources and pollution (Chester and Horvath, 2008).

2. Data Feasible to Collect

Indicators should be selected so the necessary data are feasible to collect and of adequate quality. As much as possible, data collection should be standardized to allow comparison between organizations, jurisdictions, times and groups. Standardized data should allow sustainability impacts to be evaluated at various project phases – planning, design, and operations – though the indicator or the way the indicator is measured may vary. Standardized data collection methods should also allow for comparison and measurement toward sustainability objectives across multiple jurisdictions and continents.

Some indicators may rely on existing data sets. Others may require special data collection or analysis. There are currently gaps between the data collected for transport planning purposes and what is needed for sustainable planning evaluation. Improving and expanding the collection of transportation-related data will support all sorts of transportation planning, including sustainability planning. For example, improving travel surveys and traffic counts to collect better information on non-motorized travel, travel by children and people with disabilities, energy consumption, and user costs is useful for general transportation planning as well as for sustainability planning.

3. Understandable and Useful

Indicators should be understandable to the general public and useful to decision-makers. The usefulness and value of individual indicators may vary in importance among project phases, jurisdictions, and stakeholders. Indicators, analysis details, and data should be available to all stakeholders. In general, the more information condensed into a single index the less meaning it has for specific policy targets (for example, the *Ecological Footprint* incorporates many factors).

4. Disaggregation

Indicator data may need to be disaggregated in various ways to support specific types of analysis, such as by travel activity (mode, location, time period, trip purpose), demographics (age, income class, physical ability, ethnic group) and geographic location. For example, for economic analysis it may be useful to compare travel costs by modes, and for equity analysis it may be useful to compare mobility and transport affordability for various demographic groups (for example, by income, physical ability and age).

5. Reference Units

Reference units (also called *ratio indicators*) are measurement units normalized to facilitate comparisons, such as per-year, per-capita, per-mile, per-trip, per-vehicle-year and per dollar (Litman, 2003; GRI, 2006). The selection of reference units can affect how problems are defined and solutions prioritized. For example, measuring impacts such as emissions, crashes and costs per *vehicle-kilometer* ignores the effects of changes in vehicle travel. Measuring these impacts *per capita* accounts for the effects of changes in total vehicle travel.

6. Level of Analysis

If possible, indicators should reflect ultimate impacts of concern rather than intermediary effects. For example, *days of poor air quality* is a better indicator than *tons of pollutant emissions* because it takes into account how pollutants interact in the atmosphere, recognizing that a given volume of emissions may cause more harm in some situations than others. Care is needed to account for possible double-counting of impacts, for example, if indicators include both vehicle fuel efficiency and climate change emissions.

7. Performance Targets

Performance targets are specific measurable objectives to be achieved by a stated deadline, such as defined reductions in climate change emissions by a specific date. Such targets are useful for motivating and evaluating progress toward sustainability. Such targets should be based on scientific analysis when applicable, and updated over time as better information becomes available. If performance targets are not specified, the desired direction of change should be indicated. For example, if no pollution emission reduction targets have been established it is still important to determine whether emissions are declining or increasing as an indication of progress (or lack thereof) toward sustainability. Many performance targets are specific to a particular organization or jurisdiction.

Selecting Sustainable Transport Indicators

Table 3 lists indicators within different categories of sustainable transport planning concern. It also proposes possible disaggregations, and rates indicator as follows:

A = Proposed for application in virtually all situations.
B = Proposed for application if relevant/feasible.
C = Proposed for application when needed to address specific community needs.

There is debate as to whether motorized mobility (such as annual vehicle-mileage) should be considered a sustainable transportation indicator (Samuel and Litman, 2001). Some experts argue that unsustainability consists of problems that can be corrected individually, for example, by improving vehicle fuel efficiency, shifting fuels, and reducing crash rates. Others argue that a high level of motor vehicle travel is inherently unsustainable (for example, high annual mileage imposes significant economic, social and environmental costs, even if it is propelled by nuclear or solar power), and that sustainable transportation requires mobility management (strategies that change travel behavior) to increase transportation system efficiency rather than just vehicle efficiency.

Some research indicates that a significant portion of current vehicle travel results from market distortions that underprice driving and reduce travel options (Litman, 2006; Metschies, 2001). As a result, planning and market distortions that increase mobility, and the additional motor vehicle travel that results, can be considered unsustainable, and vehicle travel reductions can be considered sustainability objectives. Reductions in vehicle travel can certainly be considered to increase sustainability if they result from efficient planning and market reforms, such as more cost-based pricing and comprehensive and neutral planning.

Impacts on people (such as consumer costs, congestion delays and deaths) can generally be measured per capita, but because the earth is a limited resource, environmental impacts should generally be measured in total. This means, for example, that per capita pollution emissions and land consumption may need to decline in response to population growth, so that total impacts do not exceed ecological capacity.

Table 3 **Potential Sustainability Indicators** (CST, 2003; Marsden, et al., 2005; Litman, 2007)

Category	Subcategory	Indicator	Disaggregation	Rating
Travel Activity	Vehicles	Motor vehicle ownership	By type of vehicle, owner demographics, location	A
	Mobility	Motor vehicle travel	Trip type, traveler type, travel conditions	A
	Mode split	Portion of trips by auto, public transit, and non-motorized modes	Trip type, traveler type, travel conditions	A
Air Pollution Emissions	Emissions	Total vehicle emissions	Type of emission, mode, location	A
	Air pollution exposure	Number of days of exposure per year	Demographic groups affected	A
	Climate change	Climate change emissions (CO_2, CH_4)	Mode	A
	Embodied emissions	Emissions from vehicle and facility construction	Type of emission and mode	A
Noise Pollution	Traffic noise	People exposed to traffic noise above 55 LAeq,T	Demographic group, location, transport mode	B
	Aircraft noise	People exposed to aircraft noise above 57 LAeq,T	Demographic group, location, transport mode	B
Traffic risk	Crash Casualties	Crash deaths and injuries	Mode, road, type and cause of collision.	A
	Crashes	Police-reported crashes	Mode, road, type and cause of collision.	A
	Crash costs	Traffic crash economic costs	Mode, road, type and cause of collision.	B
Economic Productivity	Transport costs	Consumer expenditures on transport	Mode, user type, location	A
	Commute costs (time and money)	Access to employment	Mode, user type, location	A
	Transport reliability	Per capita congestion costs	Mode, location	B
	Infrastructure costs	Expenditures on roads, public transit, parking, ports, etc.	Mode, location	A
	Shipping costs	Freight transport efficiency	Mode, geographic area	B

Category	Subcategory	Indicator	Disaggregation	Rating
Overall Accessibility	Mobility options	Quality of walking, cycling, public transit, driving, taxi, etc.	Trip purpose, location, user	A
	Land use accessibility	Quality of land use accessibility	Trip purpose, location, user	B
	Mobility substitutes	Internet access and delivery service quality	Trip purpose, location, user	B
Land Use Impacts	Sprawl	Per capita impervious surface area	By location and type of development	B
	Transport land consumption	Land devoted to transport facilities	By mode	B
	Ecological and cultural degradation	Habitat and cultural sites degraded by transportation facilities	Type of habitat and resource, location	B
Equity	Affordability – Transport	Portion of household budgets needed to provide adequate transport.	Demographics, especially disadvantaged groups	A
	Affordability – Housing	Affordable housing accessibility	By demographic group, especially low income and disabled groups	C
	Basic accessibility	Quality of accessibility for people with disabilities	By geographic area, mode, type of disability	B
Transport Policy and Planning	Pricing efficiency	Cost-based pricing	By mode, type of cost (road, parking, etc.)	B
	Strategic planning	Degree to which individual planning decisions support strategic goals	By mode, agency.	B
	Planning efficiency	Comprehensive and neutral planning	By mode, agency.	C
	User satisfaction	User survey results.	By group (disabled, children, low income...)	B

This table lists various possible sustainable transportation indicators. Ratings indicate priorities:

A = Proposed for application in virtually every situations and jurisdictions;

B = Proposed for application if relevant/feasible;

C = Proposed for application when needed to address specific community needs.

Data Standards and Quality

Accurate statistics are essential for any planning, and are particularly important for sustainable transportation planning. Although transportation-related statistics are widely gathered, their quality is highly variable, ranging from good to abysmal, and even the best data sets are often incompatible with those created in other jurisdictions and agencies due to differences in definition and collection methods (BTS, 2007; DfT, 2007; VTPI, 2007). This is a waste of resources and a lost opportunity to improve our understanding of important trends and relationships.

A few efforts have been made to create standardized transportation data sets, including Kenworthy and Laube's *International Sourcebook of Automobile Dependence in Cities*, which has since evolved into the *Mobility In Cities Database* (UITP, 2005), the OECD's *International Road Traffic and Accident Database*, data collected in the *World Bank Transport Website* (www.worldbank.org/transport), and Rutger University's *Cross National Time Series* (www2.scc.rutgers.edu/cnts/about.php). However, these rely primarily on available data, with often differing definitions and uncertain quality, rather than standardized data sets suitable for comparison.

Sustainable transportation indicators will require international standards for transportation-related statistics, which clearly define the information to be collected and methods of collection and analysis. An example is the EMEP/CORINAIR (2007) *Emission Inventory Guidebook*, which indicates how various air pollutant emissions are measured in the European Union.

Improving transportation-related statistics' quality and consistency can provide very large benefits by improving our understanding of travel activities and their impacts. Each year transportation statistics affect tens of billions of dollars in planning decisions, which affects hundreds of billions of dollars worth of transport activity.

A research program is needed to establish basic standards for transportation-related data which can be adopted by transportation research organizations and their members. We recommend that TRB work with other transportation professional organizations (such as ITE, AASHTO and APTA) and other international organizations (such as the OECD, World Bank and European Union) to establish transportation data quality standards, including a protocol for audits. These standards would then become the basis for evaluating and improving data collection and dissemination. This effort is consistent with good management in general and sustainable transportation planning in particular.

Conclusions

Policy analysis and planning require accurate information for guidance. This is particularly important for sustainability planning, which takes into account diverse, indirect and long-term impacts. Sustainable transportation indicators are an important tool for better transportation planning.

There is currently no standard set of sustainable transportation indicators. A variety of indicators are used, some of which we believe are particularly appropriate and useful for planning and policy analysis. It would be highly desirable for transportation professional organizations to develop standardized, "baseline" indicator sets, with consistent definitions and collection methods, suitable for comparing impacts and trends between different organizations, jurisdictions and times. This can include some indicators suitable for all situations, and others for specific needs and conditions.

We therefore recommend that TRB initiate efforts to establish standardized sets of sustainable transportation indicators. This should build on existing efforts to improve the collection of transportation statistics, expanding these efforts to reflect key economic, social and environmental impacts.

This paper identifies and evaluates various indicators that we believe would provide useful guidance without being too difficult to collect or analyze. We propose that a subset of these indicators (those rated *A*) be applied in virtually every situation. Another subset (rated *B*) are proposed for application where they are relevant and feasible for a project, plan, or program. A third subset (rated *C*) are proposed for specific applications. These are not an ultimate or exhaustive list of useful indicators, but we believe that they are a suitable start for developing indicator sets and defining data collection requirements.

We also discuss data quality issues. Although transportation-related statistics are widely gathered, their quality is highly variable, and even the best data are often incompatible with those from other organizations and jurisdictions. This is a waste of resources and a lost opportunity for improving our ability to understand important trends and relationships. We therefore recommend that TRB work with other transportation professional organizations and international organizations to establish international standards for the collection of transportation-related statistics.

We hope that a strategy for development and application of sustainable transportation indicators can be established by TRB so this strategy can inform transportation data collection and planning programs. Specifically, we recommend that TRB:

- Endorse the need for indicators of sustainable transportation as a significant element in comprehensive transportation planning.
- Establish a research program concerning the collection, analysis and application of high quality, standardized transportation data, with a special focus on data for indicators listed as 'A' in this paper and including a program setting data quality standards.
- Work with other professional organizations in the US and abroad to establish indicators sets suitable for transportation planning and policy benchmarking.

References

BTS (annual reports), *National Transportation Statistics*, Bureau of Transportation Statistics (www.bts.gov/publications/national_transportation_statistics).

Mikhail Chester and Arpad Horvath (2008), *Environmental Life-cycle Assessment of Passenger Transportation: A Detailed Methodology for Energy, Greenhouse Gas and Criteria Pollutant Inventories of Automobiles, Buses, Light Rail, Heavy Rail and Air v.2*, UC Berkeley Center for Future Urban Transport, Paper vwp-2008-2; at http://repositories.cdlib.org/its/future_urban_transport/vwp-2008-2.

CST (2003), *Sustainable Transportation Performance Indicators*, Centre for Sustainable Transportation (www.cstctd.org); at http://cst.uwinnipeg.ca/completed.html.

CST (2005), *Defining Sustainable Transportation*, Centre for Sustainable Transportation (www.cstctd.org); at http://cst.uwinnipeg.ca/documents/Defining_Sustainable_2005.pdf.

DfT (2007), *National Statistics Quality Review Programme*, UK Department for Transport (www.dft.gov.uk); at www.dft.gov.uk/pgr/statistics/standardsreview/nationalstatisticsqualityrev5473.

ECMT (2004), *Assessment and Decision Making for Sustainable Transport*, European Conference of Ministers of Transportation, Organization of Economic Coordination and Development (www.oecd.org).

EMEP/CORINAIR (2007), *Emission Inventory Guidebook*, UNECE/EMEP Task Force on Emissions Inventories and Projections for the European Environment Agency; at http://reports.eea.europa.eu/EMEPCORINAIR5/en/page002.html.

GRI (2007), *Sustainable Reporting Guidelines*, Global Reporting Initiative (www.globalreporting.org).

Henrik Gudmundsson (2001), *Indicators and Performance Measures for Transportation, Environment and Sustainability in North America*, National Environmental Research Institute, Roskilde, Denmark (www.dmu.dk/1_viden/2_Publikationer/3_arbrapporter/default.asp).

Henrik Gudmundsson (2003), "Making Concepts Matter: Sustainable Mobility And Indicator Systems In Transport Policy," *International Social Sciences Journal* vol. 176, pp. 199-217

iRAP International Transport Statistics Database (www.iraptranstats.net), by the Transport Statistics Programme, funding by the FIA Foundation for the Automobile and Society, provides a wide selection of transport statistics.

Jeffrey R. Kenworthy and Felix B. Laube (1999), *An International Sourcebook of Automobile Dependence in Cities, 1960-1990*, University Press of Colorado (Boulder).

Todd Litman (2006), *Socially Optimal Transport Pricing and Markets*, VTPI (www.vtpi.org); at www.vtpi.org/sotpm.pdf.

Todd Litman (2007) *Well Measured: Developing Indicators for Comprehensive and Sustainable Transport Planning*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/wellmeas.pdf.

Todd Litman and David Burwell (2006), "Issues in Sustainable Transportation," *International Journal of Global Environmental Issues*, Vol. 6, No. 4, pp. 331-347; at www.vtpi.org/sus_iss.pdf.

Greg Marsden, et al. (2005), *Appraisal of Sustainability: Environmental Indicators*, Institute for Transport Studies, University of Leeds ; at www.its.leeds.ac.uk/projects/sustainability/resources/Appraisal%20of%20Sustainability%20in%20Transport%20-%20Environment%20Indicators.pdf.

Greg Marsden, C. Kelly, J. Nellthorp, K. Lucas and M. Brookes (2005), *A Framework for the Appraisal of Sustainability in Transport*, Project Report, www.its.leeds.ac.uk/projects/sustainability/index.html.

Gerhard Metschies (2001), *Adam Smith and the Principles of a Sustainable: An analysis of the 12 principles of road policy, based on An Enquiry into the Nature and Causes of the Wealth of Nations by Adam Smith, first published 1776*, for Historical Roots of the Road Management Initiative (RMI), the International Road Federation and Deutsche Gesellschaft für Technische Zusammenarbeit GTZ (http://zietlow.com/docs/adamsmith.pdf).

Peter Samuel and Todd Litman (2001), "Optimal Level of Automobile Dependency; A TQ Point/Counterpoint Exchange," Transportation Quarterly, Vol. 55, No. 1, Winter 2001, pp. 5-32.

UITP (2005), *Mobility In Cities Database*, International Association of Public Transport (www.uitp.com/rome2005/RMR/en/pics/MCD-en.pdf).

VTPI (2007), "Transportation Statistics," *Online TDM Encyclopedia*, Victoria Transport Policy Institute (www.vtpi.org); at www.vtpi.org/tdm/tdm80.htm.

WCED (1987) *Our Common Future*, World Commission on Environment and Development, www.un.org.