Smart Mobility: A Survey of Current Practice and Related Research

Requested by
Christine Ratekin, Caltrans Division of Transportation Planning

April 25, 2012

The Caltrans Division of Research and Innovation (DRI) receives and evaluates numerous research problem statements for funding every year. DRI conducts Preliminary Investigations on these problem statements to better scope and prioritize the proposed research in light of existing credible work on the topics nationally and internationally. Online and print sources for Preliminary Investigations include the National Cooperative Highway Research Program (NCHRP) and other Transportation Research Board (TRB) programs, the American Association of State Highway and Transportation Officials (AASHTO), the research and practices of other transportation agencies, and related academic and industry research. The views and conclusions in cited works, while generally peer reviewed or published by authoritative sources, may not be accepted without qualification by all experts in the field.

Executive Summary

Background

Caltrans' groundbreaking report, *Smart Mobility 2010: A Call to Action for the New Decade*, laid out a vision for developing a new approach to transportation that is multimodal, sustainable and integrated with land use. As part of its preparation for testing the implementation of the Smart Mobility Framework through pilot studies, Caltrans is interested in identifying the sustainability tools, research, guidance and best practices that have been developed or initiated since the January 2010 publication of *Smart Mobility 2010*.

To aid in this effort, this Preliminary Investigation examines completed and ongoing domestic and international research and investigates federal, state and regional activities to assess the current state of the practice of sustainability-oriented planning and performance measurement.

Summary of Findings

Even given the relatively short time period that is the focus of this Preliminary Investigation (January 2010 to the present), we found an abundance of publications that address sustainability in transportation planning. We gathered information in three topic areas:

- National Guidance and Tools.
- Transportation Agency Tools.
- Related Research.

The table that begins on page 2 summarizes the tools and measures highlighted in this Preliminary Investigation. Items appearing in this table are culled from all three sections of this report. The column labeled "For More Information" provides the page number where additional information on each tool or measure appears in this Preliminary Investigation.

Sustainability Tools and Measures			
Tool/Measure	**Agency/Region/Organization**	**Description**	**For More Information**
CEEQUAL	International	Online assessment tool that scores project performance on management and a range of environmental and social issues.	21
Composite Sustainability Index	Atlanta, GA	Considers multidimensional conflicting criteria in the transportation planning process and identifies the most sustainable (or least unsustainable) plan for predetermined objectives.	13
Envision	Institute for Sustainable Infrastructure (Founded by American Society of Civil Engineers, American Public Works Association, and American Council of Engineering Companies)	Evaluates, grades and gives recognition to the community, environmental and economic benefits of infrastructure projects.	11
Evaluative and Logical Approach to Sustainable Transport Indicator Compilation (ELASTIC)	United Kingdom	Framework for identifying and selecting a small subset of sustainable transport indicators.	20
Green Guide for Roads	Transportation Association of Canada	Initial framework includes 13 areas where sustainability practices can be applied, with a description of requirements and associated best practices or strategies. Applies to all types of roads in urban and rural settings and includes sustainability considerations such as improved compatibility and livability; universal accessibility; modal equity; conservation of resources; affordability on a full life-cycle basis; and environmental protection.	21
GreenLITES	New York State Department of Transportation	Expanded program includes rating systems, spreadsheets and other metrics to assess projects, plans, operations and maintenance programs, and regional programs.	15

Sustainability Tools and Measures			
Tool/Measure	**Agency/Region/Organization**	**Description**	**For More Information**
Greenroads	Greenroads Foundation (Developed by University of Washington researchers and global engineering firm CH2M Hill)	Project-based sustainability rating system. Performance metric awards points for more sustainable practices during the design and construction phases of roadway projects.	16
Illinois Livable and Sustainable Transportation (I-LAST)	Illinois Department of Transportation	Checklist of potentially sustainable practices is followed by a description of the intent of each category in the checklist and the rationale and measures of effectiveness for each item. Lists of source materials and additional background resources for each item assist in understanding and applying the practices.	14
Infrastructure Voluntary Evaluation Sustainability Tool (INVEST)	Federal Highway Administration (FHWA)	Web-based self-evaluation tool with three categories or criteria: project development, operations and maintenance, and system planning. Assigns each practice a point value (weight) according to its relative impact on roadway sustainability.	11
Least Cost Planning	Oregon Department of Transportation	Model for use as a decision-making tool in the development of plans and projects at both the state and regional levels. Livability, safety, equity, economic vitality and environmental stewardship will be evaluated side-by-side with traditional considerations such as capital costs.	16
Model of Sustainability and Integrated Corridors (MOSAIC)	Maryland State Highway Administration	Tool employs a Microsoft Excel spreadsheet. Six categories of sustainability indicators: mobility, safety, socioeconomic impact, natural resources, energy and emissions, and cost. Includes more than 30 sustainability performance measures.	14

Sustainability Tools and Measures			
Tool/Measure	**Agency/Region/Organization**	**Description**	**For More Information**
Project Assessment Tool	State of Rhode Island	Tool includes the following categories: • Transportation choice and accessibility. • Housing choice and affordability. • Economic development. • Support of existing communities and designated growth centers. • Community character and collaboration. Most categories contain five to six questions. Weighting is available but not required.	17
Sustainability Enhancement Tool	Texas Department of Transportation	Excel-based calculator that applies performance measures for sustainability at the highway corridor level; includes 12 performance measures.	18
Sustainable Corridor Rating System	University of Delaware, Newark	Methodology for rating systems applied to urban corridors.	19
Sustainable Transportation Access Rating System (STARS)	Collaboration of public and private sector transportation professionals from Oregon, Washington, California and Nevada	Framework applies 29 credits organized into six categories: integrated process; access; climate and energy; ecological function; cost-effectiveness analysis; and innovation.	12
Urban.Access	Israel	Developed as an ArcGIS extension that can be used in urban regions worldwide where high-resolution geographic information system (GIS) data is available. Enables a detailed representation of travel times by transit and car and makes it possible to compare accessibility levels by transport mode.	24

In addition to the tools and measures highlighted in the table, the remaining publications cited in each topic area are summarized below.

National Guidance and Tools

- An August 2011 guide published by the Environmental Protection Agency describes 12 performance measures that focus on decision-making at the regional or metropolitan level.
- Several of the tools highlighted in this Preliminary Investigation are reviewed in a June 2011 NCHRP report that examines how state departments of transportation (DOTs) can implement performance measurement to assess the relative sustainability of transportation networks and corridors. An Excel-based tool is available on a CD-ROM included with the report.
- A guidebook published by FHWA in January 2011 addresses key issues associated with sustainability practices, including data availability, and provides case studies that demonstrate sustainability practices implemented by transportation agencies within the United States and abroad.
- A December 2010 update to a 2003 guide published by the Institute of Transportation Engineers provides guidelines that advance sustainability.
- Case studies that demonstrate how livability principles have been incorporated into transportation planning, programming and project design are included in a 2010 guidebook published by FHWA and the Federal Transit Administration.

Transportation Agency Tools

- A 2012 TRB Annual Meeting paper presented the lessons learned from more than 10 years of applying Florida DOT's 15 mobility performance measures.

Related Research

This section includes research in the following categories:

- Tools and measures.
- Economic issues.
- Data collection and interpretation.
- Transit-related issues.
- Emissions.

Tools and Measures

- A 2010 TRB Annual Meeting paper describes the use of influence diagrams to define causal relationships between sustainability parameters.
- A 2011 paper examines how the environmental impacts of transportation can be represented by operational indicators, and how those indicators can be used in planning and decision-making.
- The authors of a 2010 paper describe a multicriteria assessment model that considers three dimensions of sustainability: economic, social and environmental. Researchers tested the assessment model in a Spanish case study using a GIS framework.
- A May 2010 publication, the final report of a collaboration of European scientists, includes five case studies that examine indicators applied to transportation policies, plans or projects.

- Seven attributes of robust performance measurement systems are used to analyze five case studies in the United States and Europe in a 2010 *Transportation Research Record* paper.
- Ongoing projects are investigating sustainability practices in transportation planning:
    - An Alabama DOT project is developing a framework for using sustainable transportation performance measures and identifying required data elements and data sources.
    - The North Carolina Sustainability Blueprint will include sustainability transportation indicators, performance measures and a return on investment tool.
    - FHWA is undertaking an outreach program in connection with its INVEST tool.

Economic Issues

- A 2011 TRB Annual Meeting paper examined alternative project rating mechanisms and performance metrics that relate transportation improvements to economic growth to illustrate how differences in factor weights affect project selection.
- Researchers in Texas are developing a user-friendly economic impact model that will allow decision-makers to see the effects transportation improvements have on the local market and enable them to make more informed choices.

Data Collection and Interpretation

- A 2010 TRB Annual Meeting paper investigated the quality and availability of data required for sustainable transportation indicators.

Transit-Related Issues

- A 2011 paper describes the use of a model based on survey outcomes to measure the impact of accessibility on the odds of nondrivers leaving their homes on a given day.
- A case study of a transit expansion plan for the light rail system in Santa Clara County, CA, is the subject of a 2011 TRB Annual Meeting paper that describes a travel demand model integrated with land use development strategies and emissions modeling.
- Ongoing projects include:
    - A project sponsored by the University Transportation Center for Alabama will identify and summarize analytical methods appropriate for estimating transit's economic benefits as they relate to travel, economic development, society and health.
    - Researchers are collecting existing data to support the development of transit-oriented development analytical tools in a project sponsored by Maryland State Highway Administration.
    - A Transit Cooperative Research Program project will develop a handbook that presents a framework for assessing the livability outcomes of transit corridor planning and decision-making.

Emissions

- In a 2010 paper, the authors propose environmental impact assessment indices to evaluate the environmental effects of link capacity degradation in road networks.

Gaps in Findings

We did not find recent research on some of the more specific aspects of sustainability-oriented transportation planning. While there is clearly a great deal of interest and research activity associated with this topic, many of the measures or tools are relatively new or still in development. In some cases, a tool or measure is ready for use but has yet to be applied by a significant number of users. Their relative novelty means that the efficacy of the best practices identified and reflected in these sustainability measurement methodologies may still be an open question.

Next Steps

Caltrans might consider the following in a continuing evaluation of best practices for the application of sustainability-oriented transportation planning and performance measurement:

- Contact the transportation agencies that are using sustainability tools and measures to identify how well the tools are performing and garner any lessons learned from initial implementation. Potential contacts include:
    - Illinois DOT—Illinois Livable and Sustainable Transportation (I-LAST).
    - Maryland State Highway Administration—Model of Sustainability and Integrated Corridors (MOSAIC).
    - New York State DOT—GreenLITES.
    - Oregon DOT—Greenroads.
    - Rhode Island DOT—Project Assessment Tool.
    - Santa Cruz County Regional Transportation Commission and Portland Bureau of Transportation—Sustainable Transportation Access Rating System (STARS).
    - Texas DOT—Sustainability Enhancement Tool.
- Contact agencies with measures or tools in development to learn more about the development process and plans for implementation, including:
    - Alabama DOT (framework for sustainable performance measures). December 2012 is the expected completion date of this project that will also identify data elements and data sources required to quantify the measures.
    - FHWA (INVEST). Feedback generated during the pilot test phase will be incorporated into Version 1.0, which is scheduled for release in spring 2012.
    - Institute for Sustainable Infrastructure (Envision). A third-party objective rating verification for preconstruction became available in January 2012; a self-assessment checklist will be available in spring 2012. Tools for complex or multistage projects and optimization support will be released after 2012.
    - North Carolina DOT (NCDOT Sustainability Blueprint). An interactive spreadsheet model computes a composite score based on place-based weighting of sustainable transportation indicators. The final blueprint, which will include a return on investment tool, is in development.
    - Oregon DOT (Least Cost Planning Tool). Implementation of a beta version of the tool and a guidebook for how to apply the tool at the state, regional or corridor level is scheduled to begin later in 2012.

- Transportation Association of Canada (Green Guide for Roads). Summer 2012 is the expected completion date for this framework that assesses the sustainability of urban and rural roads.

- Contact Florida DOT to gain insight into the successes and challenges of the application of mobility performance measures over time.
- Evaluate the Excel-based tool described in a 2011 NCHRP report, which applies performance measures in assessing the sustainability of transportation networks or corridors.
- Consider the applicability of international tools and models, including CEEQUAL, ELASTIC and Urban.Access, to the Caltrans environment.

National Guidance and Tools

Guidance

Guide to Sustainable Transportation Performance Measures, Environmental Protection Agency, August 2011.
http://www.epa.gov/smartgrowth/pdf/Sustainable_Transpo_Performance.pdf
This guidebook describes 12 performance measures that focus on decision-making at the regional or metropolitan level, though many of the performance measures could also be used at the state or local level. For each measure, the guidebook presents possible metrics, summarizes the relevant analytical methods and data sources, and illustrates the measure's use by one or more transportation agencies. The 12 profiled measures are transit accessibility; bicycle and pedestrian mode share; vehicle miles traveled per capita; carbon intensity; mixed land uses; transportation affordability; distribution of benefits by income group; land consumption; bicycle and pedestrian activity and safety; bicycle and pedestrian level of service; average vehicle occupancy; and transit productivity.

A Guidebook for Sustainability Performance Measurement for Transportation Agencies, *NCHRP Report 708*, June 2011.
http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_708.pdf
This guidebook for state DOTs demonstrates how performance measurement can be implemented to assess the relative sustainability of the agencies' transportation networks and corridors over space and time.

Researchers reviewed the following transportation sustainability systems in connection with this project:

- FHWA's Sustainable Highways.
- Sustainable Transportation Access Rating System (STARS).
- Greenroads.
- GreenLITES.
- Illinois Livable and Sustainable Transportation (I-LAST).
- Green Guide for Roads.
- BE^{2}ST-in-Highways.
- GreenPave.

Appendices to the report provide tools and resources for applying the measures.

> **Appendix B, Performance Measures Compendium** (page 64 of the PDF). The objectives and performance measures are organized by goal and focus area. The 11 recommended transportation sustainability goals are safety; basic accessibility; equity/equal mobility; system efficiency; security; prosperity; economic viability; ecosystems; waste generation; resource consumption; and emissions and air quality. One measure in each area is included in Appendix D, which illustrates implementation by transportation agencies.
>
> The CD-ROM included with the guidebook contains an Excel spreadsheet–based version of the performance measures compendium. The spreadsheet allows the existing measures to be modified, and macros enable the user to generate and export a custom list of measures.

Appendix C, Electronic Compendium User Instructions (page 131 of the PDF). Contains detailed instructions and screen captures to help users navigate the electronic compendium and filter, sort and export objectives and performance measures to meet their specific requirements.

Appendix D, Sustainability Performance Measure Examples (page 137 of the PDF). Provides examples in practice for a selected set of performance measures from the compendium. For each goal, one measure per focus area is illustrated by an example of a similar measure in use by a transportation agency.

Appendix E, Data Sources (page 173 of the PDF). Lists some generic resources for data that may be used to support many of the performance measures included in the compendium. Only data sources that may be relevant for a large number of agencies are included.

Appendix F, Case Studies and Rating Systems Summaries (page 175 of the PDF). Contains one-page summaries of the 14 case studies conducted as part of this research project, along with detailed descriptions of eight popular transportation sustainability rating systems that were studied.

Related resource:

Sustainability Performance Measures for State DOTs and Other Transportation Agencies, Final Report, NCHRP Project No. 08-74, July 2011.
http://onlinepubs.trb.org/onlinepubs/nchrp/docs/NCHRP08-74_FR.pdf
This is the final report that provided the source material for preparation of the guidebook. The report includes results of the literature review, surveys of the state of the practice, case study interviews, detail on research methodology and findings, and a discussion of future research needs.

Transportation Planning and Sustainability Guidebook, Office of Planning, Environment and Realty, FHWA, January 2011.
http://www.fhwa.dot.gov/hep/climate/sustainability/index.cfm
From the abstract: The guidebook presents critical issues involved in planning for sustainable transportation systems (Chapter 2) and then reviews current practices in the U.S. and abroad that address these issues (Chapter 3). One of the major challenges in implementing sustainability assessment for planning relates to data availability, so Chapter 4 describes potential data sources and examples of how data has been used in sustainability-related initiatives. Chapter 5 consists of case studies of sustainability practices that have been implemented by U.S. transportation agencies or comparable agencies abroad. It also describes cutting-edge evaluation methods that have not been widely applied by transportation agencies, but could greatly advance sustainability evaluation and planning.

Smart Growth Transportation Guidelines: An ITE Recommended Practice, Institute of Transportation Engineers, December 2010.
Citation at http://trid.trb.org/view/2010/M/1093961
This report replaces the proposed recommended practice published in January 2003. The guidelines advance five goals:

- The pursuit of efficient, compact land use patterns that maximize transportation efficiency and improve the environment.
- Provision of mobility utilizing multimodal transportation within developed areas.
- Provision of accessibility in built-up areas that are currently in existence.
- Efficiently utilizing transportation infrastructure.
- Utilizing sustainable financing and pricing to support smart growth.

Livability in Transportation Guidebook: Planning Approaches That Promote Livability, FHWA, Federal Transit Administration, Report No. FHWA-HEP-10-028, 2010.
http://environment.transportation.org/pdf/sustainability/fhwalivability-in-transportation-guidebook.pdf
This guidebook's primary purpose is to illustrate how livability principles have been incorporated into transportation planning, programming and project design, using examples from state, regional and local sponsors. Chapter 4, Policy, which begins on page 45 of the report (page 57 of the PDF), provides a series of case studies, including Smart Transportation (PennDOT); Atlanta (GA) Regional Commission Livable Centers Initiative; Charlotte (NC) Integrated Transit and Land Use Planning; and the Maryland Department of Transportation Transit-Oriented Development Initiative.

Tools

INVEST, Infrastructure Voluntary Evaluation Sustainability Tool, FHWA.
http://www.sustainablehighways.org/
INVEST is a web-based self-evaluation tool that allows states to integrate sustainability into transportation projects by evaluating roadway projects against the best practices—identified as "criteria"—in the tool's evaluation system. The user can choose to what extent to measure success against the absolute scale of how many overall points are achieved by a given project.

Criteria in the tool are organized in three categories: project development, operations and maintenance, and system planning. Each criterion describes a particular sustainable practice and assigns it a point value (weight) according to its relative impact on roadway sustainability. Weighting of the criteria is based on both principles and benefits of sustainability. FHWA notes that INVEST differs from other tools that assess sustainability in that it focuses on highways and transportation, while some of the other tools cover broader topics, such as general civil infrastructure or site development.

FHWA conducted pilot testing of the tool in the summer and fall of 2011. Feedback generated during the pilot test phase will be incorporated into Version 1.0, which is scheduled for release in spring 2012.

Envision, Institute for Sustainable Infrastructure.
http://www.sustainableinfrastructure.org./rating/index.cfm
From the web site: Envision is the product of a joint collaboration between the Zofnass Program for Sustainable Infrastructure at the Harvard University Graduate School of Design and the Institute for Sustainable Infrastructure.

Envision provides a holistic framework for evaluating and rating the community, environmental, and economic benefits of all types and sizes of infrastructure projects. The Envision Rating System evaluates, grades, and gives recognition to infrastructure projects that use transformational, collaborative approaches to assess the sustainability indicators over the course of the project's life cycle. The initial draft version of the Envision rating system has been tested on 18 projects that represent a broad spectrum of infrastructure projects across various locations, phases of development and project objectives. (See http://www.sustainableinfrastructure.org./casestudies/index.cfm for links to these case studies.)

Envision will be released in stages, with Stage 1, a self-assessment checklist, available in spring 2012. Stage 2, a third-party objective rating verification for preconstruction, became available in January 2012; verification systems for construction and operations and maintenance will be available later in 2012. Stages 3 and 4, which are tools for complex or multistage projects and optimization support, will be released after 2012.

Related resource:

Summary of ASCE-ACEC-APWA Sustainable Infrastructure Project Rating System, American Society of Civil Engineers, American Public Works Association, American Council of Engineering Companies, undated.
http://www.asce.org/uploadedFiles/Sustainability/ISI_Certification/SIPRS%20Summary%20-%20rev3%208-10.doc
This document provides background on development of the web-based Envision tool.

Transportation Agency Tools

This section lists publications that offer information about a range of methods employed by transportation agencies in advancing sustainability-oriented transportation planning and performance measurement.

Collaborative Projects

Sustainable Transportation Access Rating System (STARS) Pilot Project Application Manual, North American Sustainable Transportation Council, Portland Bureau of Transportation, Version 1.1, February 6, 2011.
http://www.portlandonline.com/transportation/index.cfm?c=34749&a=330336
The STARS framework is being developed by public and private sector transportation professionals from Oregon, Washington, California and Nevada. STARS is a planning and evaluation tool for transportation projects that evaluates multimodal access benefits and costs over the full life cycle, including operations, where most of a project's benefits and impacts occur. STARS also has a unique emphasis on reducing energy use and climate pollution, and on evaluating the cost-effectiveness of different strategies. STARS is most effective when used to plan a project or series of corridor projects; other systems are most effective during project design and construction phases.

STARS is organized into 29 "credits," 12 of which are detailed in this manual. Not all credits are applicable to or realistic for all projects, so only a portion of the credits are required for a given project. The 29 credits are organized into six categories: integrated process; access; climate and energy; ecological function; cost-effectiveness analysis; and innovation. The first credit in each of the first five categories is a required credit.

Subsequent versions of STARS will include credit weighting, scoring and certification for all projects that enter the STARS program. At that point, STARS will serve as both a planning tool and as a rating system for transportation projects, plans and employer commute trip reduction incentive programs. A 2012 national rollout is planned.

Related resources:

STARS, Multi-Modal Projects, Santa Cruz County Regional Transportation Commission (SCCRTC).
http://sccrtc.org/projects/multi-modal/stars/
In the fall of 2010, the SCCRTC's Highway 1 Improvement Project became the first project to apply STARS credits. This web site notes that "the focus of STARS is on access, rather than mobility. Access is mode-neutral and assumes that there are multiple ways to meet a community's needs (e.g., compact communities, transit, virtual communications, driving)."

STARS, Portland Bureau of Transportation.
http://www.portlandonline.com/transportation/index.cfm?a=319882&c=34749

This site includes links to STARS documents; the agency is one of the developers of the STARS framework.

"**Sustainable Transportation Analysis & Rating System (STARS) Performance Measures,"** Peter Hurley, Portland Bureau of Transportation, *4th International Transportation Systems Performance Measurement Conference*, May 19, 2011.
http://onlinepubs.trb.org/onlinepubs/conferences/2011/PerformanceSystemsMeasurement/Hurley.pdf
This conference presentation outlined potential benefits of STARS, including:

- Simplifies and standardizes projects and plans around "triple bottom line" (equity, environment, economy) goals.
- Allows direct comparison of alternatives and projects using triple bottom line metrics.
- Identifies a green dividend (money leaving the local economy is retained by reducing fuel spending).
- Saves time and money via a simplified process and focused goals and objectives.
- Increases healthy transportation (walking, cycling, transit by employees and residents).
- Helps meet economic, climate, livability and equity goals.

Florida

"Florida's Mobility Performance Measures and Experience," Douglas S. McLeod, Gordon Morgan, *TRB 91st Annual Meeting Compendium of Papers DVD*, Paper #12-0038, 2012.
Citation at http://trid.trb.org/view/2012/C/1128535
This conference paper presented an overview of Florida DOT's mobility performance measures, as well as the authors' perspectives on their usefulness and lessons learned. FDOT's 15 primary mobility performance measures address four dimensions: quantity of travel; quality of service; accessibility; and capacity utilization. The authors and FDOT have been tracking and reporting on most of FDOT's 15 performance measures for over 10 years. Further discussion includes a look to the future of mobility performance measures focusing on the quality of service measures, delay, travel time reliability and level of service.

Georgia

"Evaluating Plan Alternatives for Transportation System Sustainability: Atlanta Metropolitan Region," Christy Mihyeon Jones, Adjo A. Amekudzi, Randall L. Guensler, *International Journal of Sustainable Transportation*, Vol. 4, No. 4, July 2010: 227-247.
Citation at http://www.informaworld.com/10.1080/15568310902940209
In this paper, the authors demonstrate an application of the multiple criteria decision-making approach for evaluating selected transportation and land use plans in the Atlanta region using multiple sustainability parameters. A composite sustainability index that considers multidimensional conflicting criteria in the transportation planning process should help decision-makers incorporate sustainability considerations into transportation planning and identify the most sustainable (or least unsustainable) plan for predetermined objectives.

Related resource:

> **"Incorporating Uncertainty into Transportation Decision Making: Sustainability-Oriented Approach,"** Christy Mihyeon Jeon, *Transportation Research Record,* Vol. 2174, 2010: 58-67. Citation at http://dx.doi.org/10.3141/2174-09
> *From the abstract*: The objective of the study is to demonstrate how [uncertainty] can be incorporated when a multiple-criteria decision-making method is used to choose the most desirable among competing alternatives. Using data from the Atlanta, Georgia, metropolitan region, this paper examines the sensitivity of the relative desirability of competing transportation and land use plans to changes in regional priorities and weights for sustainability parameters. Throughout the study, sensitivity analysis is used as a tool to incorporate the variability in criteria weights and concurrent variation in the sustainability evaluation results and final decision. These exercises could help decision-makers determine how changing the emphasis on different regional priorities could most effectively result in desired regional outcomes.

Illinois

I-LAST: Illinois - Livable and Sustainable Transportation Rating System and Guide*,* Illinois Department of Transportation, January 8, 2010.
http://www.dot.state.il.us/green/documents/I-LASTGuidebook.pdf
This guide provides a comprehensive list of practices that have the potential to bring sustainable results to highway projects. I-LAST uses a point system for evaluating the sustainable measures included in a project with respect to livability, sustainability and effect on the natural environment.

The I-LAST Project Environmental Sustainability Rating System Scorecard begins on page 7 of the PDF. The scorecard includes the following categories: context-sensitive solutions; land use/community planning; alignment selection; context-sensitive design; protect, enhance or restore wildlife and its habitat; trees and plant communities; noise abatement; reduce impervious areas; storm water treatment; construction practices to protect water quality; traffic operations; transit; improve bicycle and pedestrian facilities; reduced electrical consumption; stray light reduction; materials; and innovation. A checklist of potentially sustainable practices is followed by a description of the intent of each category included in the checklist and the rationale and measures of effectiveness for each item. Lists of source materials and additional background resources for each item assist in understanding and applying the practices.

Maryland

Comprehensive Highway Corridor Planning with Sustainability Indicators, Maryland State Highway Administration, Report No. MD-11-SP009B4E, October 2011.
http://ntl.bts.gov/lib/42000/42900/42954/MD-11-SP009B4E_-_Comprehensive_Highway_Corridor_Planning_with_Sustainability_Indicators_-_Final_Report.pdf
Researchers developed a Model of Sustainability and Integrated Corridors (MOSAIC) to assist the Maryland State Highway Administration (SHA) in selecting the most sustainable corridor improvement option for its Highway Needs Inventory (a long-term, financially unconstrained technical reference and planning document that identifies highway improvements to serve existing and projected population and economic activity in the state) and long-range planning processes. Elements of MOSAIC include:

- The current version runs within a Microsoft Excel spreadsheet environment and includes a user input module where users can select a corridor and candidate highway improvement options for that corridor; several analysis modules that quantitatively estimate the impact of user-specified improvement options on all sustainability indicators; and an output module that provides both numerical and graphical outputs.

- Six categories of sustainability indicators (mobility, safety, socioeconomic impact, natural resources, energy and emissions, and cost) and more than 30 sustainability performance measures are used as evaluation criteria for the selection of highway corridor improvement options.
- The first version of MOSAIC considers the no-build case and two highway improvement options, including adding a general-purpose lane and converting at-grade intersections to grade-separated interchanges.
- Planned future research will integrate the existing MOSAIC tool into the SHA Enterprise GIS environment to further streamline MOSAIC input and output procedures.
- Future research will expand the highway improvement options in MOSAIC to include road diets (removing auto travel lanes to better accommodate alternative modes of transportation); bus rapid transit; bus-only lanes; high-occupancy vehicle lanes; high-occupancy toll lanes; freight truck–only lanes; light rail transit; express toll lanes; intelligent transportation system/advanced traffic information system deployment; and access management.

Researchers applied MOSAIC to the US 15 corridor north of Fredrick, MD, to demonstrate the tool's feasibility and usefulness for sustainable highway corridor planning.

New York

"Moving Towards Sustainability: New York State Department of Transportation's GreenLITES Story," Gary R. McVoy, Debra A. Nelson, Paul Krekeler, Elisabeth Kolb, Jeffery S. Gritsavage, Conference Proceedings, *2010 Green Streets and Highways Conference*: 461-479.
https://www.dot.ny.gov/programs/greenlites/repository/ASCE%20GreenLITES%20Final%20Paper%207-12-10.pdf
This conference paper described the evolution of New York State DOT's GreenLITES program from its environmentally based beginnings to a more comprehensive approach. Initially designed to assess the environmental sustainability elements of capital projects, the GreenLITES program has adopted a more holistic approach over time to the triple bottom line of economy, equity and environment. The program has expanded to include a growing collection of tools (rating systems, spreadsheets and other metrics) to assess projects, plans, operations and maintenance programs, and regional programs.

Related resources:

> **GreenLITES**, New York State Department of Transportation.
> https://www.dot.ny.gov/programs/greenlites
> *From the web site*: GreenLITES is a self-certification program that distinguishes transportation projects and operations based on the extent to which they incorporate sustainable choices. This is primarily an internal management program for NYSDOT to measure our performance, recognize good practices, and identify where we need to improve. It also provides the department with a way to demonstrate to the public how we are advancing sustainable practices. NYSDOT project designs and operations are evaluated for sustainable practices and based on the total credits received, an appropriate certification level is assigned. The rating system recognizes varying certification levels, with the highest level going to designs and operational groups that clearly advance the state of sustainable transportation solutions.
>
> A staged program implementation began in September 2008 with the GreenLITES Project Design Program, continuing in April 2009 with the GreenLITES Maintenance/Operations Plan Spreadsheet. The ongoing Regional Pilot Program launched in March 2010.

Project Design Certification Program, GreenLITES, New York State Department of Transportation.
https://www.dot.ny.gov/programs/greenlites/project-design-cert
This web page includes links to documents associated with the GreenLITES certification program, including design guidance and an Excel scorecard.

Project Solicitation Tool, GreenLITES for Sustainable Planning, New York State Department of Transportation, undated.
https://www.dot.ny.gov/programs/greenlites/repository/GreenLITES%20Project%20Solicitation%20Tool%20v1%202.doc
This project solicitation tool aimed at municipalities provides a mechanism for project sponsors to review and rate the sustainability of a proposed transportation project.

Oregon

ODOT's Greenroads Pilot Program, Oregon Department of Transportation, undated.
http://www.oregon.gov/ODOT/TD/CLIMATECHANGE/docs/Greenroads_background.pdf
ODOT's two-year pilot Greenroads program, which continued through 2011, involved the evaluation of three pilot projects based on the Greenroads sustainability performance metric. The Greenroads performance metric awards points for more sustainable practices during the design and construction phases of roadway projects and awards a certification level based on the number of points earned, much like the LEED (Leadership in Energy and Environmental Design) program does for buildings.

Related resources:

Greenroads, Greenroads Foundation.
http://www.greenroads.org/
Greenroads is a sustainability rating system for roadway design and construction. It is applicable to all roadway projects including new, reconstruction and rehabilitation (including overlays), bridges, or any other project in which a road is involved.

Greenroads Project Handbook, Greenroads Foundation, April 18, 2011.
http://www.greenroads.org/files/244.pdf
An update of this handbook is in process.

Greenroads Project Checklist, Greenroads Foundation, undated.
http://www.greenroads.org/files/238.pdf
This project checklist is also available as an Excel spreadsheet.

"Evaluating a Project-Based Roadway Sustainability Rating System for Public Agency Use," Steve Muench, Maleena Scarsella, Margorie Bradway, Liz Hormann, Lyn Cornella, *TRB 91st Annual Meeting,* January 2012.
http://www.oregon.gov/ODOT/TD/TP_RES/docs/2012NWTC/2012NWTC_Presentations/29_EvalGreenroads.pdf?ga=t
This conference presentation examined Oregon DOT's use of Greenroads. The presenters note that there is no commonly accepted method to monetize the costs and benefits of sustainability.

Least Cost Planning, Oregon Department of Transportation.
http://www.oregon.gov/ODOT/TD/TP/LCP.shtml
In 2009, the Oregon Legislature defined least cost planning (LCP) for Oregon and directed the Oregon DOT to develop an LCP model for use as a decision-making tool in the development of plans and projects at both the state and regional levels. Informed by research and best practices from around the world, LCP

will provide a method to evaluate impacts of transportation decisions. Livability, safety, equity, economic vitality and environmental stewardship will be evaluated side-by-side with traditional considerations such as capital costs.

Related resources:

Update on Oregon's Least Cost Planning Project: Next Generation Planning Tool, Oregon Department of Transportation, Summer 2011.
http://www.oregon.gov/ODOT/TD/TP/docs/LCP/ProjUpdate.pdf
The project began in 2010 by defining objectives, focus areas, current procedures and general indicators. In the current phase, the project team is identifying specific indicators and an indicator comparison process, and LCP analysis methodology. Implementation of a beta version of the LCP tool and a guidebook for how to apply LCP at a state, regional or corridor level is scheduled to begin later in 2012.

Recommendations Memo #2, Livability and Quality of Life Indicators, Memorandum to Least Cost Planning Project Management Team and Least Cost Planning Working Group, May 9, 2011.
http://www.oregon.gov/ODOT/TD/TP/docs/LCP/Livability.pdf
This memo was prepared to aid the working group's analysis of quality of life and livability indicators for inclusion of these indicators in the LCP tool. The memo includes a summary of the issues related to the quantification and monetization of quality of life and livability indicators and a final set of recommendations. See page 16 of the PDF for Table 5, Relation of Potential Indicators to OLCP Categories of Transportation System Performance.

Rhode Island

"KeepSpace Project Selection and Evaluation Frameworks," Jeff Davis, Harrison Rue, *New Partners for Smart Growth Conference*, February 4, 2012.
http://www.newpartners.org/docs/presentations/Saturday/10.15am%20-%2012.15pm/Saturday%204th%20%20%2010.15-%2012.15%20Getting%20It%20Done/NP12_Davis_Rue.pdf
This conference presentation describes the development of a project selection tool for use in Rhode Island. The project assessment tool includes the following categories:

- Transportation choice and accessibility.
- Housing choice and affordability.
- Economic development.
- Support of existing communities and designated growth centers.
- Community character and collaboration.

Most categories contain five to six questions, and each category includes an "open response" question. Weighting is available but not required.

Related resource:

Developing a Sustainable Communities Project Selection Tool, Transportation Performance Measures Webinar Series, ICF International, February 2012.
http://www.icfi.com/insights/webinars/2012/02/recording-developing-sustainable-communities-project-selection-tool
ICF presented this webinar focusing on the development, testing and application of a project selection tool for use by Rhode Island state and nonprofit agencies to evaluate applications for competitive

funding. The tool was developed through a grant to the KeepSpace Partners, a coalition of state agencies and nonprofit organizations.

Texas

"Sustainability Enhancement Tool for State Departments of Transportation Using Performance Measurement," Tara L. Ramani, Josias Zietsman, William E. Knowles, Luca Quadrifoglio, *Journal of Transportation Engineering*, Vol. 137, No. 6, June 2011: 404-415.
Citation at http://dx.doi.org/10.1061/(ASCE)TE.1943-5436.0000255
In this project, researchers developed a performance measurement–based framework and evaluation methodology for sustainable transportation that is linked to agency strategic planning goals. The methodology was applied and tested for Texas DOT in the agency's highway-corridor planning process. Researchers identified 12 performance measures, including measures of congestion, safety, alternative modes and air quality, to address the goals and objectives in TxDOT's strategic plan. The authors also present results from a pilot application of the methodology for a section of US 281 in San Antonio, TX.

Related resources:

Incorporating Sustainability into TxDOT's Transportation Decision Making—Summary of Work Performed, Methods Used, and Results Achieved, Texas Transportation Institute, Report No. 5-5541-01-1, February 2011.
http://tti.tamu.edu/documents/5-5541-01-1.pdf
This Texas DOT implementation project involved the development of workshop material aimed at disseminating research findings and training participants in hands-on use of the Excel-based calculator—Sustainability Enhancement Tool—that applies performance measures for sustainability at the highway corridor level.

User's Manual for Sustainable Transportation Performance Measures Calculator, Texas Transportation Institute, August 2010.
http://tti.tamu.edu/documents/5-5541-01-P2.zip
This set of documents is the product of the 2009 research project "Developing Sustainable Transportation Measures for TxDOT's Strategic Plan." The overall goal of that project was to develop sustainable transportation performance measures for TxDOT's strategic goals and objectives as well as a framework for TxDOT to implement a sustainable transportation system in Texas. This report contains the user's manual for the user-friendly analysis tool developed in Microsoft Excel to serve as a platform for evaluating the performance measures and combining them into a final sustainability index tool. Included are a user's manual, an Excel spreadsheet and sample results, and instructor and participant materials for training sessions.

Related Research

This section provides publications in the following topic areas related to assessing the sustainability of transportation projects:

- Tools and measures.
- Economic issues.
- Data collection and interpretation.
- Transit-related issues.
- Emissions.

Citations in each topic area are organized by the type of research:

- Domestic research.
- International research.
- Case studies.
- Research in progress.

Tools and Measures

Domestic Research

"Method for Evaluation of Sustainable Transportation: Toward a Comprehensive Approach," Stuart Samberg, Alon Bassok, Shawna Holman, *Transportation Research Record*, Vol. 2242, 2011: 1-8.
Citation at http://dx.doi.org/10.3141/2242-01
Noting that it is crucial that current transportation projects not preclude the provision of multimodal mobility options in the future, the authors present a sustainable transportation evaluation method that builds on the benefits of the existing evaluation systems and attempts to address their shortcomings. The proposed system relies on established multicriterion techniques that allow for quantitative and qualitative evaluation of the sustainability of transportation projects during the planning, design and construction phases. The method is designed to be flexible so that it can be easily implemented by a wide range of stakeholders who are considering diverse issues.

"Understanding of Relationships Among Key Sustainability Measures in Transportation: Using Influence Diagrams," Christy Mihyeon Jeon, Adjo Amekudzi, *TRB 89th Annual Meeting Compendium of Papers DVD*, Paper #10-3196, 2010.
Citation at http://trid.trb.org/view/2010/C/910945
In this project, researchers aimed to define causal relationships between important sustainability parameters using an influence diagram, and discuss the systems interactions between/among common domains of sustainability. These diagrams should at the very least serve as an overview guide for decision-makers who attempt to incorporate sustainability considerations into transportation planning and understand key factors of sustainability and their relationships.

"Rating Sustainability: Transportation Investments in Urban Corridors as a Case Study," Michelle R. Oswald, Sue McNeil, *Journal of Urban Planning and Development*, Vol. 136, No. 3, September 2010: 177-185.
Citation at http://trid.trb.org/view/2010/C/932530

From the abstract: This research develops a methodology for rating systems and applies the system to transportation investments, specifically urban corridors. Urban transportation corridors serve to illustrate the concepts because of their essential role of providing mobility and interaction between and within communities. The end product, sustainable corridor rating system (SCRS), is intended to alter the behavior of transportation practitioners and induce sustainable transportation practices by defining a methodology for developing green rating systems. In addition, the methodology defined in this research can be applied universally to the development of green rating systems similar to SCRS.

International Research

"Framework for Assessing Indicators of Environmental Impacts in the Transport Sector," Robert Joumard, Henrik Gudmundsson, *Transportation Research Record*, Vol. 2242, 2011: 55-63.
Citation at http://dx.doi.org/10.3141/2242-07
The following questions were addressed in this study: How can environmental impacts of transport be identified? How can the impacts be represented by operational indicators? How can several indicators be considered jointly? How can indicators be used in planning and decision-making? This paper presents examples of the application of the criteria for individual indicators of seven chains of causality and for selected aggregated indicators.

"Integration of Sustainability Issues in Strategic Transportation Planning: A Multi-criteria Model for the Assessment of Transport Infrastructure Plans," Elena Lopez, Andres Monzon, *Computer-Aided Civil and Infrastructure Engineering*, Vol. 25, No. 6, August 2010: 440-451.
Citation at http://trid.trb.org/view/2010/C/921527
Noting the lack of an assessment model integrating the sustainability paradigm in transportation planning methodologies, researchers propose a multicriteria assessment model embedded in a GIS. The criteria address the three dimensions of sustainability: economic, social and environmental. This assessment model constitutes an interdisciplinary approach tightly linking network analysis, spatial geography, and regional economic and environmental issues in a GIS-based computer framework. Researchers tested the methodology in a case study of the extension of the high-speed rail network included in the Spanish Transport and Infrastructure Plan 2005-2020.

"ELASTIC: A Methodological Framework for Identifying and Selecting Sustainable Transport Indicators," Herb Castillo, David E. Pitfield, *Transportation Research Part D: Transport and Environment*, Vol. 15, No. 4, June 2010: 179-188.
Citation at http://trid.trb.org/view/2010/C/917773
The authors present the Evaluative and Logical Approach to Sustainable Transport Indicator Compilation (ELASTIC), a framework for identifying and selecting a small subset of sustainable transport indicators. ELASTIC is demonstrated with an application to the English regions in the United Kingdom.

Indicators of Environmental Sustainability in Transport: An Interdisciplinary Approach to Methods, Robert Joumard, Henrik Gudmundsson, Editors, Institut National de Recherche sur les Transports et Leur Sécurité, May 2010.
http://cost356.inrets.fr/pub/reference/reports/Indicators_EST_May_2010.pdf
This volume is the final report of COST 356, a collaboration among a network of scientists specializing in environmental impacts, decision-making processes and transportation and environmental planning. Chapter 6, which begins on page 193 of the PDF, includes five case studies where methods to jointly consider indicators have been applied to transportation policies, plans, projects or technologies.

CEEQUAL, CEEQUAL Ltd., Version 5, March 2012.
http://www.ceequal.com/structure.html
From the web site: CEEQUAL is a self-assessment process that CEEQUAL-trained Assessors use to rigorously assess project or contract performance on management and a range of environmental and social issues of concern, arranged in Version 5 in nine sections (12 in Version 4). Assessors use the appropriate CEEQUAL Manual to score performance against questions relevant to the project or contract. Assessors collect evidence supporting their scores for each question, and use our Online Assessment Tool for capturing those scores and evidence. Upon project or contract completion, each Assessment is externally verified by a CEEQUAL-appointed Verifier.

CEEQUAL schemes are available for projects in the United Kingdom and Ireland and for international projects. The nine sections in Version 5 include project strategy; project management; people and communities; land use and landscape; historic environment; ecology and biodiversity; water environment; physical resources; and transport. With Version 5, the transition of CEEQUAL from an environmental assessment scheme to a sustainability scheme is complete.

Case Studies

"Performance Measurement Frameworks and Development of Effective Sustainable Transport Strategies and Indicators," Yi Lin Pei, Adjo A. Amekudzi, Michael D. Meyer, Elise M. Barrella, Catherine L. Ross, *Transportation Research Record*, Vol. 2163, 2010: 73-80.
Citation at http://trb.metapress.com/content/j8736p8046770822/
From the abstract: This paper identifies seven attributes of robust performance measurement systems by analyzing five performance measurement frameworks and their use of transportation system performance indicators. The attributes are then used to examine three case studies from Europe and the United States to demonstrate the value of performance measurement frameworks for developing and improving sustainable transportation strategies and indicators.

Research in Progress

Green Guide for Roads, Transportation Association of Canada. Expected completion date: summer 2012.
http://tac-atc.ca/english/projects/greenguide.cfm
The goal of this project is to promote sustainable growth and alternative multimodal transportation solutions within corridors, along with safe, long-lasting roadway infrastructure and green construction principles. Researchers identified 13 application areas where sustainability principles and environmental stewardship can be applied, and developed working templates for each that describe requirements and highlight associated best practices and strategies.

The guide under development will be applicable to all types of roads in urban and rural settings and include sustainability considerations such as improved compatibility and livability, universal accessibility, modal equity, conservation of resources, affordability on a full life-cycle basis, and environmental protection. The guide is expected to help users:

- Evaluate the sustainability benefits of an existing or new project.
- Create an approach for improving sustainability benefits on a project.
- Consider various ways to maximize the sustainability benefit.

Related resource:

Green Guide for Roads, Working Template, Transportation Association of Canada, undated.
http://tac-atc.ca/english/projects/pdf/greenguide.pdf
This document describes the initial framework of 13 areas where sustainability practices can be applied with a description of requirements and associated best practices or strategies. Users assign the appropriate numerical score (low, moderate or high) from a self-evaluation of fulfilling the requirements. The 13 areas include:

- Community interface.
- Valued environmental components and land consumption.
- Mobility choices.
- Intersections and driveways.
- Hard surfaces.
- Landscaping.
- Amenities.
- Drainage.
- Safety.
- Energy consumption.
- Construction.
- Operations and maintenance.
- Services and utilities.

"Developing Sustainable Transportation Performance Measures for ALDOT," University Transportation Center for Alabama. Expected completion date: December 31, 2012.
http://trid.trb.org/view/2012/P/1133774
This project will develop a performance measurement system for Alabama DOT to evaluate sustainable transportation while addressing the agency's strategic planning goals. The project's main objectives are to:

- Review major sustainable transportation studies and initiatives in North America and Europe.
- Create a framework for using sustainable transportation performance measures by type of application.
- Develop a sustainability enhancement tool.
- Develop sustainable transportation performance measures to address ALDOT's strategic plan goals.
- Identify data elements and data sources required to quantify the measures.

"NCDOT Sustainability Blueprint: Indicators," Center for Transportation and the Environment, North Carolina State University. Expected completion date not indicated.
http://www.itre.ncsu.edu/cte/Research/project.asp?ID=196
This project is developing a place-specific methodology for quantifying the sustainability of transportation investments made by the North Carolina DOT. A variety of indicators are weighted based on the relative importance of capital to the context of the project. An interactive spreadsheet model computes a composite score based on place-based weighting of sustainable transportation indicators. The Sustainability Blueprint will institutionalize sustainable principles and practices throughout all phases and functions of NCDOT, including planning, project/program development, project delivery and internal operations.

Following completion of an outreach process in September 2011, the project team began preparing the final NCDOT Sustainability Blueprint, which will include a set of performance measures to monitor implementation progress and effectiveness over time.

Related resources:

Sustainability Blueprint Working Group, Center for Transportation and the Environment, North Carolina State University.
http://www.cte.ncsu.edu/sustainability/index.html
The working group's web site includes information about the group's meetings, literature review findings, an inventory of sustainable best practices and more.

"Using Performance Measures/Indicators to Calculate the Triple Bottom Line," Leigh Lane, Center for Transportation and the Environment, North Carolina State University, *Conference on Performance Measures for Transportation and Livable Communities,* September 8, 2011.
http://utcm.tamu.edu/LivabilityConference/presentations/pdfs/Lane.pdf
Highlights from this conference presentation include:

- The NCDOT Sustainability Blueprint project focuses on ascertaining whether sustainable practices are justifiable. The project is also examining indicators of sustainability for use as performance measures.
- Sustainable transportation indicators and return on investment (ROI) overlap. Indicators and tools are conceptually linked.
- Indicators can be generated from ROI tool outputs. Tools can be improved with a better set of indicators to provide guidance.
- The importance of place is evident in examining sustainable transportation indicators, performance measures and sustainability ROI. Place-type indicators might include intersection density, patent density, average lot size, and the ratio of building value to land value. These indicators relate to the built environment, economic functions and development sustainability.

"Sustainable Highways Strategic Outreach & Program Support," FHWA. Expected completion date: August 19, 2014.
http://trid.trb.org/view/2010/P/1095205
In this project, FHWA's Office of Natural and Human Environment is working with the Volpe Center to provide strategic outreach and program management support for FHWA's INVEST tool. See page 11 of this Preliminary Investigation for information about INVEST.

Economic Issues

Domestic Research

"Incorporating Economic Impact Metrics in Transportation Project Ranking and Selection Processes," Glen Weisbrod, *TRB 90th Annual Meeting Compendium of Papers DVD*, Paper #11-2438, 2011.
http://www.edrgroup.org/attachments/410_Hwy-Ranking-Criteria.pdf
Previous literature reviews have summarized alternative project rating mechanisms and different performance metrics that relate transportation improvements to economic growth. In this conference paper, the author sought to critically examine their differences and implications for project selection, finding that alternative rating systems share a common underlying theory but reflect different factor weights. The author notes that the difference in factor weights affects project selection, and illustrates this with the use of an empirical analysis of alternative rating approaches developed in Kansas. Findings from this research can aid transportation agencies in refining performance metrics, analysis methods and their interpretation for use in future decision-making.

Research in Progress

"Refining a Methodology for Determining the Economic Impacts of Transportation Improvements," Texas Transportation Institute. Expected completion date: May 31, 2012.
http://trid.trb.org/view/2011/P/1111836
Researchers recognized a need to set standards for economic impact measurements of transportation improvements and incorporate these measures into a refined and usable system. This project, sponsored by the University Transportation Center for Mobility, will develop a user-friendly, cohesive method that can be used for various levels of analysis. A literature review will be used to assemble the most applicable measures and techniques for economic impact estimations and combine them to create a more standardized method of evaluation. The resulting economic impact model will allow decision-makers to see the effects transportation improvements have on the local market and enable them to make more informed choices.

Data Collection and Interpretation

Domestic Research

"Sustainable Transportation Indicator Data Quality and Availability," Todd Alexander Litman, *TRB 89th Annual Meeting Compendium of Papers DVD*, Paper #10-2496, 2010.
Citation at http://trid.trb.org/view/2010/C/910553
From the abstract: This paper investigates the quality and availability of data required for sustainable transportation indicators. This analysis indicates that much of the information required is already collected, but inconsistencies in definitions and collection methods, a lack of disaggregation to appropriate geographic scales, and difficulties accessing data reduce the utility of this information. With relatively little incremental costs, transportation professional organizations could improve the quality of transportation-related statistics to facilitate transportation research, policy analysis and planning.

Transit-Related Issues

Domestic Research

"Accessibility-Based Factors of Travel Odds: Performance Measures for Coordination of Transportation and Land Use to Improve Nondriver Accessibility," Robert B. Case, *Transportation Research Record*, Vol. 2242, 2011: 106-113.
Citation at http://dx.doi.org/10.3141/2242-13
This paper presents a technique for measuring the performance of government in coordinating transportation and land use to improve nondriver accessibility. Researchers used a model based on surveyed outcomes to measure the impact of accessibility on the odds of nondrivers leaving their homes on a given day.

International Research

"Measuring the Gap Between Car and Transit Accessibility: Estimating Access Using a High-Resolution Transit Network Geographic Information System," Itzhak Benenson, Karel Martens, Yodan Rofe, *Transportation Research Record*, Vol. 2144, 2010: 28-35.
Citation at http://trid.trb.org/view/2010/C/910300
In this paper, the authors propose a set of accessibility measures that directly relates transit-based and car-based accessibility to each other, and present a tool based on a GIS that measures accessibility at a high

level of resolution. The tool—Urban.Access—was developed as an ArcGIS extension and can be used in urban regions worldwide given the availability of high-resolution GIS data. Urban.Access enables a detailed representation of travel times by transit and car and makes it possible to compare accessibility levels by transport mode. The first application of Urban.Access to the Tel Aviv, Israel, region shows substantial gaps between car-based and transit-based accessibility throughout the metropolitan area.

Case Studies

"Integration of Travel Demand, Land Use, and Emissions Modeling for a Transit Corridor Expansion Project in Santa Clara County, California," Chun-Hung Peter Chen, George A. Naylor, *TRB 90th Annual Meeting Compendium of Papers DVD,* Paper #11-3162, 2011.
Citation at http://trid.trb.org/view/2011/C/1092878
From the abstract: This study integrates travel demand modeling with land use development strategies and emissions modeling to provide a method to evaluate various scenarios considering transportation, land use, and environmental impacts simultaneously. A case study of this integrated methodology to a transit expansion plan for the light rail system in Santa Clara County, California, is presented. Using Transit Oriented Development concepts, nine scenarios with denser residential and/or commercial land uses around new light rail stations are developed. The scenario comparisons show the densest mixed-use scenario has significant increases in transit ridership, nonmotorized modes of travel and significant decreases in vehicle miles traveled (VMT) and emissions.

Research in Progress

"Impacts of Transit in a Complete Streets Context," University of Alabama, Birmingham. Expected completion date: February 15, 2012.
http://utca.eng.ua.edu/research/projects/?id=11206
Sponsored by the University Transportation Center for Alabama, this project's goals are to identify and summarize analytical methods appropriate for estimating transit's economic benefits as they relate to travel, economic development, society and health. Using inputs from earlier studies, national or regional data, and available methods, the research team will quantify both health-related and economic impacts of transit integration in a complete street environment. Recommendations will be developed to incorporate the findings into transportation planning at the local and national levels.

"Developing a Framework and Models for Transit-Oriented Development (TOD) Analysis," University of Maryland, College Park, Morgan State University. Expected completion date: February 1, 2013.
http://trid.trb.org/view/2012/P/1132324
In a project sponsored by Maryland State Highway Administration, researchers are collecting existing data to support the development of transit-oriented development (TOD) analytical tools. Statistical models will analyze the impact of TODs on selected travel behaviors, and simulation tools such as TRANSIMS will analyze the impact of TOD-induced behavioral changes on corridor-level traffic congestion, pollution, greenhouse gas emissions and other sustainability indicators.

Livable Transit Corridors: Methods, Metrics, and Strategies, TCRP Project H-45. Expected completion date: July 19, 2013.
http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3091
The objective of this research is to develop a handbook that presents a framework for assessing the livability outcomes of transit corridor planning and decision-making. The framework should include methods for evaluating transit corridor-level livability outcomes, and metrics that relate transit corridor planning to livability. The framework should address the six livability principles identified in the interagency *Partnership for Sustainable Communities* (see http://www.epa.gov/smartgrowth/pdf/partnership/2010_1230_psc_ejflyer.pdf).

Emissions

Domestic Research

"Environmental Impact Assessment of Transportation Networks with Degradable Links in an Era of Climate Change," Anna Nagurney, Qiang Qiang, Ladimer S. Nagurney, *International Journal of Sustainable Transportation*, Vol. 4, No. 3, 2010: 154-171.
Citation at http://trid.trb.org/view/2010/C/917792
The authors propose environmental impact assessment indices to evaluate the environmental effects of link capacity degradation in road networks. The indices are applicable in the case of either user-optimizing or system-optimizing behavior. The authors also construct environmental link importance indicators that allow for the ranking of links in transportation networks in terms of their environmental importance should they be removed or destroyed. Numerical transportation network examples illustrate the proposed quantitative environmental indicators and further substantiate that system-optimizing behavior does not necessarily lead to reduced emissions.