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Well Measured

Developing Indicators for Comprehensive and Sustainable Transport Planning

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A world view showing Africa taken Dec. 7, 1972 as Apollo 17 left Earth orbit for the Moon. (Courtesy of NASA).

Abstract

This paper provides guidance on the selection of indicators for comprehensive and sustainable transportation planning. It discusses the concept of sustainability and the role of indicators in planning, describes factors to consider when selecting indicators, identifies potential problems with conventional indicators, describes examples of indicators and indicator sets, and provides recommendations for selecting indicators for use in a particular situation.

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Introduction

There is growing interest in the concepts of sustainability, sustainable development and sustainable transportation. Sustainability is generally evaluated using various *indicators*, which are specific variables suitable for quantification (measurement). Such indicators are useful for establishing baselines, identifying trends, predicting problems, assessing options, setting performance targets, and evaluating a particular jurisdiction or organization. Which indicators are selected can significantly influence analysis results. A particular policy may seem beneficial and desirable when evaluated using one set of indicators but harmful and undesirable when evaluated using others. It is therefore important for everybody involved in sustainable transportation planning to understand the assumptions and perspectives used to select and define sustainable transportation indicators.

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.

Objective – a way to achieve a goal.

Target – A specified, realistic, measurable objective.

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.

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

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).

This paper explores concepts related to the definition of sustainable transportation and the selection of indicators suitable for policy analysis and planning. It discusses various definitions of sustainability and the role of indicators, describes factors to consider when selecting indicators, identifies potential problems with conventional transport planning indicators, describes examples of indicators and indicator sets, and provides recommendations for selecting indicators for use in a particular situation.

Sustainable Transportation

There is growing interest in *sustainability* and its implications for transport planning (Litman and Burwell, 2006). Sustainability reflects the fundamental human desire to make the world better. Sustainability emphasizes the integrated nature of human activities and therefore the need to coordinate decisions among different sectors, groups and jurisdictions. Sustainability planning (also called *comprehensive planning*)[1] insures that local, short-term decisions are consistent with strategic, global, long-term goals. This contrasts with *reductionist* planning, in which problems are assigned to a profession or organization with narrow responsibilities and goals, which can result in solutions to one problem that exacerbate other problems facing society (Litman, 2003).

There is no universally accepted definition of sustainability, sustainable development or sustainable transport (Beatley, 1995). Below are examples:

> Sustainable development *"meets the needs of the present without compromising the ability of future generations to meet their own needs."* (WCED, 1987)
>
> *"Sustainability is equity and harmony extended into the future, a careful journey without an endpoint, a continuous striving for the harmonious co-evolution of environmental, economic and socio-cultural goals."* (Mega and Pedersen, 1998)
>
> *"The common aim [of sustainable development] must be to expand resources and improve the quality of life for as many people as heedless population growth forces upon the Earth, and do it with minimal prosthetic dependence.* (Wilson, 1998)
>
> "…sustainability is not about threat analysis; sustainability is about systems analysis. Specifically, it is about how environmental, economic, and social systems interact to their mutual advantage or disadvantage at various space-based scales of operation." (TRB, 1997)
>
> Sustainability is: *"the capacity for continuance into the long term future. Anything that can go on being done on an indefinite basis is sustainable. Anything that cannot go on being done indefinitely is unsustainable."* (Center for Sustainability, 2004).
>
> Environmentally Sustainable Transportation (EST) is: *Transportation that does not endanger public health or ecosystems and meets needs for access consistent with (a) use of renewable resources at below their rates of regeneration, and (b) use of non-renewable resources at below the rates of development of renewable substitutes.* (OECD 1998)
>
> *"The goal of sustainable transportation is to ensure that environment, social and economic considerations are factored into decisions affecting transportation activity."* (MOST, 1999)

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[1] *Sustainability* is a popular concept in some communities but not others, where it may be better to use the term *comprehensive planning*. The distinction is more ideological then functional.

A sustainable transportation system is one that (ECMT, 2004; CST, 2005):

- Allows the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations.
- Is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy.
- Limits emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources, limits consumption of renewable resources to the sustainable yield level, reuses and recycles its components, and minimizes the use of land and the production of noise.

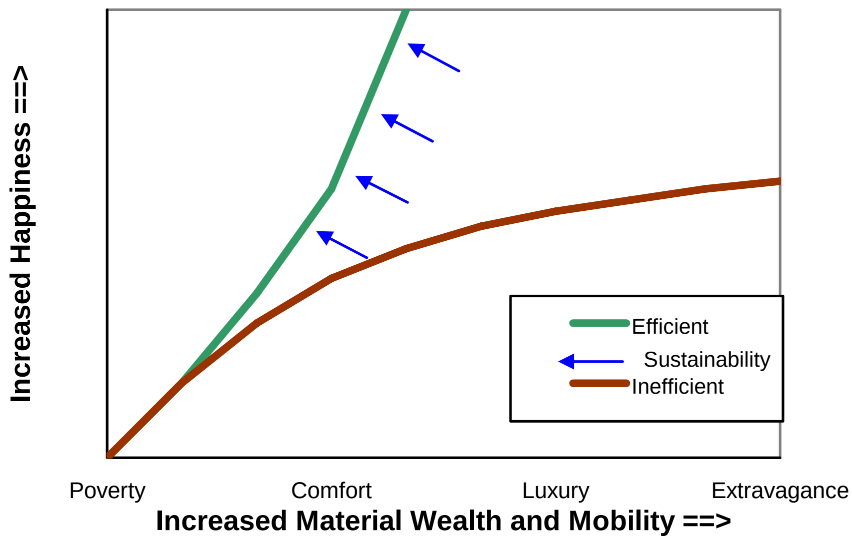
This last definition is preferred by many experts, including the Transportation Research Board's Sustainable Transportation Indicators Subcommittee (ADD40[1]), the European Council of Ministers of Transport, and the Canadian Centre for Sustainable Transportation, because it is comprehensive, and clearly indicates that sustainable transportation must balance a variety of economic, social and environmental goals.

Concern about sustainability can be considered a reaction to the tendency of decision-making to focus on easy-to-measure goals and impacts while undervaluing those that are more difficult to measure. Sustainable decision-making can therefore be described as *planning that considers goals and impacts regardless of how difficult they are to measure*. Interest in sustainability originally reflected concerns about long-term risks of current resource consumption, reflecting the goals of *intergenerational equity* (being fair to future generations). But if *future* equity and environmental quality are concerns, it makes little sense to ignore equity and environmental impacts occurring during this generation. Thus, sustainability ultimately reflects the goals of equity, ecological integrity and human welfare regardless of time or location.

Sustainable economics maintains a distinction between *growth* (increased quantity) and *development* (increased quality). It focuses on social welfare outcomes rather than simply measuring material wealth, and questions common economic indicators such as Gross Domestic Product (GDP), which measure only the quantity but not the quality of market activities. *Ecological economics* (which is concerned with valuing ecological resources) defines sustainability in terms of *natural capital*, the value of natural systems to provide services such as clean air and water, and climatic stability (Jansson, et al, 1994). Ecological economics attempts to account for non-market costs of economic activities which tend to be ignored in traditional economics, and which are sometimes considered positive economic events by indicators such as GDP (Daly and Cobb, 1989). For example, GDP ignores the value of household gardening and fishing, but values food purchased to replace household production lost to environmental degradation. Ecological economists argue that consumption should not deplete natural capital faster than it can be replaced by viable and durable human capital. This suggests, for example, that non-renewable resources such as petroleum should not be depleted without sufficient development of renewable energy sources.

Sustainable economics strives for *sufficiency*, as opposed to conventional economics which generally assumes that continually increasing consumption is desirable. Sustainability requires a *conservation ethic*, which strives to maximize resource efficiency, for example, with efficient pricing of road use and parking facilities, in contrast to the current *consumption ethic*, which strives to maximize the amount of resource (including mobility) that people can consume, for example, by minimizing motor vehicle ownership and operating costs.

Figure 1 **Sustainable Development** (Litman, 2006b)

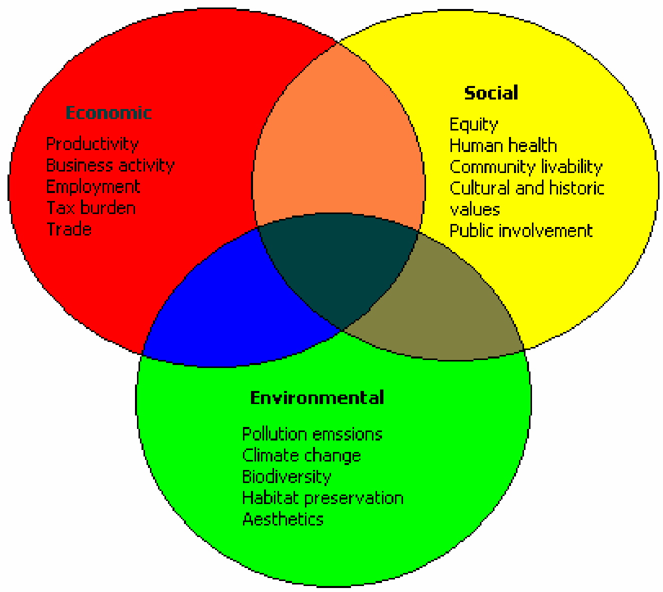


Sustainability development maximizes the efficiency with which material wealth provides happiness, resulting in high levels of happiness with modest levels of consumption. Similarly, sustainable transportation maximizes the happiness produced per unit of mobility.

Sustainability requires limiting resource consumption to ecological constraints (such as limiting land use to protect habitat and fossil fuel use to minimize climate change), so sustainable development requires maximizing the efficiency with which wealth provides social welfare (happiness), as indicated in Figure 1. Similarly, sustainable transportation requires that we maximize the amount of happiness produced per unit of mobility.

Sustainability is sometimes defined narrowly, focusing on a few specific problems such as resource depletion and pollution, but is increasingly defined broadly to include other issues (Figure 2). Narrowly defined sustainability can overlook connections between issues and opportunities for integrated solutions. For example, comprehensive analysis helps identify strategies that achieve multiple planning objectives, and so are truly optimal ("Win-Win Solutions," VTPI, 2005). For example, comprehensive analysis allows planners to identify the congestion reduction strategies that also help achieve equity and environmental objectives, or at least avoid those that are socially and environmentally harmful. These integrated solutions can be considered the most sustainable.

Figure 2 **Sustainability Issues**



This figure illustrates various sustainability issues.[2]

If sustainable transportation is defined only in terms of resource depletion and climate change risks, more efficient and alternative fuel vehicles may be considered the best solutions. But these strategies fail to help achieve other planning objectives such as congestion reduction, facility cost savings, safety, improved mobility for non-drivers, or more efficient land development; in fact, by reducing vehicle operating costs, it tends to increase these problems (Litman, 2004a). When these additional impacts are considered, other policies are considered more sustainable. Described differently, when defined narrowly, sustainable planning is a specialized activity, but when defined more broadly it can be integrated with other planning activities (Nicolas, Pochet and Poimboeuf, 2003).

Table 1 **Comparing Benefits**

Impacts	Efficient Vehicles and Alt. Fuels	Alternative Modes	Pricing Reforms	Smart Growth Development
Energy and emissions reductions	✓	✓	✓	✓
Congestion reduction		✓	✓	✓
Facility cost savings		✓	✓	✓
Increased safety		✓	✓	✓
Improved mobility for non-drivers		✓	✓	✓
Increased public fitness and health		✓	✓	✓
More efficient development		✓	✓	✓

[2] Although this figure implies that each issue fits into a specific category, there is actually overlap. For example, pollution is an environmental concern, affects human health (a social concern) and fishing (an economic concern).

More efficient and alternative fuel vehicles help achieve a few planning objectives. Reducing total vehicle travel helps achieve more objectives and so can be considered more sustainable.

Factors to Consider When Selecting Indicators

Indicators are things that we measure in order to evaluate progress toward goals and objectives. For example, teachers track students' participation and test scores to evaluate their learning progress. Motorist track their vehicle's fuel and oil consumption rates, engine and brake noise to determine when it requires servicing.

Indicators should be carefully selected to provide useful information. In most situations, no single indicator is adequate, so a set should be selected. An indicator set should reflect various goals and objectives. For example, it is desirable that a sustainable transportation indicator set reflect the impacts listed in Table 2, and possibly more. People using indicators should understand their perspectives and limitations.

Table 2 **Sustainable Transportation Impacts**

Economic	Social	Environmental
Traffic congestion	Equity / Fairness	Air pollution
Infrastructure costs	Impacts on mobility disadvantaged	Climate change
Consumer costs	Human health impacts	Noise and water pollution
Mobility barriers	Community cohesion	Habitat loss
Accident damages	Community livability	Hydrologic impacts
DNRR	Aesthetics	DNRR

DNRR=Depletion of Non-Renewable Resources

These impacts can be defined in terms of goals, objectives, targets and thresholds. For example, a planning process may involve establishing traffic congestion *indicators* (defining how congestion will be measured), *goals* (the amount of congestion reduction desired, including factors such as whether reductions are particularly important for certain trips or vehicles, such as trucks and buses), *objectives* (shifts in travel time and mode to reduce congestion) and *targets* (specific, feasible changes in congestion impacts or travel behavior that should be achieved), and *thresholds* (levels beyond which additional actions will be taken to reduce congestion).

Different types of indicators reflect different perspectives and assumptions. Some focus on *vehicle travel* or *mobility*, but a better perspective considers *accessibility* (the ability to reach activities and destinations), taking into account travel options and land use patterns (Litman, 2003). For example, roadway level-of-service (LOS) primarily reflects automobile travel congestion. It indicates little about the quality of other modes or land use accessibility. A planning process that relies primarily on roadway LOS to evaluate transport system performance implicitly assumes that automobile travel is the most important mode and congestion is the most important problem. Two areas can have equal roadway LOS ratings but very different overall transport system performance due to differences in transport diversity and the distribution of destinations. Similarly, measuring impacts per vehicle-mile, per passenger-mile, per capita or per unit of economic activity reflect different perspectives and assumptions about what is important and desirable.

Indicators can reflect various levels of analysis, as illustrated in Table 3. For example, indicators may reflect the decision-making process (the quality of planning), responses (travel patterns), physical impacts (emission and accident rates), effects this has 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 indictors 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 pollutants 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 3 **Levels of Analysis**

Level	Examples
External Trends ➔	Changes in population, income, economic activity, political pressures, etc.
Decision-Making ➔	Planning process, pricing policies, stakeholder involvement, etc.
Options and Incentives ➔	Facility design and operations, transport services, prices, user information, etc.
Response (Physical Changes) ➔	Changes in mobility, mode choice, 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.

Quantitative data refers to numerically measured information. *Qualitative data* refers to other types of information. Qualitative data can be quantified using lettered or numbered rating systems such as Level-Of-Service (LOS). Similarly, the value people place on convenience, comfort and livability can be quantified using various economic evaluation techniques (Litman, 2004b). Quantitative data tends to be considered more objective and easier to analyze, which can create a problem: easier to measure impacts tend to receive more consideration than more difficult to measure impacts (which are often dismissed as "intangibles"). For example, vehicle traffic speeds and delays are easy to measure, but walkability, equity, and livability are more difficult to quantify, and so they often receive less consideration than justified by their value to affected people. Sustainability indicators therefore require quantifying impacts as much as possible.

Table 4 **Quantitative and Qualitative Data**

Quantitative Data	Qualitative Data
Vehicle and person trips	Survey data
Vehicle and person miles of travel	User preferences
Traffic crashes and fatalities	Convenience and comfort
Expenditures, revenues and costs	Community livability
Property values	Aesthetic factors

This table compares examples of quantitative and qualitative transportation data.

Many impacts are best evaluated using *relative* indicators, such as trends over time, comparisons between different groups or jurisdictions, or units such as per capita or per vehicle. For example, an increase in transportation energy consumption over time can be considered unsustainable. Similarly, a community can evaluate its current level of sustainability and its potential for achieving sustainability objectives by comparing its indicators with those of peer cities (cities considered similar). Equity can be evaluated based on the transport options and impacts of disadvantaged groups (people with low incomes, disabilities or other disadvantages) compare with advantaged groups. Communities and agencies can be evaluated by comparing their performance with peers.

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-mile* ignores the effects of changes in vehicle mileage; for example, it does not consider increases in per capita vehicle travel as a contributor to these problems, and ignores mobility management strategies as solutions. Measuring these impacts *per capita* does account for changes in vehicle travel. Comparisons can be structured in various ways to reflect different perspectives, such as comparisons between different areas and groups, or trends over time. However, care is needed when interpreting such comparisons. For example, differences in fatality rates may reflect random variation (particularly if they involve small numbers, such as just a few annual deaths), or confounding factors such as changes in demographics or traffic conditions rather than the factor under consideration, such as transport policies.

Individual indicators should be selected based on their decision-making usefulness and ease of collection. There is tension between convenience and comprehensiveness when selecting indicators. A smaller set of indicators using easily available data is more convenient to collect and analyze, but may overlook important impacts. A larger set can be more comprehensive but have excessive data collection and analysis costs. By defining indicators early in a planning process and working with other organizations it is often possible to minimize data collection costs. For example, travel surveys can be modified to collect demographic data (such as income, age, disability status, driving ability, etc.) for equity evaluation, and land use modeling can incorporate more multi-modal factors.

Transport and land use have interactive effects, and both affect sustainability. As a result, "smart growth" policies, which create more accessible and multi-modal land use, tend to support sustainability, while "sprawl" tends to reduce sustainability by increasing per capita land impacts and motor vehicle travel ("Smart Growth," VTPI, 2004).

It may be helpful to prioritize indicators and develop different sets for particular situations. For example, it can be useful to identify some indicators that should always be collected, others that are desirable if data collection costs are acceptable, and some indicators to address specific planning objectives that may be important in certain cases. When developing indicators for a particular sector, jurisdiction or organization it is important to consider which impacts and objectives are within their responsibility.

Sustainability indicators can be integrated with other types of accounting statistics (Federal Statistical Office Germany, 2005). Indicator sets should be derived as much as possible from existing accounting data sets, while existing accounting data should be extended towards sustainable development requirements.

Hart (1997) recommends asking the following questions about potential indicators:

- Is it relevant to the community's definition of sustainability? Sustainability in an urban or suburban area can be quite different from sustainability in a rural town. How well does the direction the indicator is pointing match the community's vision of sustainability?
- Is it understandable to the community at large? If it is understood only by experts, it will only be used by experts.
- Is it developed, accepted, and used by the community? How much do people really think about the indicator? We all know how much money we make every year. How many people really know how much water they use in a day?
- Does it provide a long-term view of the community? Is there information about where the community has been as well as where the community should be in 20, 30, or 50 years?
- Does it link the different areas of the community? The areas to link are: culture/social, economy, education, environment, health, housing, quality of life, politics, population, public safety, recreation, resource consumption/use, and transportation.
- Is it based on information that is reliable, accessible, timely and accurate?
- Does the indicator consider local impacts at the expense of global impacts, for example, by encouraging negative impacts to be shifted to other locations?

The use of indicators is just one step in the overall planning process, which includes consulting stakeholders, defining problems, establishing goals and objectives; identifying and evaluating options, developing policies and plans, implementing programs, establishing performance targets and measuring impacts ("Planning and Evaluation," VTPI, 2005).

Vehicle Travel As A Sustainability Indicator

Motor vehicle travel (measured as *Vehicle Miles Traveled* [*VMT*] or *Vehicle Kilometers Traveled* [*VKT*], and *Passenger Miles Traveled* [*PMT*] or *Passenger Kilometers Traveled* [*PKT*]) is sometimes used as a sustainability indicator, assuming that motorized travel is unsustainable because it is resource intensive and environmentally harmful. But this is controversial because motorized travel also provides economic and consumer benefits. Some people argue that high levels of motorized travel can be sustainable with technological improvements in vehicle and roadway designs (Dudson, 1998).

This issue can be viewed from an economic efficiency perspective. Current transport markets are distorted in ways that result in economically excessive motor vehicle travel, including various forms of road and parking underpricing, uncompensated environmental impacts, biased transport planning practices (e.g., dedicated highway funding, modeling that overlooks generated traffic effect, etc.), and land use planning practices that favor lower-density, automobile-oriented development (e.g., restrictions on density and multi-family housing, minimum parking supply, pricing that favors urban-fringe locations, etc.) ("Market Principles," VTPI, 2005). Some analysis indicates that more than a third of all motor vehicle travel results from these distortions (Litman, 2005b).

To the degree that market distortions increase vehicle travel beyond what is economically optimal (beyond what consumers would choose in an efficient market), the additional vehicle travel can be considered unsustainable and policies that correct these distortions increase sustainability. In this context, vehicle mileage and shifts to non-automobile modes can be considered sustainability indicators. This may not apply in some situations, such as in developing countries when vehicle ownership is growing from low to medium levels, and where transportation markets are efficient.

Specific planning decisions can be evaluated according to whether they increase or reduce market efficiency. For example, when evaluating potential congestion reduction strategies, those that increase automobile traffic and sprawl (e.g., roadway expansion) can be considered unsustainable, while those that correct underpricing (e.g. road and parking pricing), increase transport system diversity (e.g., walking, cycling, rideshare and transit improvements), and encourage more efficient travel behavior (e.g., commute trip reduction programs) can be considered to increase sustainability. In situations where a significant portion of vehicle travel is excessive (such as urban peak conditions) blunter incentives may be justified, such as regulations that limit automobile travel and favor alternative modes.

Indicators By Category

This section describes the selection of sustainable transportation indicators by category.

Economic Indicators

Economic development refers to a community's progress toward economic objectives such as increased income, wealth, employment, productivity and social welfare. *Welfare* (as used by economists) refers to total human wellbeing and happiness. Economic policies are generally intended to maximize welfare, although this is difficult to measure directly. Instead, monetary income, wealth and productivity (such as Gross Domestic Product [GDP]) are often used as economic indicators. But these indicators can be criticized on several grounds (Cobb, Halstead and Rowe, 1999; Dixon, 2004).

- They only measure material wealth that is traded in a market, and so overlook other factors that contribute to wellbeing such as health, self-reliance, love, community, pride, environmental resources, freedom, etc.
- These indicators give a positive value to destructive activities that reduce people's health and self-reliance, and therefore increase their use of market goods (medical services, purchased rather than home-grown or gathered foods and fuel).
- As they are typically used, these indicators do not reflect the distribution of wealth (although they can be used to compare wealth between different groups).

Two communities can have similar economic productivity, and two people can have similar wealth, yet one has greater wellbeing overall due to differences in how the wealth is created, distributed and used. There are many possible traps by which increased wealth can fail to increase welfare, for example, if a productive process harms the environment and makes people sick, if wealth distribution is severely unequal, if wealth is spent inefficiently, and if increased material wealth disrupts community cohesion, pride, freedom or other nonmarket goods.

Put differently, people often have significant *nonmarket* wealth ignored by conventional economic indicators, such clean air and water, health, public resources, self-reliance skills, the ability to farm and gather food, and social networks that provide security, education, entertainment, and other services. Market activities that degrade these free and low-cost resources make people poorer, forcing them to earn and spend more money for commercial replacements. Conventional economic indicators treat these shifts as entirely positive. More accurate indicators account for both the losses and gains of such changes.

Material wealth provides *declining marginal social welfare benefits*, which means that each additional unit of wealth provides less benefit than the last, because consumers purchase the most rewarding goods first, so additional wealth allows increasing less rewarding expenditures. For example, if a person only earns $10,000 annually, giving them another $10,000 makes them far better off. But the same $10,000 increase in income provides less benefit to somebody earning $50,000 annually, and less to somebody earning $100,000, and even less to somebody earning $500,000.

However, people seldom recognize these diminishing benefits, because as they become wealthier their financial expectations increase. As consumers become wealthier an increasing portion of their expenditures reflect status (also called *prestige* or *positional*) goods. Although such expenditures provide perceived benefits to individuals, they provide little or no net benefit to society since as one consumer displays more wealth, others must match it to maintain status. If you purchase a mansion, I feel obliged to purchase an equal size home, even if we both end up with larger houses than we can really use. In this way, a large increase in productivity and income may provide little gain in social welfare, particularly if it is directed at already wealthy consumers.

Transportation activities reflect these patterns. In accessible communities people can reach most destinations using low-cost modes such as walking, bicycle, wagon and public transit, but increased automobile dependency tends to reduce the performance of these modes ("Automobile Dependency," VTPI, 2005). It makes nonmotorized travel difficult and dangerous. Low-cost modes receive less consideration in planning and investments. More dispersed land use patterns result in more trips beyond walking and cycling distances. As private vehicles become common, other modes lose status and consumers must own more costly vehicles to maintain prestige. As a result, motor vehicle ownership and use may increase with little net gain in accessibility or social welfare.

Transportation can leverage other economic impacts ("Economic Development Impacts," VTPI, 2005). Vehicle and fuel expenditures tend to provide less business activity and employment than most other consumer expenditures, since they are mostly imported and capital rather than labor intensive. Such expenditures are particularly burdensome to the economies of developing countries that import petroleum. Increased motor vehicle ownership and use increase road and parking facility costs, reduce productivity due to congestion, and harm certain industries, particularly those that require clean environments such as tourism, agriculture and fisheries.

Sustainable transportation economic indicators should reflect both the benefits and costs of motor vehicle use, and the possibility that more motorized mobility reflects a reduction in overall accessibility and transport diversity, rather than a net gain in social welfare. Increased mobility that provides little or negative net benefits to society can be considered to reduce sustainability, while policies that increase the net benefits from each unit of mobility can be considered to increase sustainability.

Table 5 lists possible economic indicators of sustainable transportation.

Table 5 Economic Indicators of Sustainable Transportation

Indicator	Description	Direction	Data Availability
User satisfaction	Overall transport system user satisfaction ratings.	More is better	3
Commute Time	Average door-to-door commute travel time.	Less is better	1
Employment Accessibility	Number of job opportunities and commercial services within 30-minute travel distance of residents.	More is better	3
Land Use Mix	Average number of basic services (schools, shops and government offices) within walking distance of homes.	More is better	3
Electronic communication	Portion of population with Internet service.	More is better	2
Vehicle travel	Per capita motor vehicle-mileage, particularly in urban-peak conditions.	Less is better	1
Transport diversity	Variety and quality of transport options available in a community.	More is better	3
Mode Split	Portion of travel made by non-automobile modes: walking, cycling, rideshare, public transit and telework.	More is better	2
Congestion delay	Per capita traffic congestion delay.	Less is better.	2
Travel costs	Portion of household expenditures devoted to transport.	Less is better.	2
Transport cost efficiency	Transportation costs as a portion of total economic activity, and per unit of GDP.	Less is better.	2
Facility costs	Per capita expenditures on roads, parking and traffic services.	Less is better	1
Cost Efficiency	Portion of road and parking costs borne directly by users.	More is better	2
Freight efficiency	Speed and affordability of freight and commercial transport.	More is better	3
Delivery services	Quantity and quality of delivery services (international/intercity courier, and stores that offer delivery).	More is better	2
Commercial transport	Quality of transport services for commercial users (businesses, public agencies, tourists, convention attendees).	Higher is better	3
Crash costs	Per capita crash costs	Less is better	2
Planning Quality	Comprehensiveness of the planning process: whether it considers all significant impacts and uses best current evaluation practices.	More is better	2
Mobility management	Implementation of mobility management programs to address problems and increase transport system efficiency.	More is better	2
Pricing reforms	Implementation of pricing reforms such as congestion pricing, Parking Cash Out, tax reforms, etc.	More is better	2
Land use planning	Applies smart growth land use planning practices, resulting in more accessible, multi-modal communities.	More is better	2

Data availability: 1 = usually available in standardized form; 2 = often available but not standardized; 3 = limited, may require special data collection.

Social Indicators

Social impacts include equity, human health (which is also an economic impact if disease imposes financial costs or reduces productivity), community livability (the quality of the local environment as experienced by people in an area) and community cohesion (the quality of interactions among people living in a community), impacts on historic and cultural resources (such as historic sites and traditional community activities), and aesthetics. Various methods can be used to quantify these impacts (Forkenbrock and Weisbrod, 2001; Litman, 2004b; "TDM Evaluation," VTPI, 2005).

Transportation equity can be evaluated with a variety of perspectives and impacts (FHWA and FTA, 2002; Caubel, 2004; Litman, 2005a). It requires comparing differences in transport options, service quality, impacts and between different groups, particularly impacts on people who are economically, physically and socially disadvantaged.

Human health impacts of transportation include accident injuries, pollution illness, and health problems from inadequate physical activity. Policies that improve walking and cycling conditions and increase nonmotorized travel improve mobility for disadvantaged people and increase fitness and so tend to support sustainable transportation. Community livability and cohesion (Litman, 2006a) can be measured using field surveys to see how transport facilities and activities impact the human environment, surveys of residents to determine how these impacts affects interactions among neighbors, and economic surveys to see how this affects property values and business activity. Historic and cultural resources can be evaluated using surveys which ascertain the value people place on them.

Table 6 lists examples of possible social indicators of sustainable transportation.

Table 6 **Social Indicators of Sustainable Transportation**

Indicator	Description	Direction	Data Availability
User rating	Overall satisfaction of transport system by disadvantaged users.	More is better	3
Safety	Per capita crash disabilities and fatalities.	Less is better	1
Fitness	Portion of population that walks and cycles sufficient for fitness and health (15 minutes or more daily).	More is better	3
Community livability	Degree to which transport activities support community livability objectives (local environmental quality).	More is better	3
Cultural preservation	Degree to which cultural and historic values are reflected and preserved in transport planning decisions.	More is better	3
Non-drivers	Quality of transport services and access for non-drivers.	More is better	3
Affordability	Portion of budgets spent on transport by lower income households.	Less is better	2
Disabilities	Quality of transport facilities and services for disabled people.	More is better	2
NMT transport	Quality of walking and cycling conditions.	More is better.	3
Children's travel	Portion of children's travel to school and other local destinations by walking and cycling.	More is better	2
Inclusive planning	Substantial involvement of affected people, with special efforts to insure that disadvantaged and vulnerable groups are involved	More is better	2

Data availability: 1 = usually available in standardized form; 2 = often available but not standardized; 3 = limited, may require special data collection.

Environmental Indicators

Environmental impacts include various types of air pollution (including gases that contribute to climate change), noise, water pollution, depletion of nonrenewable resources, landscape degradation (including pavement or damage to ecologically productive lands, habitat fragmentation, hydrologic disruptions due to pavement), heat island effects (increased ambient temperature resulting from pavement), and wildlife deaths from collisions. Various methods can be used to measure these impacts and quantify their ecological and human costs (EEA, 2001; Litman, 2004b; FHWA, 2004).

Of course there is considerable uncertainty about many of these costing methodologies and the resulting values. There are various ways of dealing with such uncertainty, including improved analysis methodologies, use of cost ranges rather than point values, and establishment of reference standards (such as acceptable levels of ambient air pollution and noise levels).

Many existing estimates of environmental impacts are partial analyses. For example, many monetized estimates of air pollution costs only include a portion of the types of harmful emissions produced by motor vehicles, and many only consider human health impacts, ignoring ecological, agricultural and aesthetic damages (Litman, 2004b).

Table 7 lists possible environmental indicators of sustainable transportation.

Table 7 **Environmental Indicators of Sustainable Transportation**

Indicator	Description	Direction	Data Availability
Environment			
Climate change emissions	Per capita fossil fuel consumption, and emissions of CO_2 and other climate change emissions.	Less is better	1
Other air pollution	Per capita emissions of "conventional" air pollutants (CO, VOC, NOx, particulates, etc.)	Less is better	2
Air pollution	Frequency of air pollution standard violations.	Less is better	1
Noise pollution	Portion of population exposed to high levels of traffic noise.	Less is better	2
Water pollution	Per capita vehicle fluid losses.	Less is better	3
Land use impacts	Per capita land devoted to transportation facilities.	Less is better	3
Habitat protection	Preservation of high-quality wildlife habitat (wetlands, old-growth forests, etc.)	More is better	3
Habitat fragmentation	Average size of roadless wildlife preserves.	More is better	3
Resource efficiency	Non-renewable resource consumption in the production and use of vehicles and transport facilities.	Less is better	2

Data availability: 1 = usually available in standardized form; 2 = often available but not standardized; 3 = limited, may require special data collection.

In practice, it is often infeasible to apply all the indicators described above, due to data collection and analysis costs. Later in this report these indicators are prioritized to indicate those that are most important and should usually be applied.

Accounting Indicators

Sustainable indicator systems are generally separate from conventional statistics and accounting systems commonly used by public and private organizations to evaluate the value of assets and activities, such as censuses, national accounts and corporate reports. Yet, both systems are based on the same principles and similar data. It may be possible to integrate these systems to provide comprehensive indicators, so sustainability evaluation systems incorporate economic accounting, and economic accounting systems incorporate sustainability indicators (Federal Statistical Office Germany, 2005).

Integrating these different systems requires the following:

- Accountants and statisticians be consulted concerning the developing of sustainability indicators so that, as much as possible, indicators are consistent with standard accounting principles and practices. For example, resource consumption data, such as energy and water use, can be collected and incorporated into annual reports in order to indicate the resource efficiency of production (energy and water consumed per unit of output).
- As much as possible, nonmarket impacts (such as environmental assets and human health damages) be monetized (measured in monetary units) so that they can be incorporated into standard accounts. For example, corporate accounts can include an “environmental assets” section, and the value of lost ecological services that results when land is paved can be treated as depreciation, and the value of improved environmental quality that results when a brownfield site is cleaned up can be treated as asset appreciation.
- Sustainability indicators include special analysis of long-term asset valuation and profitability. For example, strategic plans can be evaluated in terms of their impacts on corporate value a decade in the future.

There is a danger that efforts to integrate economic and sustainability indicators will end up focusing on factors that are easier to measure (such as quantified economic impacts) and overlook factors that are more difficult to measure (such as qualitative environmental and social impacts) and so perpetuate current biases.

Conventional Transport Indicators

Conventional transport indicators mostly consider motor vehicles traffic conditions. Below are examples (ITE, 1999; Homberger, et al., 2001).

- Roadway level-of-service (LOS), which is an indicator of vehicle traffic speeds and congestion delay at a particular stretch of roadway or intersection. A higher rating is considered better.
- Average traffic speeds. Assumes higher is better.
- Average congestion delay, measured annually per capita. Lower is considered better.
- Parking convenience and price. Increased convenience and lower price is generally considered better.
- Crash rates per vehicle-mile. Lower crash rates are considered better.

Because they focus on motor vehicle travel quality and ignore other impacts, these indicators tend to justify policies and projects that increase motorized travel. For example, they justify road and parking facility capacity expansion that tends to create more automobile-oriented transport and land use systems, increasing per capita vehicle travel and reducing the viability of walking, cycling and public transit. This tends to contradict sustainability objectives by increasing per capita resource consumption, traffic congestion, road and parking facility costs, traffic accidents, pollution emissions and land consumption, and reducing travel options for non-drivers, exacerbating inequity

By evaluating impacts per vehicle-mile rather than per capita, they do not consider increased vehicle mileage to be a risk factor and they ignore vehicle traffic reductions as possible solution to transport problems (Litman, 2003). For example, from this perspective an increase in per capita vehicle crashes is not a problem provided that there is a comparable increase in vehicle mileage. Increased vehicle travel can even be considered a traffic safety strategy if it occurs under relatively safe conditions, because more safe miles reduce per-mile crash and casualty rates.

A variety of methods are now available for evaluating the quality of alternative transport mode (walking, cycling, public transit, etc.), but they require additional data collection and are not yet widely used (FDOT, 2002; “Evaluating Transport Options, VTPI, 2005).

Examples of Sustainable Transportation Indicator Sets

Below are examples of sustainability and sustainable transport indicator sets. For more examples see Gudmundsson, 2001 and Mihyeon Jeon and Amekudzi, 2005.

Table 8 is an example of a *Genuine Progress Indicator* developed for Alberta, Canada, reflecting overall sustainability. Other regions, goals and analysis perspectives may require somewhat different indicators. These indicators can be applied to transport planning, by selecting those that are affected by transport facilities and activities, and using them to evaluate options.

Table 8 **Sustainability Indicators** (Pembina Institute, 2001)

Economic	Social	Environmental
Economy, GDP and Trade Economic growth (GDP) Economic diversity Trade Personal Consumption Expenditures, Disposable Income and Savings Disposable income Personal expenditures Taxes Savings rate Money, Debt, Assets and Net Worth Household Debt Income Inequality, Wealth, Poverty and Living Wages Income distribution Poverty Public and Household Infrastructure Public infrastructure Household infrastructure Employment Weekly wage rate Unemployment rate Underemployment Transportation Transportation expenditures	Time Use Paid work time Household work Parenting and eldercare Free time Volunteerism Commuting time Human Health and Wellness Life expectancy Premature mortality Infant mortality Obesity Suicide Suicide Substance Abuse: Alcohol, Drugs and Tobacco Drug use (youth) Auto Crashes and Injuries Auto crashes Family Breakdown Divorce Crime Crime Gambling Problem gambling Democracy Voter participation Intellectual & Knowledge Capital Educational attainment	Energy Oil and gas reserve life Agriculture Agricultural sustainability Forests Timber sustainability Forest fragmentation Parks and Wilderness Parks and wilderness Fish and Wildlife Fish and wildlife Wetlands and Peatlands Wetlands Peatlands Water Resource and Quality Water quality Energy Use Intensity and Air Quality Energy use intensity Air quality-related emissions Greenhouse gas emissions Carbon Budget Carbon budget deficit Municipal and Hazardous Waste Hazardous waste Landfill waste Ecological Footprint Ecological footprint

This table summarizes Genuine Progress Indicators used to evaluate sustainability.

Green Community Checklist

The US Environmental Protection Agency (EPA, 2003) proposes that a "green" community strives to:

Environment

- Comply with environmental regulations.
- Practice waste minimization and pollution prevention.
- Conserve natural resources through sustainable land use.

Economic

- Promote diverse, locally-owned and operated sustainable businesses.
- Provide adequate affordable housing.
- Promote mixed-use residential areas which provide for open space.
- Promote economic equity.

Social

- Actively involve citizens from all sectors of the community through open, inclusive public outreach.
- Ensure that public actions are sustainable, while incorporating local values and historical and cultural considerations.
- Create and maintain safe, clean neighborhoods and recreational facilities for *all*.
- Provide adequate and efficient infrastructure (water, sewer, etc.) that minimizes human health and environmental harm, and transportation systems that accommodate broad public access, bike and pedestrian paths.
- Ensure equitable and effective educational and health-care systems.

Ecological Footprint (www.footprintnetwork.org)

The *Ecological Footprint* is a resource management tool that measures how much land and water area a human population requires to produce the resources it consumes and to absorb its wastes under prevailing technology. This includes, for example, the amount of farmland needed to provide food and fibers, the amount of forest needed to provide wood and paper, the amount of watershed needed to provide water, the amount of land needed to produce energy, and the amount of land needed to absorb wastewater on a sustainable basis for person's consumption pattern.

Today, humanity's Ecological Footprint is over 23% larger than what the planet can regenerate. In other words, it now takes more than one year and two months for the Earth to regenerate what we use in a single year. We maintain this overshoot by liquidating the planet's ecological resources. By measuring the Ecological Footprint of a population (an individual, a city, a nation, or all of humanity) we can assess our overshoot, which helps us manage our ecological assets more carefully. Ecological Footprints enable people to take personal and collective actions in support of a world where humanity lives within the means of one planet.

Happy Planet Index (www.happyplanetindex.org)

The Happy Plant Index (HPI) developed by *Friends of the Earth* is calculated by multiplying indicators of *Life Satisfaction* times *Life Expectancy* and dividing by *Ecological Footprint* (resource consumption). Developing nations tend to rate relatively high by this index because they require fewer resources to achieve a given level of happiness, indicating greater ecological efficiency.

USDOT Environmental Performance Measures

The US Departement of Transportation uses the following environmental performance indicators (FHWA, 2002).

Emissions – Tons of mobile source emissions from on-road motor vehicles

Greenhouse Gas Emissions – Metric tons of carbon equivalent emissions from transportation sources.

Energy – Transportation-related petroleum consumption per gross domestic product.

Wetlands Protection – Acres of wetlands replaced for every acre affected by Federal-aid Highway projects.

Livable Communities/Transit Service – Percent urban population living within 1-mile of transit stop with service of 15 mintues or less.

Airport Noise Exposure – Number of people in US exposed to significant aircraft noise levels.

Maritime Oil Spills – Gallons of oil spilled per million gallons shipped by maratime sources.

Fisheries Protection – Compliance with Federal fisheries regulations.

Toxic Materials – Tonns of hazardous liquid materials spilled per millon ton-miles shipped; and gallons of hazardous liquid spilled per serious transportation incident.

Hazardous Waste – Percent DOT faciliteis categorized as No Further Remedial Action Planned under Superfund Act.

Environmental Justice – Environmental justice cases that remain unresolved over one year.

Sustainable Transportation Performance Indicators

The Sustainable Transportation Performance Indicators (STPI) project by the Centre for Sustainable Transportation produced the indicators summarized in Table 9.

Table 9 **Sustainable Transportation Performance Indicators** (Gilbert, et al, 2003)

Framework	Initial STPI	Short-term Additions	Long-Term Additions
1. Environmental and Health Consequences of transport.	Use of fossil fuel energy for all transport. Greenhouse gas emissions for all transport. Index of emissions of air pollutants from road transport. Index of incidence of road injuries and fatalities.	Air quality. Waste from road transport. Discharges into water. Land use for transport. Proximity of infrastructure to sensitive areas and ecosystem fragmentation.	Noise Effects on human health. Effects on ecosystem health.
2. Transport activity	Total motorized movement of people. Total motorized movement of freight. Share of passenger travel *not* by land-based public transport. Movement of light-duty passenger vehicles.	Utilization of passenger vehicles. Urban automobile vehicle-kilometers. Travel by non-motorized modes in urban areas. Journey-to-work mode shares.	Urban and intercity person-kilometers. Freight modal participation. Utilization of freight vehicles.
3. Land use, urban form and accessibility	Urban land use per capita.	Urban land use by class size and zone. Employment density by urban size, class and zone. Mixed use (percent walking to work, ratio of jobs to employed labour force.	Share of urban population and employment served by transit. Share of population and employment growth on already urbanized lands. Travel and modal split by urban zone.
4. Supply of transport infrastructure and services.	Length of paved roads.	Length of sustainable infrastructure. Transit seat-kilometers per capita.	Congestion index.
5. Transport expenditures and pricing.	Index of relative household transport costs. Index of relative cost of urban transport.	Percent of net government transport expenditures spent on ground-based public transport.	Transport related user charges. Expenditures by businesses on transportation.
6. Technology adoption.	Index of energy intensity of cars and trucks. Index of emissions intensity of the road-vehicle fleet.	Percent of alternative fuel vehicles in the fleet.	Percent of passenger-kms and tonne-kms fuelled by renewable energy. Percent of labour force regularly telecommuting.
7. Implementation and monitoring.		Number of sustainable transport indicators regularly updated and widely reported. Public support for initiatives to achieve sustainable transport.	Number of urban regions where planning and delivery of transport and related land use matters have a single authority.

Environmentally Sustainable Transport

The Organization for Economic Cooperation and Development (OECD, 2001) developed the following indicators of Environementally Sustainable Transport (EST).

- *CO_2* – Climate change is prevented by avoiding increased per-capita carbon-dioxide emissions.
- *NO_X* – Ambient NO_2, ozone levels and nitrogen deposition is greatly reduced.
- *VOC* – Damage from carcinogenic VOCs and ozone is greatly reduced.
- *Particulates* – Harmful ambient air levels are avoided by reducing emissions of fine particulates (particularly those less than 10 microns in size).
- *Noise* – Ambient noise levels that present a health concern or serious nuisance (maximum 55-70 decibels during the day and 45 decibels at night and indoors).
- *Land use* – Transport facility land consumption is reduced to the extent that local and regional objectives for ecosystem protection are met.

The OECD concludes that environmentally sustainable transport will require:

- Significant reduction in car ownership and use, and shifts to more efficient vehicles.
- Reduced long-distance passenger and freight travel, particularly air travel, and increased non-motorized short-distance travel.
- Energy-efficient, electric powered, high-speed rail.
- Energy-efficient, less polluting shipping.
- More accessible development patterns.
- Increased use of telecommunications to substitute for physical travel.
- More efficient production to reduce long-distance freight transport.

Global Reporting Initiative (www.globalreporting.org)

The Global Reporting Initiative provides guidance for organizations to use for disclosure about their sustainability performance using a universally-applicable *Sustainability Reporting Framework* that allows consistent, understandable and comparable results. This effort supports a variety of reporting and accounting programs, including the UN Global Compact (UNGC) and ISO 14000.

Performance Indicators

Transportation planners use various performance indicators for evaluating transportation conditions, prioritizing improvements, and day-to-day operations. Meyers (2005) describes and compares various performance indicators used by transportation planners in three countries. These include indicators related to roadway conditions (congestion, travel times, crashes), freight transport efficiency, pollution emissions, quality of various modes (including walking, cycling and public transit) and user satisfaction.

Mobility For People With Special Needs and Disadvantages

Special consideration should be given to evaluating the ability of a transportation system to serve people who face the greatest mobility constraints, such as wheelchair users and people with very low incomes (Litman and Richert, 2005; Litman, 2005a). Special effort may be made to identify these users in transportation surveys and ridership profiles, evaluation of transportation system features in terms of their ability to accommodate people with disabilities. The following are possible performance indicators.

1. Surveys of disadvantaged people to determine the degree to which they are constrained in meeting their basic mobility needs (travel to medical services, school, work, basic shopping, etc.) due to inadequate facilities and services.

2. Travel surveys that identify the degree of mobility by disadvantaged people, and how this compares with the mobility of able-bodied and higher-income people.

3. The degree to which various transportation modes and services accommodate disadvantaged people, including the ability of walking facilities and transit vehicles to accommodate wheelchair users and users with other disabilities, and transportation service discounts and subsidies for people with low incomes.

4. Degree to which disadvantaged people are considered in transportation planning through the involvement of individuals and advocates in the planning process, special data collection, and special programs.

5. The portion of pedestrian facilities that accommodate wheelchair users, and the number of barriers within the system.

6. The frequency of failures, such as excessive waiting times, inaccurate user information and passups of disadvantaged people by transportation services.

7. User surveys to determine the problems, barriers and costs disadvantaged people face using transportation services.

8. The portion of time and financial budgets devoted to transportation by disadvantaged people.

9. Indicators of the physical risks facing people with disabilities using the transportation system, such as the number of pedestrians with disabilities who are injured or killed by motor vehicles, and the frequency of assault on transit users, particularly those with disabilities and lower incomes (who are often forced to use transit services in less secure times and locations, due to fewer transportation options).

World Business Council Sustainable Mobility Indicators

The table below summarizes sustainable mobility indicators developed for the World Business Council's Sustainable Mobility project.

Table 10 **Sustainable Mobility Indicators** (Eads, 2001)

User Concerns	Societal Concerns	Business Concerns
Ease of access to means of mobility Financial outlay required of user Average door-to-door time required Reliability, measured as variability in average door-to-door time Safety (chance of death or serious injury befalling the user) Security (chance of the user being subjected to robbery, assault, etc.)	Impacts on the environment and on public health and safety Greenhouse gas emissions (CO_2 equivalent) "Conventional" emissions – NOx, CO, SO_2, VOC, particulates Safety (number of deaths and serious injuries) Security Noise Land use Resource use (including recycling) Impacts on public revenues and expenditures "Launching aid" Publicly-provided infrastructure Required operating subsidies Potential for reducing public expenditures Potential for generating government revenues Equity impacts	Profitability (ability to earn at least a competitive return on investment) Total market size Conditions determining market acceptance Required competences Private investment required Necessity/possibility of "launching aid" and payback conditions Investment net of publicly-provided infrastructure Cash flow generation Potential cash flow from operations Gap between likely actual and required cash flow; potential for public subsidies Policy barriers/incentives

Eliminating overlaps resulted in the following set

- Ease of accessibility to means of mobility.
- Financial outlay required.
- Average required door-to-door time.
- Reliability (variability in required average door-to-door time).
- Safety (risk of death or serious injury befalling the user).
- Security (risk of the user being subjected to robbery, assault, etc.).
- Transport-related GHG emissions.
- Impact on environment, public health and safety (with associated sub-indicators).
- Impact on public revenues and expenditures (with associated sub-indicators).
- Equity implications (with associated sub-indicators).
- Prospective rate of return (with associated sub-indicators).

Sustainability Checklist

Below are sustainability indicators developed by Region 10 USEPA employees working on sustainable planning implementation.

- *Identify Non-sustainability*: Determine if the project has identified those currently non-sustainable practices and behaviors that are to be addressed by the project.

- *Value Natural Capital*: Determine if the project will succeed at placing value on natural capital (soil and agricultural productivity, climate regulation, wetlands treatment of contaminants, etc.).

- *See Waste as Food*: Ask if our activity is systems-focused in that it seeks to model nature's patterns of waste as food where the goal is established of eliminating the practice and concept of waste.

- *Use Local Resources*: Identify whether the project maximizes or has a plan to maximize the efficient use of local resources (human, material, energy) rather than depending more on the import of material goods and services for its success.

- *Promote Social Equity*: Determine if the project explicitly addresses a goal of fairly sharing its benefits and burdens within the affected community.

- *Practice Value-added Economics*: Examine whether the project features maximum value-added economic activity as a way of optimizing the efficient use of human and natural resources within the community.

- *Promote Ecosystem Health*: Ask if the project demonstrates and promotes the goal of enhanced ecosystem integrity for the specific bioregional project areas to be affected by the proposal (watershed, riparian zone, wetlands, headwaters, grasslands, forest, and maintenance of biodiversity).

- *Enhance Meaningful Work*: Identify if the project will provide both the quality and quantity of employment opportunities needed to address a pre-existing situation of underemployment with the affected community.

- *Support Community Inclusiveness*: Ask whether the project features or encourages the participation of all members of the community directly or indirectly affected by the proposed course of action. Is greater opportunity for equity promoted?

- *Avoid Problem-Shifting*: Look to see if the project minimizes the shifts of impacts from one community to another (locally, regionally, nationally, or internationally) in areas such as waste disposal, resource depletion, and economic dislocation.

- *Reflect Intergenerational Equity*: See if the project has a sufficiently long-term time horizon that addresses the likelihood that the project can continue indefinitely without violating any of the checklist items above.

TERM

The European Union's *Transport and Environment Reporting Mechanism* (TERM) identifies the sustainable transportation indicators summarized in Table 11.

Table 11 **Proposed TERM Indicator List** (EEA, 2002)

Group	Indicators	
Transport and Environment Performance		
Environmental consequences of transport	Transport final energy consumption and primary energy consumption, and share in total (fossil, nuclear, renewable) by mode.	
	Transport emissions and share in total emissions for CO_2, NO_x, NM, VOCs, PM_{10}, SO_x, by mode.	
	Exceedances of air quality objectives.	
	Exposure to and annoyance by traffic noise.	
	Infrastructure influence on ecosystems and habitats ("fragmentation") and proximity of transport infrastructure to designated sites.	
	Land take by transport infrastructures.	
	Number of transport accidents, fatalities, injured, polluting accidents (land, air and maritime).	
Transport volume and intensity	*Passenger transport (by mode and purpose):* total passengers total passenger-kilometers passenger-kilometers per capita passenger-kilometers per GDP	*Freight transport (by mode and group of goods):* total tonnes total tonne-kilometers tonne-kilometers per capita tonne-kilometers per GDP
Determinants of the Transport/environment System		
Spatial planning and Accessibility	Average passenger journey time and length per mode, purpose (commuting, shopping, leisure) and territory (urban/rural).	
	Access to transport services e.g.: motor vehicles per household, portion of households located within 500m of public transport.	
Transport supply	Capacity of transport infrastructure networks, by mode and by type of infrastructure (e.g. motorway, national road, municipal road etc.).	
	Investments in transport infrastructure/capita and by mode.	
Price signals	Real passenger and freight transport price by mode.	
	Fuel price.	
	Taxes.	
	Subsidies.	
	Expenditure for personal mobility per person by income group.	
	Proportion of infrastructure and environmental costs (including congestion costs) covered by price.	
Technology and utilization efficiency	Energy efficiency for passenger and freight transport (per pass-km and per tonne-km and by mode).	
	Emissions per pass-km and emissions per tonne-km for CO_2, NO_x, NM, VOCs, PM_{10}, SO_x by mode.	
	Occupancy rates of passenger vehicles.	
	Load factors for road freight transport (LDV, HDV).	
	Uptake of cleaner (unleaded petrol, electric, alternative fuels) and alternative fuelled vehicles.	
	Vehicle fleet size and average age.	
	Proportion of vehicle fleet meeting certain air and noise emission standards (by mode).	
Management integration	Number of Member States that implement an integrated transport strategy.	
	Number of Member States with national transport and environment monitoring system.	
	Uptake of strategic environmental assessment in the transport sector.	
	Uptake of environmental management systems by transport companies.	
	Public awareness and behaviour.	

This table summarizes indicators used to evaluate transport sustainability in the TERM project.

SUMMA

SUMMA (SUstainable Mobility Measures and Assessment) is a European Commission sponsored project to define and operationalize sustainable mobility, develop indicators, assess the scale of sustainability problems associated with transport, and identify policy measures to promote sustainable transport (www.SUMMA-EU.org). Table 12 shows the scope of its analysis.

Table 12 **SUMMA Outcomes of Interest**

Economic	Environmental	Social
EC1: Accessibility Economic accessibility has two aspects: (1) local access of goods and people to services, work, industrial plants, etc., and (2) long distance links among regions.	*EN1: Resource use* The use of materials, energy and other resources by the transport sector.	*SO1: Accessibility and affordability* The time and cost required to reach basic services. Lower income individuals generally have poorer accessibility to basic services than those well off.
EC2: Transport operating costs The costs to the user of the transport system, both direct user costs (fuel, ticket prices, transport equipment), and indirect costs, such as the costs of congestion.	*EN2: Direct ecological intrusion* The impacts of transport on flora and fauna that are not caused by emissions or pollution, but rather by transport infrastructure (building, using, and maintaining).	*SO2: Safety and security* Safety implies freedom from danger. Security concerns freedom from fear (of crime or other undesired actions).
EC3: Productivity/Efficiency Providing conditions for an expanding, productive and efficient economy, and therefore for more individual and public welfare. Inefficiencies increase the resources needed to produce benefits.	*EN3: Emissions to air* Emissions of pollutants, etc. into the air, which affect health and harm buildings. Also the emission of greenhouse gasses, which contributes to global warming.	*SO3: Fitness and health* The trend to perform short trips by car decreases fitness and increases the threat to health (through increased pollution).
EC4: Costs to economy All costs of transport (except for the individual user), i.e. infrastructure investments, maintenance, public subsidies, final energy consumption and external costs of transport.	*EN4: Emissions to soil and water* Emissions of pollutants to soil and water, wastewater from manufacture and maintenance, runoff from roads, discharges of oil and wastewater by ships, etc.	*SO4: Livability and amenity* Transport influences our *quality of life*. It concerns an individual's direct surroundings and the impact transport has on it. It concerns not only measurable aspects (noise, pollution) but also perceptions and attitudes.
EC5: Benefits to economy The gross value added generated by the transport sector, national revenues from taxes and traffic system charging, and economic growth induced by transport.	*EN5: Noise* Transport is one of the most significant sources of noise in urban areas. There is evidence that noise is related to human and animal health and wellbeing.	*SO5: Equity* This concerns the fair distribution of costs and benefits among different groups in society, among income classes, among regions, and among generations.
	EN6: Waste Transport vehicles and infrastructure create large amounts of waste during their life cycle, which can partly be recycled or reused, but is otherwise disposed of by incineration and in landfills.	*SO6: Social cohesion* The ongoing process of developing a community of shared values, challenges and opportunities based on trust, hope and reciprocity. It is related to *social capital*, which refers to features of social organisation such as networks, norms, and social trust that facilitate co-operation for mutual benefit.

This table summarizes analysis used in the SUMMA project.

Aviation Sustainability Indicators

Aviation presents unique sustainable transportation challenges (Upham and Mills, 2003; Grimley, 2006). Table 13 illustrates indicators developed for evaluating airport environmental and operational sustainability. This is an example of sustainability indicators developed for evaluating a particular transport sector or facility. Such indicators can be converted into reference values, such as impacts per passenger-trip (arrivals and departures), for tracking performance over time and comparing performance with peer airports and other interregional travel modes. Threshold indicators are used to evaluate performance with respect to established limits and targets.

Table 13 **Indicators Of Airport Sustainability** (Upham and Mills, 2003)

Indicators	Absolute Measures	Threshold-Related Measures
1. Number of surface access vehicles: cars, light goods vehicles, heavy goods vehicles, buses, motorcycles, rail.	Number arriving at airport boundary (monthly, annually) Number departing airport boundary (monthly, annually)	- Movement number relative to hourly maxima
2. Aircraft Movements	Arrivals (hourly, monthly, yearly). Departures (hourly, monthly, yearly).	- Movement number relative to hourly maximum
3. Static power consumption	Fossil-fuelled electricity consumption. Fossil-fuelled gas consumption. Wind, solar or bio-generated electricity consumption.	- Consumption relative to any relevant hourly maxima
4. Gaseous pollutant emissions (from surface vehicles, static power, aircraft)	NOx, CO2, N_2O, CO_2, CO, NMVOC, and PM_{10} (g) per source. Ambient concentrations.	- Ambient concentrations relative to statutory EU limits
5. Aircraft noise emissions	Day, evening and night LAeq (dB) and LA max (A-weighted long-term average and peak sound level)	Land area and numbers of people within noise contours (LAeq 50 and upward increments) relative to limits.
6. Terminal passengers	Number arriving at gates (Number departing gates)	Arrivals and departures relative to hourly maxima.
7. Surface access passengers	Number arriving at airport boundary. Number departing airport boundary.	Arrivals and departures relative to hourly maxima.
8. Water consumption & waste water emission	Monthly volume consumed. Effluent concentrations. Ambient concentrations of water pollutants.	- Volume consumed relative to hourly maximum. - Pollutant concentrations (effluent and ambient) relative to limits.
9. Solid waste	Monthly volume arising. Monthly volume recycled or re-used Monthly volume of hazardous waste.	Set targets for absolute volumes and relate performance to these.
10. Land take & biodiversity	Area paved (m2, within airport boundary and ownership, includes building footprints). Area of high and medium biodiversity (m2, within airport boundary and ownership, includes building footprints).	Set target for absolute areas and relate performance to these.

This table summarizes airport sustainability indicators. Threshold indicators indicate performance relative to standards and stated limits.

Lyons Regional Indicators

Nicolas, Pochet and Poimboeuf (2003) describe how local travel survey data and other available information is used to evaluate transport system sustainability in Lyons, France. This region has 1.2 million inhabitants with a relatively centralized, urban development pattern.

Indicators were organized to reflect economic, social and environmental impacts. Economic indicators reflect transport cost-efficiency, that is, the economic costs per unit of travel, including costs to residents, businesses, and governments. Social indicators reflect the relative mobility and transportation cost burdens for people in different income classes. Environmental indicators reflect various transport pollution emissions and land requirements. These impacts were disaggregated by mode (automobile, public transit, walking), geographic location (central, middle and outer urban areas) and household demographics. Table 14 summarizes these indicators

Table 14 **Lyons Indicators** (Nicolas, Pochet and Poimboeuf, 2003)

Dimension	Indicator	Level of Analysis
Mobility		
Service provided	Daily number of trips Trip purposes Average daily travel time	Overall and by geographic location
Organization of urban mobility	Mode split Daily average distance traveled Average travel speed	Overall and by travel mode
Economic		
Cost for the community	Annual transportation costs (total, per resident and per passenger-km) • Households • Businesses • Local government	Overall and per mode
Social		
	Household vehicle ownership Personal travel distance Household transportation expenditures (total and as a portion of income)	Overall, by income and geographic location
Environmental		
Air pollution - global	Annual energy consumption and CO2 emissions (total and per resident)	Overall, by mode, by location of emission, and location of resident.
Air pollution - local	CO, NOx, hydrocarbons and particulates (total and per resident)	Overall, by mode, by location of emission, and location of resident.
Space consumption	Daily individual consumption of public space for transport and parking. Space required for transport infrastructure.	Overall, by mode and place of residence.
Other	Noise Accident risk	Overall, by mode and place of residence.

This table summarizes sustainable transportation indicators used in Lyons.

Good Example Of Bad Indicators

An organization recently sent the following sustainable transportation indicators set:

1. Air quality index ratings and frequency of air pollution standard violations.
2. Number of asthma cases.
3. Number of privately owned hybrid and Alterative Fuel Vehicles (AFVs).
4. City vehicles that are hybrid or AFV.
5. Number of hybrids or AFV taxis.
6. Policies to promote purchase and use of hybrid and AFVs, such as parking incentives, tax incentives or permission to use HOV lanes.
7. Number of public transit users.
8. Trips by foot or bicycle per capita.
9. Number of conventional vehicles.
10. Carpooling/car sharing program in the city.
11. High Occupancy Vehicle (HOV) lanes: percentage of road network.
12. Subway or trolley lines or streetcars.
13. Per capita vehicle fuel consumption.
14. Availability of alternative fuel in the city.
15. Availability of transportation to assist disabled people (handydarts etc.)
16. Ratio of annual investment in public transport versus private transport infrastructure.
17. Ratio of public versus private transport energy use per passenger kilometer.
18. Number of school buses.

This is a good example of bad indicators. Why? Because it assumes that the only sustainable transport objectives are energy conservation and air pollution emission reductions, and promoting hybrid and alternative fuel vehicles is the main way to achieve these objectives. It considers no other sustainability issues, and fails to define how the indicators are to be interpreted (for example, is increased transit ridership good even if it reflects poverty?). It lumps together *policies* (promoting hybrid and alternative fuel vehicles) with *outcomes* (air quality levels and asthma cases).

Some of these indicators promote policies that can actually reduce sustainability. For example, allowing hybrids to use HOV lanes can cause those lanes to become congested so they no longer encourage transit and rideshare use, which may increase total energy consumption, pollution emissions, and other transport problems. Similarly, “Number of school buses” apparently assumes that more busing is better. While school busing may be better than individual parents chauffeuring children, it is more sustainable for children to walk to school; high rates of school busing may be an indication of poor land use planning and bad walking conditions, both of which indicate unsustainable transport.

Best Practices

The following principles should be applied when selecting transportation performance indicators (Hart, 1997; Marsden, Kelly and Snell, 2006):

- *Comprehensive* – Indicators should reflect various economic, social and environmental impacts, and various transport activities (such as both personal and freight transport).
- *Data quality* – Data collection practices should reflect high standards to insure that information is accurate and consistent.
- *Comparable* – Data collection should be standardized so the results are suitable for comparison between various jurisdictions, times and groups. Indicators should be clearly defined. For example, "Number of people with good access to food shopping" should specify 'good access' and 'food shopping.'
- *Easy to understand* – Indicators must useful to decision-makers and understandable to the general public. The more information condensed into a single index the less meaning it has for specific policy targets (for example, *Ecological Footprint* analysis incorporates many factors) and the greater the likelihood of double counting.
- *Accessible and Transparent* – Indicators (and the data they are based on) and analysis details should be available to all stakeholders.
- *Cost effective* – The suite of indicators should be cost effective to collect. The decision-making worth of the indicators must outweigh the cost of collecting them.
- *Net Effects* – Indicators should differentiate between net (total) impacts and shifts of impacts to different locations and times.
- *Performance targets* – select indicators that are suitable for establishing usable performance targets.

Table 15 lists recommended indicator sets grouped into *Most Important* (should usually be used), *Helpful* (should be used if possible) and *Specialized* (should be used to reflect particular needs or objectives).

Much of the data required for these indicators may be available through existing sources, such as censuses and consumer surveys, travel surveys and other reports. Some data can be collected during regular planning activities. For example, travel surveys and traffic counts can be modified to better account for alternative modes, and to allow comparisons between different groups (e.g., surveys can include questions to categorize respondents). Some indicators require special data that may require additional resources to collect.

Some of these indicators overlap. For example, there are several indicators of transport diversity (quality and quantity of travel options, mode split, quality of nonmotorized transport, amount of non-motorized transport, etc.), and cost-based pricing (the degree to which prices reflect full costs) is considered an indicator of both economic efficiency and equity/fairness. It may be most appropriate to use just one such indicator, or if several similar indicators are used, give each a smaller weight.

Table 15 **Recommended Indicator Sets**

	Economic	Social	Environmental
Most Important *(Should usually be used)*	Personal mobility (annual person-kilometers and trips) and vehicle travel (annual vehicle-kilometers), by mode (nonmotorized, automobile and public transport). Freight mobility (annual tonne-kilometers) by mode (truck, rail, ship and air). Land use density (people and jobs per unit of land area). Average commute travel time and reliability. Average freight transport speed and reliability. Per capita congestion costs. Total transport expenditures (vehicles, parking, roads and transit services).	Per capita traffic crash and fatality rates. Quality of transport for disadvantaged people (disabled, low incomes, children, etc.). Affordability (portion of household budgets devoted to transport). Overall transport system satisfaction rating (based on objective user surveys). Universal design (degree to which the transport system accommodates people with disabilities and other special needs).	Per capita energy consumption, by fuel and mode. Energy consumption per freight ton-mile. Climate change emissions. Air pollution emissions (various types), by mode. Air and noise pollution exposure and health impacts. Land paved for transport facilities (roads, parking, ports and airports). Stormwater management practices.
Helpful *(Should be used if possible)*	Quality (availability, speed, reliability, safety and prestige) of non-automobile modes (walking, cycling, ridesharing and public transit). Number of public services within 10-minute walk, and job opportunities within 30-minute commute of residents. Portion of households with internet access.	Portion of residents who walk or bicycle sufficiently for health (15 minutes or more daily). Portion of children walking or cycling to school. Degree cultural resources are considered in transport planning. Housing affordability in accessible locations. Transit affordability.	Community livability ratings. Water pollution emissions. Habitat preservation in transport planning. Use of renewable fuels. Transport facility resource efficiency (such as use of renewable materials and energy efficient lighting). Impacts on special habitats and environmental resources.
Planning Process	Comprehensive (considers all significant impacts, using best current evaluation practices, and all suitable options, including alternative modes and demand management strategies). Inclusive (substantial involvement of affected people, with special efforts to insure that disadvantaged and vulnerable groups are involved). Based on *accessibility* rather than *mobility* (considers land use and other accessibility factors).		
Market Efficiency	Portion of total transportation costs that are efficiently priced. Neutrality (public policies do not arbitrarily favor a particular mode or group) in transport pricing, taxes, planning, investment, etc. Applies *least cost planning*.		

This table identifies various sustainable transport indicators ranked by importance and type. For equity analysis these indicators can be disaggregated by demographic group and geographic location.

Some indicators lack performance standards for evaluation. For example, there may be no suitable performance standards for stormwater management or universal design. In that case, they may be evaluated based on how well best stormwater management and universal design practices are included in the planning process.

Indicators can be disaggregated by demographic (income, employment, gender, age, physical ability, minority status, etc.) and geographic factors (urban, suburban, rural, etc.), time (peak and off-peak, day and night), and by mode (walking, cycling, transit, etc.) and trip (commercial, commuting, tourism, shopping, etc.). For equity analysis, special consideration should be given to transport service quality and cost burdens for disadvantaged people (people with disabilities, low incomes, children, etc.). For example, compare the portion of household income devoted to transport, and satisfaction with the transport system, between people with and without disabilities, the lowest and the average income quintile, and young adults with other age groups. Similarly, special consideration can be applied to the quality of “basic access” (transport with high social value, such as access to for emergency and service vehicles, medical services, education, employment, etc.), by measuring how often people are unable to make such trips.

Comprehensive, lifecycle analysis should be used, taking into account all costs and resources used, including production, distribution and disposal. The analysis should indicate if costs are shifted to other locations, times and groups.

These data can be presented in various ways to show trends, differences between groups and areas, comparison with peer jurisdictions or agencies, and levels compared with recognized standards. Overall impacts should generally be evaluated *per capita*, rather than per unit of travel (e.g., per vehicle-mile) in order to take into account the effects of changes in the amount of travel that occurs.

These indicators can be used to establish specific performance targets and contingency-based plans (for example, a particularly emission reduction policy or program is to be implemented if pollution levels reach a specific threshold, or a community will receive a reward for achieving a particular rating or award if it achieves a particular mode shift).

It may be appropriate to use a limited set of indicators which reflect the scale, resources and responsibilities of a particular sector, jurisdiction or agency. For example, a transportation agency might only measure transportation impacts involving the modes, clients and geographic area it serves. Special sustainability analysis and indicators may be applied to freight or aviation sectors.

It is important that users understand the perspectives, assumptions and limitations in different types of indicators and indicator data. Indicators should reflect different levels of impacts, from the decision-making processes; travel effects; intermediate impacts; and ultimate outcomes that affect people and the environment.

Example

A transit agency interested in developing comprehensive performance indicators starts by defining the following general planning objectives that transit is intended to help achieve:

- Improved transit service quality.
- Reduced traffic congestion.
- Reduced road and parking facility costs.
- Energy conservation.
- Pollution emission reductions.
- Increased safety.
- Improved mobility for transportation disadvantaged people.
- Consumer cost savings, increased affordability.
- Support for strategic planning objectives (reduced sprawl, urban redevelopment, etc.)
- Cost effective operation.
- Planning effectiveness.

Performance indicators are selected to reflect these objectives. Below are examples. The exact set of indicators will depend on priorities and the cost of collecting data.

- Service quality is indicated by transit service accessibility (portion of homes, businesses and public institutions with some minimal level of transit service, such as 30-minute or less headways), frequency, transit travel speeds relative to driving, reliability (indicated by the portion of trips that are on schedule), frequency of pass-ups, portion of passengers that must stand, waiting area comfort (portion with shelters), seat comfort, vehicle and waiting area cleanliness, and ease of obtaining user information.

- Congestion reduction, road and parking cost savings, energy conservation and pollution reductions result from automobile to transit mode shifts and the tendency of transit to reduce per capita automobile travel. Suitable indicators include per capita transit trips, transit passenger-miles, per capita vehicle ownership and mileage, and mode split. Congestion is particularly affected by peak-period trips, so commute mode split is a good indicator, but total trips is important for evaluating other impacts.

- Safety is indicated by crashes and injuries per million passenger-kilometers, and total traffic injuries and fatalities per 100,000 population for all residents in a community. Similarly, personal security is indicated by the frequency of security incidents.

- Mobility for transportation disadvantaged people is indicated by the quality of walking and cycling conditions, transit service accessibility, land use mix (proximity of public services to residential neighborhoods), quality of taxi services, and Internet service, with special attention to lower-income households and neighborhoods.

- Consumer costs are indicated by the portion of total household expenditures devoted to transportation, and to transportation and housing, by area residents. Affordability is indicated by the availability of transit service to lower-income residents, fares relative to average income (particularly for lower-income households, taking into account special need-based discounts, such as concession fares and free transit passes for seniors, people with disabilities, children, etc.).

- Support for strategic land use objectives may include factors such as whether compact infill development is occurring along transit lines and near transit stations, and the portion of employment located near high quality transit.

- Cost effective operation is indicated by performance data, such as cost per revenue-mile and passenger-trip, and cost recovery rates.
- Planning effectiveness is indicated by factors such as the success at establishing strategic plans, the degree to which individual short-term planning decisions are consistent with strategic planning goals, the degree to which transportation and land use planning is coordinated, and the quality of public involvement and support of plans. This may be evaluated qualitatively rather than quantitatively.

Each of these indicators should be reported separately for each mode (bus, train and demand response), service area, time period (peak and off-peak, day of week, month of year), year (to indicate trends over time), and comparing the study system or community with peers. As much as possible, this information should be presented in graphs to help readers see trends. It may be appropriate to establish a semi-independent transportation/transit evaluation agency which is in change of data collection, evaluation and reporting.

There are often conflicts between different objectives and goals. For example, improving basic mobility for non-drivers (which requires providing service even where and when demand is low) can conflict with efforts to improve productivity (which requires that transit service only be provided where and when demand is high). If possible, analysis should investigate and report on the cause of changes, and indicate whether these support overall goals. For example, lower vehicle operating costs per passenger-mile may reflect desirable influences, such as increased vehicle fuel efficiency, or it could indicate undesirable influences such as reduced service in outlying areas. Similarly, increases in transit ridership may reflect desirable influences, such as improved service that attracts discretionary travelers, or undesirable influences such as increased poverty.

Conclusions

Indicators are things we measure to evaluate progress toward goals and objectives. Such indicators have many uses: they can help identify trends, predict problems, assess options, set performance targets, and evaluate a particular jurisdiction or organization. Indicators are equivalent to senses (sight, hearing, touch, smell, taste) – they determine how things are perceived and what receives attention. Which indicators are used can significantly affect planning decisions. An activity or option may seem good and desirable when evaluated using one set of indicators, but harmful when evaluated using another. It is therefore important to carefully select indicators that reflect overall goals. It is also important to be realistic when selecting indicators, taking into account data availability, understandability and usefulness in decision-making.

Although there are many possible definitions of sustainability, sustainable development and sustainable transportation, experts increasingly agree that these should refer to a balance of economic, social and environmental health. Comprehensive and sustainable transport planning therefore requires a balanced set of indicators reflecting appropriate economic, social and environmental objectives. An indicator set that focuses too much on one impact category can result in suboptimal decisions. It is important that users understand the perspectives, assumptions and limitations of each indicator. Sustainable transportation indicators can include:

- *Planning process* – the quality of analysis used in planning decisions.
- *Options and incentives* – whether consumers have adequate travel options and incentives to use the most efficient option for each trip.
- *Travel behavior* – Vehicle ownership, vehicle travel, mode split, etc.
- *Physical impacts* – pollution emission and crash rates, land consumption, etc.
- *Human and environmental impacts* – illnesses and deaths, environmental degradation, etc.
- *Economic effects* – monetized estimates of economic costs, reduced productivity, etc.
- *Performance targets* – degree to which stated targets are achieved.

There is tension between convenience and comprehensiveness when selecting indicators. A smaller index using easily available data is more convenient to use, but may overlook important impacts and therefore distort planning decisions. A larger set can be more comprehensive but have unreasonable data collection costs and be difficult to interpret.

There are currently no standardized indicator sets for comprehensive and sustainable transport planning. Each jurisdiction or organization must develop its own set based on needs and abilities. It would be useful for major planning and professional organizations to establish recommended sustainable transportation indicator sets, data collection standards, and evaluation best practices in order to improve sustainability planning and facilitate comparisons between jurisdictions, organizations and time periods.

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Sustainable Mobility Project (www.wbcsdmobility.org) by the World Business Council for Sustainable Development (WBCSD) aims to chart pathways towards Sustainable Mobility that support societal, environmental and economic objectives.

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