SUSTAINABLE TRANSPORTATION

PROBLEMS AND SOLUTIONS

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THE GUILFORD PRESS
New York London

A Division of Guilford Publications, Inc.
72 Spring Street, New York, NY 10012
www.guilford.com

Printed in the United States of America

This book is printed on acid-free paper.

Last digit is print number: 9 8 7 6 5 4 3 2 1

Library of Congress Cataloging-in-Publication Data

Black, William R. (William Richard), 1942–
Sustainable transportation: problems and solutions / William R. Black.
p. cm.
ISBN 978-1-60623-485-3 (hard cover: alk. paper)
1. Transportation—Environmental aspects. 2. Local transit—Environmental aspects. 3. Sustainable engineering. 4. Green technology. 5. Environmental degradation. 6. Transportation and state. I. Title.
HE147.65.B57 2010
388—dc22

2009040112

CHAPTER 12

Indicator-Based Planning

> To measure the performance of something,
> it has to be made operational, including
> concepts related to transport and mobility.
> —HENRIK GUDMUNDSSON (2003)

One might initially raise a question about the title of this chapter, namely, Why would one want to base planning on an indicator? It is not what we traditionally think about when we talk about planning—or is it? Actually, most of the planning of the 20th century was essentially indicator-based planning. The indicator of interest back then was congestion. We went through such a convoluted process—inventory, trip generation, trip distribution, modal split, traffic assignment—to identify future congestion points that we perhaps lost sight of what it was we were trying to do, but the indicator was clearly congestion. Congestion remains a problem today, but it has been subsumed in a broader class of problems generally referred to as the sustainability of transport.

If the sustainability of the transport system of a given urban area, state, or nation were of particular interest to us, we would want to evaluate just how well we were doing with regard to the specific criteria defining "sustainability." We would want to assess the status of the system. Beyond that, we might be actually trying to make the system *more* sustainable, and if that were the case we would want to evaluate the progress that was being made and determine whether existing programs are working or whether something different should be tried. To accomplish this, we would need one or more indicators to help us make that assessment.

In this chapter we identify some of the indicators that have been proposed for assessing sustainability and suggest those that we believe are the most important ones to track. Then we propose how one could use these in assessing the state of the system, whether the system is becoming more or less sustainable, and how different programs can be evaluated that seek to make the system more sustainable. Before we move on, it is important to recognize two problems that will get in the way.

THE FIRST PROBLEM

What is sustainable transport? One would hope the reader would know the answer to this question by now, but if you have randomly turned to this chapter or if you have never seen this book, the question would naturally arise. If you have ever sat in on a planning meeting, you will recognize that vague concepts can be a major stumbling block. Everyone in the meeting has a different idea of what it is you are talking about. Even though the attendees of the meeting may have done a significant amount of reading prior to the meeting, this will not help, since most of the literature is contradictory. Such meetings are often reduced to arguments over definitions, and as a result nothing is accomplished.

If it is virtually impossible to agree on what sustainable transport is, then is it possible to take another tack and identify what it is that makes a transport system *unsustainable*? If we take this approach, can we identify those attributes of the system that keep it from being sustainable—from being able to serve present and future transport needs? If that is the question, then we come back to the five factors that have been referred to several times in this volume—finite fuels, emissions harmful to the global environment, emissions harmful to local environments, fatalities, and congestion. If you disagree with this perspective, that is fine—you will still be able to use the approach in the remainder of this volume for indicator-based planning. You will simply be looking at another indicator.

THE SECOND PROBLEM

A second problem will come up only if you don't agree with the author—that is, if you don't share my belief that there are only five dimensions to transport sustainability. We have noted elsewhere in this volume that many individuals who want to have a more sustainable transport system are concerned about transport's impacts on the biological world. These impacts can be substantial, but they certainly will not prevent transport from being around in several centuries, nor will they result in the elimination of species. If neither of these occurs, then the biological realm is not relevant to the argument. That is not to say that these impacts are unimportant; they are of some concern, as noted by Forman (2000) and the Dean Report (TRB, 1997). They are just not going to be of major concern in making the transport system *more sustainable.*

Another issue that has garnered more attention than it deserves is equity. Some researchers believe the transport system should be fair or just in some sense; otherwise, the system is not sustainable over the long term. Yet, we have never had a truly equitable transport system—Why would we want to burden the concept of sustainability with this mandate? This notion of equity worked its way into sustainability through the notion that the system should be available for use by future generations—sometimes referred to as transgenerational equity—and if that is the case (so goes the argument), it should also be available to all members of the current generation. This is a shortsighted argument. No matter what we have in the future, it will certainly make anything from the current generation look inferior by comparison. I do not miss having a horse and buggy or a "steamer" automobile as my major transport mode.

We should not place too many demands on our attempts to achieve a more sustainable transport system. If we do that, it will burden the concept to the point where even if we were successful we would not be able to identify the success. One is reminded of the attempts during the 1960s to revitalize urban transit in the United States. So much was expected of the Urban Mass Transportation Act of 1964 and later amendments that, even though they succeeded in the basic goals of providing additional transport for the elderly, the poor, and those unable to drive, the legislation was not heralded as a major accomplishment. If we expect more of ourselves than we can likely accomplish in the realm of sustainable transport, we may very well end up walking away from both the idea and the ideal.

THE INDICATOR INVENTORY

Because the concept of sustainability is very broad-based and wide-ranging in the literature, numerous indicators have been suggested to aid in measuring it. One of the leading efforts at isolating useful indicators was made by Heanue (1997) for the National Science and Technology Council's Transportation R&D Committee. He recommended considering:

1. Market penetration of alternatives to petroleum-based fuels.
2. Transport sector emissions of greenhouse gases.
3. Water quality, number of species endangered, and soil protection measures.
4. Number of acres of revitalized urban area and reclaimed brown field sites.
5. Number of trips made and miles traveled (by mode).
6. Amount of reliance on single-occupant vehicles.
7. Amount of access to jobs and services for the transport-disadvantaged.
8. Number of people in areas that attain national atmospheric air quality standards.

Heanue's recommended list included numerous indicators that related to the behavioral aspects of transport and travel, probably reflecting the idea that voluntary actions by drivers will be critical in making the transport system more sustainable, which was consistent with the Clinton administration's philosophy.

Litman (1999b) proposed a different approach to sustainable transport indicators, one based more on personal or household travel characteristics. Included in his list of indicators were:

1. Average portion of household expenditures devoted to transport.
2. Average amount of residents' time devoted to nonrecreational travel.
3. Per capita automobile mileage.
4. Ability of nondrivers to reach employment centers or services.
5. Per capita land area paved for roads and parking.
6. Quality of pedestrian and bicycle facilities.
7. Quality of public transit (frequency, speed, safety, etc.).
8. Special transit services and fares relative to low-income residents.
9. Transit coverage, residents within 3⁄10 of a mile. (½ kilometer).
10. Motor vehicle accident fatalities.
11. Per capita transport energy consumption.
12. Medical costs attributable to transport.
13. Publicly financed transport costs.
14. Residents' role in transport and land use decisions.

These criteria may lead to a more equitable transport system, but they are not necessarily critical in terms of the sustainability of that system. Some factors, such as those intended to reflect the quality of the transit service, have little to do with a sustainable system if the system is not used.

Several European cities have begun exploring and monitoring transport sustainability, among these cities is Berlin, which has identified the following 12 indicators:

1. Level of motorization.
2. 30 kilometer speed limit on main street network.
3. Car sharing.
4. Bicycle traffic.
5. Public transit use.
6. Facilities for disabled on public transit network.
7. Long distance accessibility.
8. Freight transport trends.
9. Number of flights.
10. Air pollution and noise.
11. Accident trends.
12. Revenues from road use taxes in relation to infrastructure costs.

The foregoing lists are typical of some of the indicator sets that have been assembled. Other major studies in this area have been completed by the U.S. Environmental Protection Agency (EPA, 1996) and the OCED (1998).

The Pentad Again: Finite Fuels, Emissions, Safety, Congestion (Global and Local)

In order to make the transport system more sustainable, we must seek to improve a number of areas related to travel and transportation. For example, we could increase the safety of the system and thereby decrease the number of incidents involving personal injury and loss of life. Improving the flow of traffic or decreasing congestion in the system would also increase the system's sustainability. We might also decrease our reliance on finite fossil fuels as an energy source for most of our transport. Doing so might also enable us to decrease emissions that harm human health in local areas as well as affecting global atmospheric conditions. The key attribute in common among these diverse potential initiatives is that they are all a function of the amount of driving that takes place. If we are going to focus on these five factors for planning or monitoring the transport system, then we need to identify indicators for each of them.

Motor Vehicle Incidents, Injuries, and Fatalities

In general, the safety of the transport system can be well assessed by using indicators of the number of incidents, the number of persons injured, and the number of fatalities. All of these indicators are available for the states and municipalities in the United States. The figures are not nearly so reliable for international comparisons since in many parts of the world motor vehicle incidents and injuries are not reported very well. For comparative purposes, the fatalities figure is probably the most reliable indicator (though in certain countries if a person does not die within a specified number of hours after the accident, a different cause of death is assigned.

Congestion

There are numerous indicators of congestion in the transport system (many of which we summarized in Chapter 7). If the RCI index is available, it could certainly be used, but we may want to use something as simple as the number of registered vehicles or a similar measure of the potential for congestion.

Fuel Use

The amount of fuel used by the transport system is highly relevant since the bulk of this supply has its origin in unrenewable fossil fuels. Fortunately, the principal fuels used (diesel and gasoline) are taxed, and therefore the number of gallons sold is available (though not always accessible except as statewide data). We are especially interested in this indicator because it tells us the extent to which we are depleting this resource.

Local Emissions

Local emissions from motor vehicles can be estimated. There are several of these that may be of interest, but we focus in particular on nitrogen oxides, volatile organic compounds, and carbon monoxide. The first of these is a precursor of urban ozone. The second usually contains carcinogens, and the third can lead to blood disorders and may cause death.

Global Emissions

The primary gas emitted from transport vehicles that contributes to global warming is carbon dioxide. Depending on fuel economy measures, motor vehicles may release up to 20 pounds of carbon dioxide for each gallon of gasoline used.

Vehicle Miles of Travel

As was noted all of these indicators are highly correlated with total vehicle miles traveled. Thus, it is worth looking at this indicator for its own contribution to the sustainability analysis as well as for its possible use in evaluating the impact of various policies on travel.

Indicators Not Used

There are a number of other variables that some planners might like to see used. If we are interested in getting people to drive less, shouldn't we also be looking at transit ridership? If the community has a program of increasing transit ridership, one could argue that this indicator should definitely be monitored. This is true. On the other hand, wouldn't we expect to see significant reductions in vehicle miles of travel if transit ridership increased. However, including transit ridership would not give us new information for measuring sustainability of the system.

The number of hybrid vehicles in use in the area is a variable of interest, but it is not an easy variable to obtain in all states; also, we see no reason to believe that hybrids are affecting total fuel use very much so far. If we want to encourage the purchasing of hybrid vehicles through some type of governmental program, then we might want to monitor this variable. Clearly, the greater the number of hybrid vehicles on the road, the less fuel that will be used. We prefer to use the fuel sales indicator as a backdoor approach to measuring the use of hybrids. It is reasonable to assume that as fuel use drops there may be a contribution coming from the use of hybrid vehicles. This assumes the economy has recovered from any recession.

Alternative (nonfossil) fuels are often viewed as desirable. There are several of these available in California, and the Midwestern states have moved toward ethanol blends with some vigor. For most urban areas these data would not be available, but even if they were we would make the same argument: as alternative fuel use increases, fossil fuel use must decrease in the short term, assuming fleet size does not change significantly. As a result, including this as an indicator does not tell us much more than the fossil fuel use indicator.

Overlap in the Indicators Identified

Of the various indicators identified for use above, one thing should be very clear: they are all related to the amount of driving taking place, or vehicle miles traveled. The greater the VMT, the higher the exposure to highway incidents and the associated fatalities and injuries. Increases in VMT also increase fuel consumption and all of the attendant emissions. Congestion as well is related to the total driving taking place.

In order to assess the degree of this interrelationship, data were collected for the states individually, and a principal component analysis was performed on these variables. Principal component analysis is a mathematical technique that yields one or more components that describe all of the variables examined (see Harmon, 1976; Rummel, 1988). In this particular case, one component was obtained. The component loading for each variable may be interpreted by understanding that these values may range from 0 to slightly less than 1. The closer the value is to 1, the more similar the variable is to the component, or vice versa. As Table 12.1 indicates, for U.S. states, VMT is nearly identical to the single component derived, its component loading being .99103.

What this means is that if we want a single indicator to monitor that will give us a fairly good idea of changes in sustainability, then that single variable would be VMT. As it increases, all of the other indicators also increase, and that means that sustainability is getting worse. Similarly, if we can decrease VMT over time, then the system is becoming more sustainable. We would not go so far as to imply that this would be true for the countries and cities of Europe, but it may be; further research would be necessary to establish if that is the case.

This key indicator may appear to be the answer to all indicator planning, but we are not quite there. The analysis above was performed using state-level data for the United States. We may want to look at cities or multicounty areas of the United States, and while these data are available for urbanized areas in *Highway Statistics* (FHWA, 2006), they may not be available for all of the areas that may be of interest.

There may be other indicators easily available. One of these is usually traffic fatalities for the county, metropolitan area, or state of interest. Some governmental authority in the area usually maintains this type of information. There may also

TABLE 12.1. Principal Component Analysis for the Individual States of the United States

Indicator	Component loading
Carbon dioxide emissions	.97648
Carbon monoxide emissions	.95825
Motor vehicle crash fatalities	.97349
Gasoline sales	.98579
Motor vehicle crash injuries	.91868
Motor vehicles registered	.96775
Emissions of nitrogen oxides	.96823
Vehicle miles traveled	.99103
Emissions of volatile organic compounds	.97134

Source: Black (2002).
Note. $N = 50$, eigenvalue 8.4, variance accounted for 93.7%. Based on data for 1997.

be congestion measurements available for the area, and these can be used to evaluate different projects and programs. Emissions data are less readily available in a usable format for program assessment unless there is a local program or agency to collect the data. It is primarily because of the difficulty of getting data on some of these measures that we suggest using VMT to evaluate most programs.

PROGRAM OR PROJECT EVALUATION: VMT REDUCTIONS

Let us illustrate how we could evaluate a program. At the outset we would identify the goal of the program and what its objectives are. Let's assume that the primary goal is to simply reduce vehicle miles of travel in the area of interest. The objective may be modest: say, a 5% decrease in vehicle miles of travel over the next 5 years. We may have a number of different ideas in mind as to how this goal could be accomplished. We may want to significantly increase the level of public transit service by adding vehicles and decreasing headways (the time between bus arrivals at a given location). We may also want to initiate a park-and-ride system. A marketing program in which the benefits of carpooling could be identified might also be a part of the plan.

We could secure estimated VMT data from local transport planners or possibly from state transport planners. If such data are not available and are not going to be available, then you need to set up a procedure for estimating the numbers. You may simply identify 1,000 drivers from the area of interest and have them regularly insert the mileage accumulated on their car or cars for given time periods on a website. This would then be extrapolated for the number of vehicles registered in the area. To be sure, the estimate you get may bear little similarity to data that may be published later by the Federal Highway Administration or other agencies. That really doesn't matter since what you are most interested in is whether any of your actions have changed the estimated VMT. The data could be collected weekly or monthly or every few months over the 5-year project term.

If your project is successful at reaching a 5% reduction, then you may infer that you have also reduced greenhouse gas emissions as well as emissions of pollutants. One should not really expect to reach the goal in this case. We do not believe that any urban area that has been able to reduce its VMT in the past several years. Perhaps a goal of no change would be more realistic.

PROGRAM OR PROJECT EVALUATION: FATALITY REDUCTION

If your goal is improving the safety of the transport system of some area, this may have the objective of reducing average annual fatalities by a set number or percentage. This will require some monitoring of fatalities for the area of interest. Although those working in the highway safety field dislike the use of the word *accident* (preferring *incident* instead), this writer believes that many fatalities are random in the sense that a vehicle hits you so quickly you have little chance to avoid contact. It is true that most fatalities have causes that can be identified, and this consideration argues against the use of the word *random* in relation to these events. Nevertheless, as one looks at a time series of fatalities, one is often struck by the seemingly random fluctuation that occurs in the series. This is the reason for seeking a reduction in the average, as opposed to a reduction in a specific annual count.

The program to accomplish such a reduction may involve stricter enforcement of speed limits in the locality. It may also involve higher fines on those who exceed the posted speeds. Public-interest television spots highlighting fatalities on the highways might also be of some value. If fatalities are occurring where vehicles are traveling at the posted speed, then it may make sense to lower those speed limits. One could add guardrails to the medians to help prevent head-on crashes, or replace solid guardrails with heavy metal cord that has less of a tendency to deflect vehicles back into the traffic lanes. These are a couple of actions that could be undertaken locally.

Of course, the program may be unsuccessful. The heaviest emphasis today is on making crashes survivable, which generally involves technological improvements in the vehicle itself. Nevertheless, these programs will also help to reduce fatalities.

These are not programs that one should simply walk away from. The tragic human dimensions of fatalities are worth emphasizing again and again so that the public is always aware of them. Similarly, speed reductions should not suddenly be lifted under the misimpression that this action will have little or no negative impact on fatalities.

Some of the programs just discussed could be implemented in different ways. Perhaps we want to set a very clear objective for 5 years from now and then determine what must occur each year in order to meet that targeted goal. While this might be possible for VMT goals, it is less likely to work for traffic fatalities for the reasons previously mentioned.

CONCLUSIONS

In this chapter we have discussed the use of indicators in planning. Numerous possible indicators were identified, but we eventually argued that the five factors identified at the outset of this volume were the primary ones of interest. We concluded that, at the least, one should attempt to monitor vehicle miles traveled since this variable is a reasonably good indicator of all the others. The chapter ended with illustrations of the ways in which two projects or action programs could be evaluated with indicators.