CHALMERS

Measuring the Sustainability of a Passenger Transportation System

Design of an assessment tool for ranking Swedish municipalities

Master of Science Thesis in the Master's Programme Infrastructure and Environmental Engineering

ALEXANDER SENNING & MATS SUNDBERG

Department of Civil and Environmental Engineering
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ABSTRACT

The concept of Sustainable Development was established in 1987 after growing concerns of how resources were consumed above the capacity of the biosphere's ability to replenish; today the concept is generally accepted. All sectors within society are responsible for progressing towards sustainability, where this study will only focus on the transport sector with the aim of generating a simplified sustainable transportation assessment model, with the purpose to assess the status of passenger transportation systems in Swedish municipalities. Methods on how to measure and monitor progress towards sustainable transportation are generally performed using indicators, a measurable variable that represents a phenomenon of interest, as accurately as possible.

The model that was created uses six of the seven TRAST aspects as topics for the framework, the structure that the indicators are categorised in. The framework was later filled with 19 indicators that relates to different key aspects of sustainable transportation. A pilot test of the model were performed on four different municipalities to ensure that the model were valid. This pilot test showed that the model gave reasonable results, municipalities that performed well in other studies performed well in the designed model as well.

The model is able to rank the sustainability status of the transport systems for the municipalities in a relative comparison. However it does not show at what level sustainability is achieved in absolute terms since each indicator is evaluated in comparison to the corresponding indicators of the other participating municipalities.

Keywords: Sustainable Transportation, Assessment model, Indicator framework, Swedish municipalities

Att mäta ett transportsystems hållbarhet

Ett utvärderingsverktyg för svenska kommuner

Examensarbete inom civilingenjörsprogrammet Väg- och vattenbyggnad

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Avdelningen för geologi och geoteknik

Väg och trafik

Chalmers tekniska högskola

SAMMANFATTNING

Begreppet hållbar utveckling introducerades år 1987 efter växande oro för hur resurser förbrukades ovanför miljöns kapacitet till återväxt, idag är begreppet allmänt vedertaget. Alla sektorer i samhället är ansvariga för utveckling mot hållbar utveckling, men denna studie kommer endast att fokusera på transportsektorn med målet att skapa en förenklad utvärderingsmodell för hållbara transportsystem, syftet är att bedöma statusen på persontransportsystem i svenska kommuner. Metoder för att mäta och utvärdera utveckling mot hållbara transporter utförs vanligen med hjälp av indikatorer, en mätbar variabel som representerar ett fenomen, så noggrant som möjligt.

Den modell som skapats använder sex av de sju TRAST-aspekter som huvudrubrikern för ramverket, den struktur indikatorerna kategoriseras in i. Ramverket fylldes senare med 19 indikatorer som täcker olika relevanta aspekter av hållbara transporter. Ett pilottest utfördes på fyra olika kommuner för att kunna säkerställa att modellen är giltig. Detta pilottest visade att modellen gav rimliga resultat, kommuner som presterade väl i andra undersökningar presterade även väl i den designade modellen.

Modellen kan användas för att rangordna hållbarhetsstatusen på transportsystem för kommunerna i en relativ jämförelse. Men det visar inte på vid vilken nivå hållbarhet uppnås i absoluta tal eftersom varje indikator utvärderas i jämförelse med motsvarande indikatorer för de andra deltagande kommunerna.

Nyckelord: Hållbara transporter, utvärderingsmodell, indikatorramverk, svenska kommuner

Contents

APPENDIX VI: SHIFT WEIGHING METHOD

Preface

This master thesis has been performed at the department of Civil and Environmental Engineering, Chalmers University of Technology between January and June 2013. The study has been carried out with the support from the supervisor Emeli Adell at Trivector Traffic and examiner Gunnar Lannér, University Lecturer at the Road and Traffic Research Group at Chalmers University of Technology.

We would like to thank all persons who have contributed to making this report possible; our supervisor Emeli Adell for continuously giving feedback throughout the study, the experts participating at the workshop for your valuable information and suggestions, the employees at the investigated municipalities that contributed in the data collection, our opponents Cecilia Friis and Lina Svensson and our examiner Gunnar Lannér.

Gothenburg June 2013

Alexander Senning & Mats Sundberg

Glossary

CMI	Complete Mobility Index
CSTI	Comprehensive Sustainable Transportation Indicators
EC	European Council
EEA	European Environment Agency
EPA	Environmental Protection Agency
EU	European Union
HASTA	Hållbar Attraktiv Stad (Sustainable Attractive City)
IOO	Input Output Outcome
JRC	Joint Research Centre
OECD	Organisation for Economic Co-operation and Development
PSR	Pressure-State-Response
PT	Public Transport
RVU	Resvaneundersökning (Travel Behaviour Study)
SCB	Statistiska Centralbyrån (Statistics Sweden)
STPI	Sustainable Transport Performance Indicators
TAC	Transportation Association of Canade
TBL	Triple Bottom Line
TERM	Transport and Environment Reporting Mechanism
TRAST	Trafik för en Attraktiv Stad (Traffic for an attractive city)
UTBI	Urban Transport Benchmarking Initiative
VTPI	Victoria Transport Policy Institute
WCED	World Commission on Environment and Development

1 Background

Today climate change is of global concern. The increased emissions of greenhouse gases and particularly carbon dioxide, which has been occurring at an unnatural level since the start of the industrial revolution in the late 16th century (European Comission, 2012a), have led to an increase of the average global temperature with approximately 0.8 degrees since the beginning of last century. If left unchanged, this will in the future yield rising sea levels, glacial retreats, more frequent extreme weather conditions and extinction of species due to altered natural habitats (European Comission, 2012b).

As a cause of the realisation of how dependent humans are of the biosphere, the United Nations World Commission on Environment and Development (WCED) established the concept of Sustainable Development in 1987 in the report *Our Common* Future (World Commision On Environment and Development, 1987). The concept is defined as: *"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."* It consists within three equally important and inter-dependent dimensions; the environmental, the social and the economic dimension, see Figure 1.1 below.

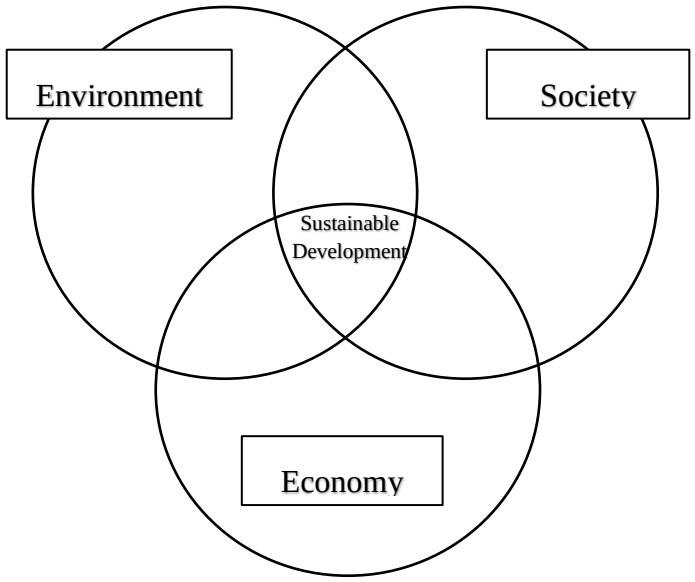

Figure 1.1 The relationship between the three dimensions of sustainability.

The environmental dimension is the denominating factor that limits the potential of the other two dimensions, since they must develop in harmony with nature. The social dimension emphasises on equity and well-being for all humankind while the economic dimension focuses on economic development without over-consuming resources at a higher pace than the environment can replenish. All sectors within society are responsible for progressing towards sustainable development; however this report will only focus on the transport sector and more specifically municipalities' passenger transport systems.

The subtopic of Sustainable Development that focuses on the transport sector is often referred to as Sustainable Mobility or Sustainable Transport. A definition of a sustainable transport system used by the European Council is as the following:

- *Allows the basic access and development needs of individuals, companies and society to be met safely and in a manner consistent with human and ecosystem health, and promotes equity within and between successive generations.*

- *Is Affordable, operates fairly and efficiently, offers a choice of transport mode, and supports a competitive economy, as well as balanced regional development.*

- *Limits emissions and waste within the planet's ability to absorb them, uses renewable resources at or below their rates of generation, and uses non-renewable resources at or below the rates of development of renewable substitutes, while minimizing the impact on the use of land and the generation of noise.* (Gudmundsson, 2007)

The three dimensions of sustainability are present here as well, with the first, second and third bullets in the list correspond to the social, economic and environmental dimension respectively.

Methods on how to measure and monitor progress towards sustainability are generally performed using indicators. An indicator regarding sustainability applicable on a transport system is a measurable variable that represents a phenomenon of interest, as accurately as possible, with a potential or actual impact on the environment caused by transport. A collection of indicators, an indicator set, can be used to analyse a system where several aspects are of interest. Such an indicator set can be used to measure the sustainability of a transport system of a municipality (Litman, 2012).

Today several municipalities in Sweden strive to have a transport system that is sustainable, however to monitor the progress and analyse the system an indicator system would be ideal to observe how far the development towards sustainability have gone. It would as well point out strengths and weaknesses a sustainable transport system could have and receive an overall value useful for reference with other municipalities

1.1 Aim

The aim of the study is to generate a simplified sustainable mobility assessment model, with the purpose to assess the status of passenger transportation systems in Swedish municipalities. The meaning of the term *simplified* is that the assessment tool should be based on existing, accessible data from municipalities or public databases, which does not require extensive analysis to obtain and thus enables a quick result.

Key objectives in this study includes:

- With the help of performed research, map the field of sustainable transportation to enable an understanding for its general components.
- To perform a review on a number of sustainable transport studies, in order to select a framework for listing indicators.
- To evaluate the accessibility of indicators through official documents and webpages with the purpose of sorting indicators.
- To perform a pilot test of the sustainable mobility model on a selection of Swedish municipalities with the purpose of gaining results that can be analysed.
- The overall objective is to design an assessment tool for municipalities to use in order to measure the sustainability level of their passenger transportation system.

1.2 Scope and limitations

This study has its focus on evaluating the level of sustainability achieved for the passenger transportation system within Swedish municipalities. In order to achieve a comprehensive model there is a need to identify the components that defines a passenger transportation system and how sustainability can be evaluated by the usage of indicators.

The models framework; indicators to include; and the limitations for both framework and indicators will be founded on a review of existing sustainability initiatives drawn from field of sustainable transportation together with a workshop performed with researcher within the field.

Four limitations have been stated in order to limit the scope of the study. These limitations are:

I. The model is, in this first stage of development, directed to Swedish municipalities.
II. Directed towards the current physical transport system and will not investigate the policy or management agendas of the municipalities.
III. Focus only on passenger transportation and transport on land, excluding train.
IV. The model will only include quantitative measures and not qualitative

The description of each limitation will be strengthened in later chapters of this report, particularly in *chapter 4* where they work as decision support for selecting framework and indicators.

1.3 Question at issue

Question the report strives to answer:

- Is it possible to build a robust sustainable transportation model with the use of simple indicators and available information?

1.4 Report structure

Here follows a short description of each chapter that is included in this study, to give insight to the general content and key features of the study. The chapters are presented in chronological order.

Chapter 2. Sustainable transportation

The chapter *Sustainable transportation* is a literature study the subject. This chapter describes the connection between sustainable development and sustainable transportation and how different aspects of society are affected by the transportation system, mainly: Economic, social and environmental aspects. In addition current viewpoints are addressed of how a sustainable transportation system is obtained. The concept of indicators is also presented here.

Chapter 3. Methodology

The methodology chapter briefly presents the layout for the analysis that is performed in later chapters, *chapter 5 to chapter 8*.

Chapter 4. Framework evaluation

Framework evaluation of 15 sustainable transportation initiatives were studied and presented. The initiative selection was based on its relevance to the subject of sustain-

able transportation. Both national and international schemes have been reviewed and four framework types were identified. The chapter includes as well a discussion about the findings of the reviews.

Chapter 5. Framework selection

*Framework selection and presentation of key categories***.** The chapter revolves around the previously performed framework evaluation and focuses on selecting a framework that is suitable in relation to the scope of the study. In addition evaluated are key categorisations that are used by the reviewed initiatives in order to measure sustainability.

Chapter 6. Indicator selection

Indicator selection was achieved by taking model limitations and objectives into account and by gathering inputs from reviewed initiatives.

Chapter 7. Model testing

Model testing of the chosen framework. A pilot test has been performed in order to evaluate the results that the model gave. In addition presented in this chapter is the scoring system that was used to calculate the result.

Chapter 8. Discussion and recommendations

Discussion and recommendation. A discussion was implemented to evaluate the strengths and weaknesses of the model, regarding both the results from the pilot test and the method used to gain these results. Recommendations on potential improvements were discussed as well.

2 Sustainable transport

This chapter introduces the general theoretical aspects of sustainable transport; describing the connection between sustainable development and sustainable transport; presenting definitions of sustainable transportation. The content of this chapter works as an orientation of the field of sustainable transport.

2.1 Creating a liveable and sustainable city

The discussion on correlations between traffic and city liveability is common. This chapter strive to highlight viewpoints present in today's research.

Ever since the introduction of motorized vehicles during the 19th century the way in which travel within cities have changed drastically, especially in the post-war era (Department of transportation, 2008). The potential to travel across the mainland has greatly increased through the shift from manpowered transportation to a motorised one. Today's developed society is, to a great extent, dependent on motorised transportation for it to function. The landscape has changed with the expansion of the transportation system network, covering sizeable areas, especially in urban setting. Figure 2.1 further illustrates how the industrial worlds travel patterns have changed over time and with it the economic development (Notteboom & Rodrigue, 2013).

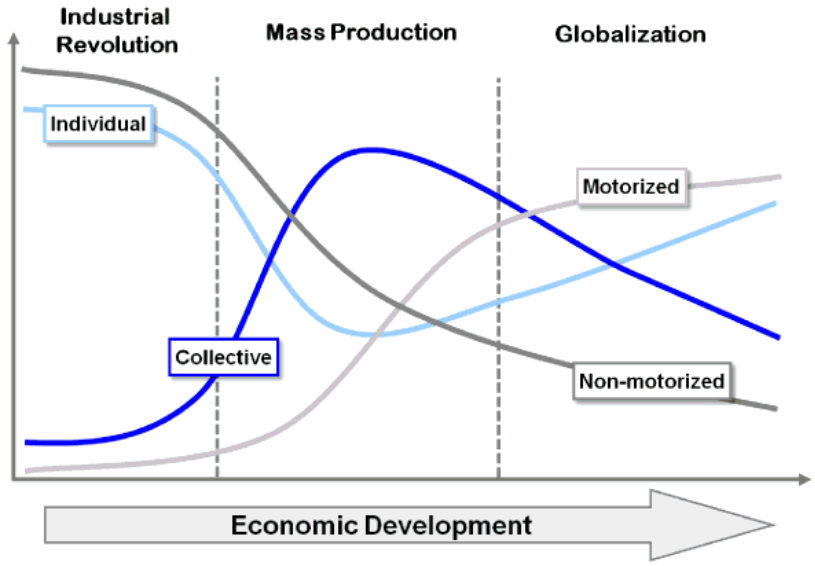

Figure 2.1 The trends in travel compared to the economic development (Notteboom & Rodrigue, 2013).

Concerns regarding the vehicle dependence first became apparent during the 1972 oil crisis and the 1979 energy crisis. Since then the agenda has begun to change, and although motorised transportation remains the dominant mean of travel, National, European and International institutions have become more active in perusing a sustainable transportation systems.

The consequences of today's travel behaviour are many; city liveability being one of them. As stated the road network covers large areas in the urban environment. Working as a barrier, the road network limits the movements of non-motorised travel as well as access to public space. Gehl Architects (Gemzøe, 2011) highlights the fact that data collection, modelling, planning, is available for motorised transportation while absent for non-motorised travel. This diversity of accessible data emphasizes the priority that motorised transport, cars in general, have attained in today's society. Hence, an important aspect for reaching sustainable transportation is the shift from *conven-*

tional transportation planning, which focuses on mobility, towards a *comprehensive planning*, which focuses on accessibility (Litman, 2006).

The conventional planning development can be seen as a linear approach, a series model, where technological advances set the standard and replace older insufficient means of transport, see Figure 2.2. In this scenario the automobile is the dominant mode and planning is based primarily according to the needs of the automobile fleet, disregarding negative effects on other transport modes, such as non-motorised modes.

Walking → Bicycle → Train → Bus → Automobile → Improved automobiles

Figure 2.2 The conventional transportation planning process (Litman, 2006).

The comprehensive planning process wants to achieve better transport for each mode by using a balanced parallel model, which takes advantage of the strengths of each transport mode (Litman, 2006). However the focus lies on what is most beneficial for the whole system and the best viable option may not be the best alternative for a specific means of transport. In general, most cities would benefit from improving walking and cycling conditions, a higher share of public transit and limiting the use of cars in congested city centres, indicating that additional factors, such as air pollution and traffic safety matters when transport planning is performed in a comprehensive manner, see Figure 2.3 below.

Walking → Improved walking conditions
Bicycle → Improved cycling conditions
Train/Bus → Improved public transit service
Automobile → Improved automobile travel conditions

Figure 2.3 The comprehensive transportation planning process (Litman, 2006).

The matter of prioritising modes of travel is often referred to as transportation hierarchy. In the context of sustainable transportation the hierarchy will prioritise a transportation system where the majority of a population would use low-impact modes of transportation (UBC, 2011). In this situation walking, bicycling, PT and car would be rated in order of preferred usage, walking and cycling being the most sustainable alternatives and car the least sustainable.

2.2 Definitions of sustainability in the context of transportation

The term sustainable development is widely regarded as defined by the United Nations World Commission on Environment and Development (WCED) in 1987 (World Commission on Environment and Development, 1987). The definition from the report is:

> *"Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts":*
>
> - *the concept of 'needs', in particular the essential needs of the world's poor, to which overriding priority should be given; and*
> - *the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs.*

In the mid 1990's the concept of three dimensions for sustainability emerged, with the economic, the social and the environmental dimensions, as three equally important aspects where the development should occur (Gudmundsson, 2007). This concept is also known as the Triple Bottom Line or TBL, a definition that will be used in this study.

The environmental dimension focuses on the biosphere and not exceeding its capacity, the social dimension refers to the cultural and political aspects and the economic dimension the available resources not being consumed at an excessive pace (The Centre for Sustainable Transportation, 2002). Figure 2.4 illustrates the correlation between each dimension of sustainable development.

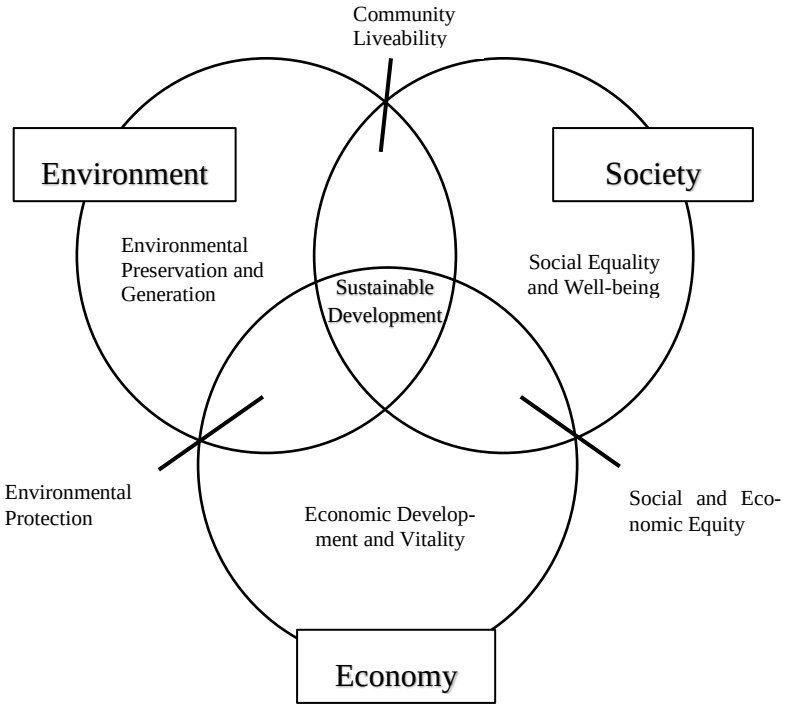

Figure 2.4 The figure illustrates the three dimensions for sustainability, (economy, environment and society) and how they overlap in the field of sustainable development (Gudmundsson, 2007).

Similarly to sustainable development, sustainable transportation can be defined through the Triple Bottom Line. Todd Litman of the Canadian independent research institute Victoria Transport Policy Institute states the specific transportation goals for each dimension in TBL, see Figure 2.5.

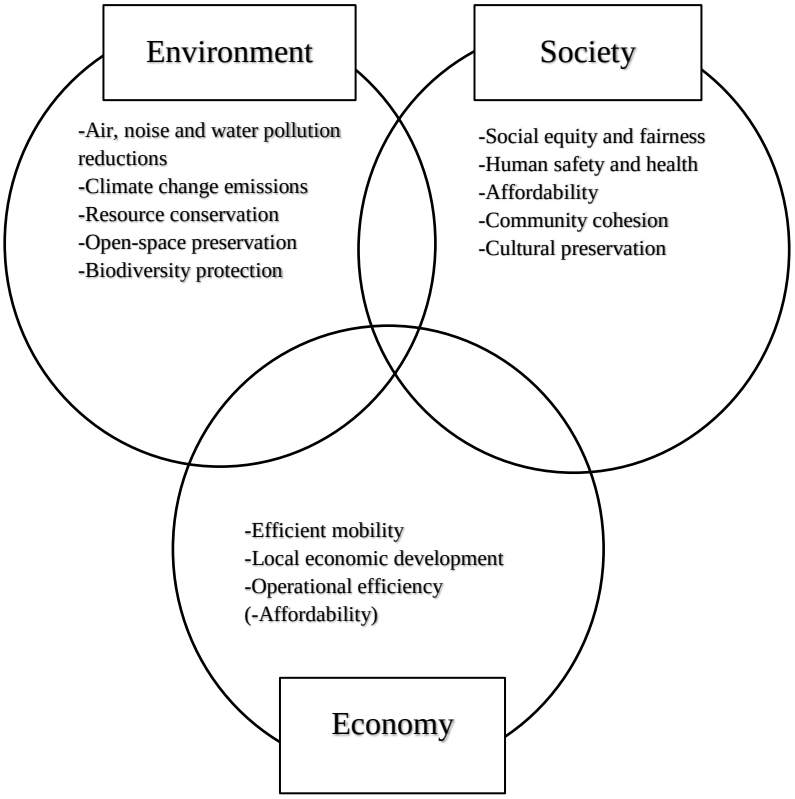

Figure 2.5 The TBL concept and how it is implemented in the field of sustainable mobility. (Litman, 2006)

The Organisation for Economic Co-operation and Development (OECD) defines sustainable transportation in its report *OECD Guidelines towards Environmentally Sustainable Transport* (OECD, 2002) as;

> *"Transport does not endanger public health or ecosystems and meets needs for access consistent with;*
>
> *(a) use of renewable resources below their rates of regeneration.*
>
> *(b) use of non-renewable resources below the rates of development of renewable substitutes."*

The European Union through the European Council defines a sustainable transport system after works done by the Canadian Centre of Environmental Transportation and European Commissions Joint Expert Group on Transport and environment as a system that states (Broken, Ceuster, Burgess, & Herbruggen, 2005):

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

The Transportation Association of Canada (TAC) presents another definition of sustainable mobility. TAC:s definition of a sustainable transportation system has the following characteristics (Victoria Transport Policy Institute, 2011):

(a) In the natural environment:

- *Limit emissions and waste (that pollute air, soil and water) within the urban area's ability to absorb/recycle/cleanse;*
- *Provide power to vehicles from renewable or inexhaustible energy sources. This implies solar power over the long run; and*
- *Recycle natural resources used in vehicles and infrastructure (such as steel, plastic, etc.).*

(b) In society:

- *Provide equity of access for people and their goods, in this generation and in all future generations;*
- *Enhance human health;*
- *Help support the highest quality of life compatible with available wealth;*
- *Facilitate urban development at the human scale;*
- *Limit noise intrusion below levels accepted by communities; and*
- *Be safe for people and their property.*

(c) In the economy:

- *Be financially affordable in each generation;*
- *Be designed and operated to maximize economic efficiency and minimize economic costs; and*
- *Help support a strong, vibrant and diverse economy.*

As can be seen there is no clear definition of the concept of sustainable transportation, however they touch upon common attributes. A sustainable system should limit impacts on the ecosystem by addressing waste, emission and resource use, supply user needs and be accessible for all while also contributing to the economy.

2.3 Measuring sustainability

In order to measure and evaluate sustainability or, as in this study, sustainable transportation, the concept of indicators will be introduced. Indicators have been widely used by scientists and policy makers since the early 1990's in order to monitor trends and progress towards sustainability (Dobranskyte-Niskota et al, 2007). In the report Indicators of Environmental Sustainability in Transport, the definition for an indicator that will be used in this report is defined in the following way (Gudmunsson & Joumard, 2010):

- "An indicator is a variable, based on measurements, representing as accurately as possible and necessary a phenomenon of interest".

The Victoria Transport Policy Institute (Litman, 2012) describes that an indicator should reflect various objectives and impacts of interest and states that in most situations a single indicator is inadequate in showing the entire picture, therefore a variety of indicators should be used.

The Victoria Transport Policy Institute has described four different indicator types that will be used in this study (Neergaard, Rye, & Vleugels, 2011):

- "*Process – the types of policies and planning activities, such as whether the organisation has a process for collecting and publishing performance data, and public involvement.*
- *Inputs – the resources that are invested in particular activities, such as the level of funding spent on various activities or modes.*
- *Outputs – direct results, such as the miles of sidewalks, paths and roads, and the amount of public transit service provided.*
- *Outcomes – ultimate results, such as the number of number of miles travelled and mode share, average travel speeds, congestion and crowding, number of accidents and casualties, energy consumption, pollution emissions, and user satisfaction."*

In addition to indicator types, indicators are described by the data they process; two distinctions are *qualitative* or *quantitative* data. Qualitative indicators use data that can be words or number ratings, such as survey data, while quantitative indicators use numerically measureable information, such as number of trips. Quantitative data is easier to measure and considered more objective than qualitative data. However since qualitative indicators are more difficult to measure and considered not as objective as quantitative indicators, they generally receive less influence and possibly important aspects can be neglected (Litman, 2012).

3 Methodology

This chapter will explain how the work to assess and determine the indicator framework and the selection of indicators was achieved. The literature study performed in previous chapter will function as a basis for this chapter, with a definition of sustainable mobility and relevant aspects regarding indicators.

As a reminder, here follows a repetition of the limitations (*found chapter 1 as well*) that are of essence to this study:

I. The model is, in this first stage of development, directed to Swedish municipalities.
II. Directed towards the current physical transport system and will not investigate the policy or management agendas of the municipalities.
III. Focus only on passenger transportation and transport on land, excluding train.
IV. The model will only include quantitative measures and not qualitative

The subsequent chapter include a general overview of the methodology used for later chapters in this study.

3.1 Framework evaluation

This part focuses on presenting and evaluating indicator frameworks. Fifteen existing indicator initiatives have been reviewed accordingly. The initiatives are all drawn from reasonably well-known organisation around the globe. In addition to the desktop review a workshop with four experts from the field was performed with the objective of gaining further input for the framework evaluation.

The first part of this chapter focuses on presenting the reviewed initiatives, grouping and describing them so that different framework approaches becomes apparent. The later part of the chapter includes a short discussion of our findings through the initiative review together with the inputs gained from the workshop.

3.2 Framework selection and presentation of categorises

The framework evaluation is used as input for selecting a framework and the chosen approach is established in the first section of this chapter. However, as the aim of this study is to present a unique model based on previously performed research, the selected framework approach may need adjustments.

The next step was to evaluate potential useful input from the frameworks that was not selected, as they may contribute to enhancing the model. To avoid any shortcomings, a categorisation of all indicators from the reviewed initiatives was performed. The aim was to present categories of interest that conforms to the set aim and limitations of the model, see limitations above.

The final part of this chapter matched the categories of interest with the framework approach that was selected initially, resulting in a conceptual model consisting of a framework and categories of interest.

3.3 Selection of indicators

As has already been stated in chapter 2.4 measuring a municipality's transport sustainability can be accomplished through the use of indicators. The initiative review

supplies a large amount of indicators to take into account, but a large amount of these indicators does:

(a) not match the aim or limitations of the study or
(b) are to advance, making it impossible to gather data

The focus of this chapter is to evaluate the suitability and accessibility of the indicators that was gathered from the reviewed initiatives and to match these with the framework and categories previously chosen, see chapter 3.2. The selection of indicators sometimes invokes an alteration of the previously set categories, since the selection of indicators and categories are connected to each other.

3.4 Model testing

To evaluate the model a test was performed on four Swedish pilot municipalities: Göteborg, Lund, Umeå and Västerås. Data was gathered, which enabled a discussion of the result, highlighting pros and cons of the model.

The first part of the chapter concludes a description on why the municipalities were selected, on what basis was this selection made? The next part of the chapter includes a description of how the result was calculated, which were the mathematical formulas and in what way should the result be interpreted?

Thereafter the result is presented and illustrated to highlight the set framework, categories and indicators. Finally the findings were discussed, mainly concerns regarding the validity of the results and recommendations on how the model can be alternated in future studies.

4 Framework evaluation

The focus of this chapter is to summarize the knowledge gained from analysing current initiatives and to suggest a framework for measuring passenger transportation system.

4.1 Review of sustainable mobility initiatives

A total number of 15 initiatives have been reviewed in this study. The selection was based on the relevance the scheme had to the subject of sustainable transportation. Both national and international initiatives have been reviewed. The following list includes all the reviewed initiatives together with a short description to its content. In appendix 1 the whole review is presented. In the literature other expressions than initiative have been used i.e. scheme, program, model and index, however in this study initiative will be used to avoid confusion.

Comprehensive Sustainable Transportation Indicators

Performed by the Victoria Transport Policy Institute, Canada. The indicators recommended by Litman are a suggestion of indicators to measure sustainable mobility as comprehensively as possible, taking into account all sustainability goals and objectives regarding transportation.

Gröna Bilister (Green Drivers in Swedish)

The scheme was achieved by the organisation Gröna Bilister, founded in 1994 with support from the Swedish Society for Nature Conservation (Naturskyddsföreningen) and World Wildlife Fund (WWF). The aim was to create a Swedish nationwide assessment scheme that measured the progress towards reducing the environmental effects of car use in municipalities.

HASTA

Initiated by the Department of Technology and Society at Lund University, Sweden. HASTA aim is to aid municipalities to make progress towards sustainability at present and to construct a policy that motivates investments for sustainability today and in the near future.

Indicators for the Integration of Environmental Concerns Into Transport Policies

The Environment Ministers of OECD member countries called on the OECD to develop guidelines for moving towards environmental sustainable transport (EST). The aim of the Environmentally Sustainable Transport is to identify tools and strategies in the long term to achieve sustainability for the transport sector.

Indicators of the Environmental impacts of transportation

Initiated by the United States Environmental Protection Agency (EPA), Bureau of Transportation Statistics (BTA) and the Department of Transportation (DOT). The aim was to develop environmental indicators for the transportation sector four main modes; road, rail, air and maritime.

Indicators to Assess Sustainability of Transport Activities

The institute for environment and sustainability (IES), a scientific institute within the European Commission's Joint Research Centre (JRC), set up the scheme.

Kommunvelometern (Swedish for Municipality Velometer)

A program designed by Cykelfrämjandet (Swedish for promoting cycling). The aim is to highlight and rank municipalities' performance as bicycle friendly cities by looking at the network coverage and efforts that aims to increase the bike share as a mean of transport.

Non-motorized transport performance indicator

Portland State University in cooperation with Alta planning and design, US. The indicator listing stands as a small part of a larger report, which aim is to create a user guide to developing pedestrian and bicycle master plans.

Performance Indicators for Transport

Initiative of the World Bank. The aims to supply indicators that can measure the sustainability for the four main modes of transport: road, air, rail and maritime.

SHIFT

The Ecomobility SHIFT project has developed a total quality management program, known as SHIFT. The function of SHIFT is to allow cities to evaluate the sustainability of their transport system. City management, travel behaviour, environmental impacts are some of the factors that are regarded by the program. Cities that perform well is awarded with a label.

Siemens Complete Mobility Index

Set up by Siemens AG. Siemens CMI aims to evaluate the sustainable mobility level of a city and compare it with best practices.

STPI

This work is funded by cooperation between the Centre for Sustainable Transportation and the Government of Canada. The aim of the project was the development of listing sustainable transportation performance indicators.

Transport and Environment Reporting Mechanism (TERM)

A project of the European Environment Agency. Its purpose is to monitor the progress and effectiveness of transport and environment integration strategies through the environmental performance of transport.

TRAST

Developed by SKL, the Swedish Transport Administration in cooperation with the Swedish Energy Agency. The aim and purpose is to guide planners and decision makers to establish an individual municipal traffic strategy that will integrate traffic-related topics in the planning process and thus progress towards a sustainable transport system.

Urban Transport Benchmarking Index (UTBI)

Initiated by the European Council, the purpose of the Urban Transport Benchmarking Initiative is to show that attractive, efficient local and regional transport systems is an important pillar for the European Union both in terms of economic development and in social cohesion. The aim of UTBI is to identify, compare and highlight best practices and interesting solutions of the different transport systems in Europe.

4.2 Indicator framework and categorisation of reviewed schemes

In this chapter each of the reviewed initiatives will be presented and described. To describe a initiative framework in a coherent way, three expressions will be used frequently in chapter 4. These are:

- Dimension
- Category
- Indicator

The dimension describes the general division of the indicators presented in the framework. Dimensions are not specific to an extent where a single indicator could

measure them e.g. economic impacts, environmental impacts, system processes, outputs or outcomes. Categories are more specific, in some cases measurable by single indicators, but generally works as the labelling for an indicator set e.g. accessibility, affordability. The indicator is the specific component within the transportation system that is measured e.g. length of road network and number of fatalities.

The concepts of dimension, category and indicator are illustrated in figure 4.1, here seen it as a tree diagram where the dimension present the upper most level, followed by categories and indicators.

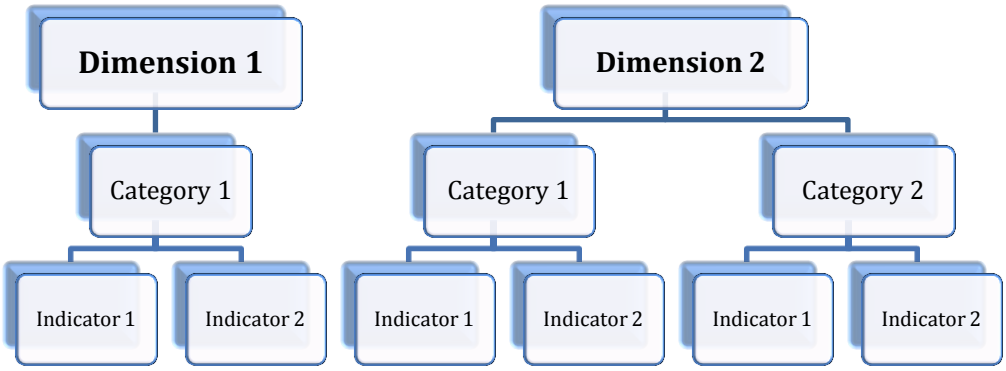

Figure 4.1. Illustration of the relationship between dimension, category and indicator

Each of the fifteen reviewed indicator initiatives differs to some extent in how the framework has been built up. However, a number of similarities were found in the reviewed initiatives. In order to highlight similarities, four framework types were introduced and the fifteen frameworks were divided among them. The following definitions were used:

Triple bottom line framework

The framework structure is influenced by the triple bottom line concept that emerged within the field of sustainable development, see *chapter 2* for explanation.

Adjustment of the triple bottom line framework

Includes frameworks that are similar to the triple bottom line (TBL), but where adjustments have been made.

Main category framework

In these frameworks there is no division into general dimensions, instead categories of interest are presented as the main dimension.

Linkage-based framework

The linkage-based approach differs to some extent. Two different, but similar, approaches were distinguished:

Pressure-State-Response Framework (PSR): The dimensions are split into pressures, state and response according to the PSR format presented by OECD.

Input-output-outcome framework: The dimensions are split into processes, inputs, outputs or outcomes.

4.2.1 Triple bottom line framework

As defined in chapter 2.2 the triple bottom line frameworks strongly draws from the TBL concept that emerge through sustainable development, were the objective is to balance economic, social and ecological issues. Out of the fifteen reviewed sustainability schemes two was found to closely fit the description. These were:

- Comprehensive Sustainable Transportation Indicators
- HASTA

Comprehensive Sustainable Transportation Indicators

Todd Litman at the Victorian Transportation Policy Institute in Canada suggested the framework *comprehensive sustainable transportation indicators* (Litman, 2006). The initiative practices a TBL approach and addresses the economic, social and environmental dimension of society.

The economic dimension measure components within the transportation system that influences the economy such as the potential for inhabitants to reach a destination quickly and in an affordable way, infrastructural cost and implementation of least-cost planning, see table 4.1. The social dimension focuses on the interaction between individuals and the transportation system such as health and safety, liveability, equity and planning for the non-motorized travel modes. The environmental dimension addresses the consequences the transportation system inflicts on the environment and measures that are taken to reduce these effects. Consequences are presented as various kinds of emissions impacting air, water and noise levels, while reduction measures include habitat protection and resource efficiency.

Table 4.1. Dimensions and categories that makes up the comprehensive sustainable transportation indicators initiative

Dimensions	*Economic*	*Social*	*Environmental*
Categories	Accessibility- commuting Accessibility- land use mix Accessibility- smart growth Transport diversity Affordability Facility Cost Freight efficiency Planning	Safety Health and fitness Community liveability Equity – fairness Equity - non drivers Equity – disabled Non-motorised transport planning Citizens involvement	Climate change emissions Other air pollution Noise pollution Water pollution Land use impact Habitat protection Resource efficiency

HASTA

The main goal of the project HASTA was to develop an indicator framework that enable follow-up on the sustainability of Swedish municipalities transport system (Toth-Szabo & Várhelyi, 2011). A review of a number of international literature studies and interviews of Swedish municipality employed, supplied the project with inputs. The project resulted in a framework mirroring the TBL concept.

The economic dimension touches on efficiency and accessibility, similarly to *Comprehensive Sustainable Transportation Indicators*, however in the HASTA framework accessibility is present in both the economic and social dimension. Accessibility in the

context of travel to and from the work place is here part the economic dimension, while non-work related travel is part of the social dimension, see table 4.2.

Table 4.2. HASTA framework including dimensions and categories.

Dimensions	*Economic*	*Social*	*Environmental*
Categories	Efficiency Accessibility – industrial	Accessibility - individual Safety Liveability	Emission Resource use

4.2.2 Adjustment of the triple bottom line framework

The adjustment of the triple bottom line framework is defined as a framework where it, although similar to TBL, lacks elements that make up the economic, social and environmental dimension. Out of the fifteen reviewed schemes, two was found to fit this description. These were:

- Indicators to Assess Sustainability of Transport Activities
- Siemens Complete Mobility Index

Indicators to Assess Sustainability of Transport Activities

The project performed by the Joint Research Centre (JRC) proposed a sustainability indicator framework aimed at measuring the transport system performance and giving input for the development of policy strategies to reduce the undesirable impacts of transportation (Dobranskyte-Niskota et al, 2007). Through an extensive literature review the JRC put forward a framework that reflects the TBL, but with the addition of two dimensions; the technical and operational dimension together with the institutional dimension, see table 4.3. The technical and operational dimension addresses the occupancy of transportation and technological status of vehicles. The institutional dimension addresses measures to improve sustainability and institutional development.

Table 4.3. Indicators to assess sustainability of transport activities framework, illustrated by dimensions and categories.

Dimensions	*Economic*	*Social*	*Environmental*
Categories	Transport demand and intensity Transport cost and prices Infrastructure	Accessibility and mobility Risk and safety Health impacts Affordability Employment	Transport emission Energy efficiency Impact on environmental resources Environmental risk and damage Renewables
Dimensions	*Technical and operational*	*Institutional*	
Categories	Occupancy of transportation Technology status	Measure to improve transport sustainability Institutional development	

Siemens Complete Mobility Index

With the objective to evaluate the sustainable mobility level of a city's transportation system Siemens CMI uses an adjusted triple-bottom line approach with three main dimensions: user focus, efficiency and sustainability, see table 4.4 (Siemens, 2009). While the dimension headings differ from the strict triple bottom line approach, user

focus relates to social aspect, such as level of service, affordability, accessibility etc. Efficiency includes mainly economic indicators i.e., means of transport, infrastructure and costs, while the dimension measuring sustainability address environmental indicators such as, pollution and energy use. However, accident indicators presented in the sustainability dimension is usually part of the social dimension, if comparisons are to be made with the fifteen reviewed initiatives.

Table 4.4. Siemens complete mobility index framework, illustrated with dimensions and categories.

Dimensions	*User focus*	*Efficiency*	*Sustainability*
Categories	Public transport level of service Transport information and payment system Affordability Reliability Accessibility	Transport management, control and security Air transport Sea transport Road infrastructure Cost of transport provision/unit GDP Performance of road network	Accidents Energy use intensity Pollution Dedicated cycle lanes

4.2.3 Main Category framework

The frameworks that have been defined as main category frameworks structure the indicators directly in their corresponding category and do not group categories in dimensions. Seven of the initiatives have been classified as a main category framework. However, out of these seven; four is seen as general frameworks that focus on measuring the overall sustainability of the transportation system; while the other three focuses on measuring the sustainability of a specific transportation mode. These are:

General;

- Performance Indicators for Transport
- STPI
- TRAST
- Urban Transport Benchmarking Index

Mode specific;

- Green Motorists
- Municipality Velometer
- Non-motorized transport performance indicator

General main category frameworks

The framework for *Performance Indicators for Transport*, initiated by The World Bank, uses nine main categories where the indicators are all categorised after mode as well, see table 4.5. The two categories, Access and Affordability, are closely related to corresponding key aspects in sustainable mobility and include indicators such as road density or private vehicle ownership. In addition to the two sustainability categories, four of the categories, Efficiency (Cost), Efficiency (Economic), Fiscal Cost and Financial Autonomy are focused on the economic dimension of sustainable transportation. The category Quality has been divided into two separate categories, one ad-

dressing technical issues while the other addresses inhabitants perception. These describe the quality of the network, accident rates and average total travel time respectively. The category institutional development describes the regional and national management and guideline efforts.

The framework for *STPI* uses seven main categories and includes future improvements on the indicator sets, from initial indicators to short-term and long-term additions, see table 4.5 as well as appendix 1. Environmental and health consequences of transport have been placed in one category, which includes emissions, discharge into water, noise and road fatalities (Gilbert & Tanguay, 2000). Transport activity describes the travel behaviour, both motorised and non-motorised. Land use, urban form and accessibility have indicators that include land use, employment density and transit coverage. The category Supply of transport infrastructure and services focuses on the infrastructure network and related services with indicators such as length of paved roads and transit seat-km per capita. Two categories focus on the economic aspects of transport cost and energy intensity, these categories are transport expenditure and pricing together with technology adaption. The later includes technological implementations towards renewable resource dependency. The last category, implementation and monitoring, aims to achieve regular updates of the in-data for the program.

TRAST is primarily used as a guideline for municipalities to use in order to implement a transport strategy (Johansson, Nilsson, & Wendl, 2011). The seven categories, named TRAST aspects are therefore influenced by aspects that are relevant from a transport planning point of view, however these correlate with important aspects of sustainable transportation, see table 4.5. The category, City Characteristics, describes how the city is composed while the categories Traffic system and Traffic volume focus on the infrastructure and traffic amounts of the city. The Accessibility aspect concentrates on number of stops that are adapted for disabled people and travel time ratio. In Traffic Safety, besides indicators for traffic accidents, indicators for vehicle velocities and bicycle helmets are present as well. Environmental Impact consists of three central and often used indicators, alternative fuel consumption, carbon dioxide emissions and noise pollution.

Urban Transport Benchmarking Index has seven general categories that are in close comparison with the three dimensions of sustainability, with Economy and Environment as two main categories, table 4.5 (Roberts & Taylor, 2004). However the social dimension is not present, instead different aspects of the transport system have replaced it and the most common social sustainability indicators are represented in these categories, i.e. Accessibility is categorised under Fleet Composition and Traffic Accidents under Road Safety. The framework has divided the indicators describing the transport system into three separate categories, Transport network, Fleet composition and Travel characteristics. Giving Road Safety an own category consisting of only one indicator shows the significance of proper traffic safety. An overview of the four general Main Category frameworks can be seen below in table 4.5.

Table 4.5. Main category indicator framework that are general. The table includes four frameworks: Non-motorized transport performance indicators, Performance indicators for transport, STPI and Urban benchmarking index.

Initiative	*Performance indicators for transport*	*STPI*	*TRAST*	*Urban benchmarking index*
Categories	Access Affordability Quality (Technical dimension) Quality (Perception) Efficiency (Cost) Efficiency (Economic) Fiscal cost Financial autonomy Institutional development	Environmental and health consequences of transport Transport activity Land use, urban form and accessibility Supply of transport infrastructure and services Transport expenditure and pricing Technology adaption Implementation and monitoring	City Characteristics Traffic System Volume of Traffic Accessibility Security Traffic Safety Environmental Impact	Region and city Transport network Fleet composition Travel characteristics Economy Road Safety Environment

Mode specific main category frameworks

Non-motorized transport performance indicator focuses on pedestrian and bicycling conditions in the transport system *(Roughton, Hengel, & Weigand, 2012)*. It uses four categories, where Infrastructure, describes the physical network of the transport system and how it is designed to support non-motorised conditions, see table 4.6. The category *Programs* focuses on implemented campaigns and activities performed during the last year to promote non-motorised transports. Use and Safety, describes the travel behaviour of the transport system with indicators such as mode share and demographic composition, together with accident rate for pedestrians and bicyclists. The category, Public opinion shows the satisfaction level of using the pedestrian and bicycle network.

The framework for *Green Motorists* uses the general main category structure with specific categories instead of general dimensions, see table 4.6 *(Gröna Bilister, 2012)*. In addition to using the main category structure the framework is mode-specific as well since it does not include other modes besides the car. This results in a specific framework that focuses on the car travel characteristics of a municipality, both municipal and private cars, and policies for promoting greener travels. The category, Cars of the municipality, describes the municipal private car-registered pool in terms of carbon dioxide emissions and procurement requirements when purchasing or leasing municipal cars.

The *Municipality Velometer* is similar to the framework of Green Motorists, since it uses the main category approach and only focuses on one mode; bicycling, see table 4.6 *(Mattsson, 2011)*. Emphasis have been laid on the economic aspect and policies, with categories such as; Investments infrastructure/maintenance, Investments infor-

mation/marketing and Bicycle politics respectively. An over-view can be seen below in Table 4.6 for the mode-specific Main Category frameworks.

Table 4.6. The table includes the two main category frameworks that are viewed as mode specific. These are Gröna Bilister and Kommunvelometern.

Initiative	*Green Motorists (car)*	*Municipality Velometer (bicycle)*	*Non-motorized transport indicators (pedestrian and bicycle)*
Categories	Cars of the municipality The car usage of the municipality-employed Procured transportation services Car-usage of the public Access to renewable fuels New car sales Air quality	Current infrastructure Investments infrastructure/maintenance Investments information/marketing Activities 2010 Bicycle politics Follow-up and measurement	Infrastructure Programs Use and Safety Public opinion

4.2.4 Linkage-based framework

A linkage-based framework is one that tries *to catch a full range of indicators that produces particular disorders affecting the sustainability, the impacts of these disorders, and counteractive actions that improves the situation.* Two types of linkage-based frameworks have been distinguished from the review, the Pressure-State-Response type (PSR) and the input-output-outcome type (IOO).

4.2.4.1 Pressure State Response

The PSR approach was brought forward by the OECD and states that (FAO, 1999):

- *Human activities exert pressures* (such as pollution emissions or land use changes) on the environment, see *figure 4.2*.
- The pressures induce *changes in the state of the environment*.
- *Society then responds* to changes in pressures or state with environmental and economic policies and programs intended to prevent, reduce or mitigate pressures and/or environmental damage.

Of the fifteen reviewed initiatives only one, the *Indicators for the Integration of Environmental Concerns Into Transport Policies*, fits the linkage-based PSR framework.

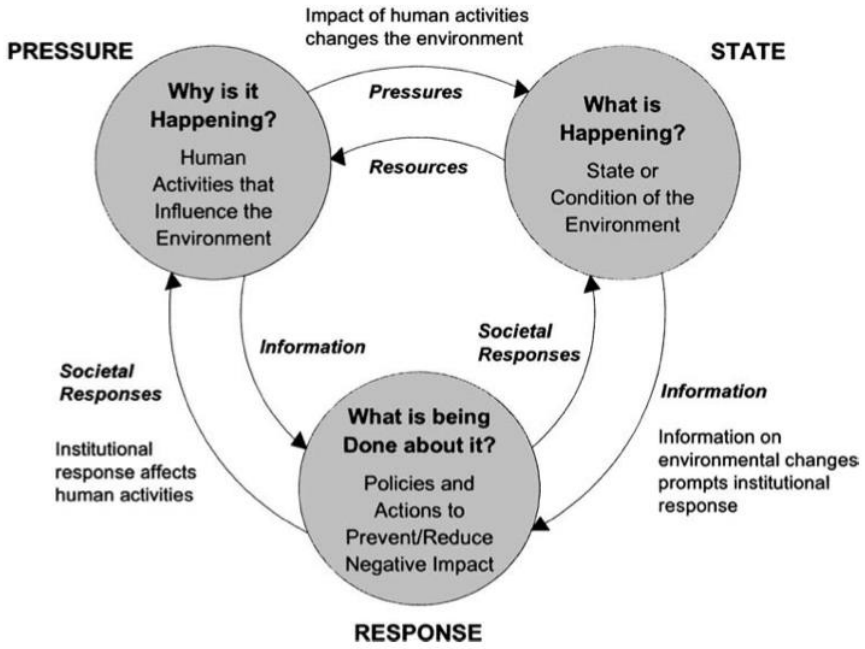

Figure 4.2. Illustration of the PSR framework approach.

Indicators for the Integration of Environmental Concerns Into Transport Policies

Indicator for the Integration of Environmental Concerns Into Transport Policies program is a part of the OECD work program regarding environmental indicators (OECD, 1999). The indicator framework is an adjusted PSR framework taking into account the specific attributes of the various components, see table 4.7. The indicators are structured around three themes. Transport trends and patterns of environmental significance (major driving forces, indirect pressures). Transport systems' interactions with the environment (direct pressures on the environment and on natural resources, related impacts). Economic and policy aspects of the transport and environment interface (economic aspects of environmental impacts, key policy and other societal instruments, trade aspects).

The work performed by OECD states that the interaction between the environment and transportation is the focus of the initiative and that social and economic issues, though present, are of less concern.

Table 4.7 Category content of the framework 'Indicators for the Integration of Environmental Concerns Into Transport Policies'.

Dimensions	*Sectorial trends and environmental significant*	*Interaction with the environment*	*Economic and policy aspects*
Categories	Overall traffic trends and modal split Infrastructure Vehicles and mobile equipment Energy use	Land use Air pollution Water pollution Noise Waste Risk and safety	Environmental damage Environmental expenditure Taxation and subsidies Price structure Trade and environment

4.2.4.2 Input Output Outcome

The Input Output Outcome (IOO) method for distribution of indicators is the second linkage-based approach. The concept of IOO first introduced by Gudmundsson differs from the PSR to some extent in how indicators are separated. IOO uses four dimensions (Neergaard, Rye, & Vleugels, 2011):

- *"Process – the types of policies and planning activities, such as whether the organization has a process for collecting and publishing performance data, and public involvement.*
- *Inputs – the resources that are invested in particular activities, such as the level of funding spent on various activities or modes.*
- *Outputs – direct results, such as the miles of sidewalks, paths and roads, and the amount of public transit service provided.*
- *Outcomes – ultimate results, such as the number of miles travelled and mode share, average travel speeds, congestion and crowding, number of accidents and casualties, energy consumption, pollution emissions, and user* satisfaction."

Out of the fifteen reviewed schemes three where defined to match the linkage-based IOO approach. These where:

- Indicators of the Environmental impacts of transportation
- SHIFT
- Transport and Environment Reporting Mechanism (TERM)

Indicators of the Environmental Impacts of Transportation

In the report *Indicators of the Environmental Impacts of Transportation* EPA suggested a framework for measuring the sustainability of transportation (EPA, 1996). It should be noted that this indicator framework was not fully developed at the time it was presented, but still includes an alternative approach with a number of indicators proposed. The framework does not include process or input indicators, however both outputs and outcomes are presented. Four dimensions make up the core of the framework, these are: root cause indicators, activity indicators, output indicators and outcome indicators.

The root cause dimension provides information about core factors such as economy, geography and demography, which influences the travel behaviour of the inhabitants and goods, see table 4.8. While EPA states that root cause indicators provide little information on environmental consequences, they could help highlight the reasons behind e.g., increased travel or decreased levels of emission. The activity dimension covers the state and actions of the transportation system such as infrastructure, vehicle fleet and travel. These indicators often contribute to direct environmental impacts. The output dimension gives quantitative evidence of the actual affects the transportation system has on the environment through land take, emissions. The outcome dimension expands on the outputs and measures what impacts emission, pollutants and noise has on animals and human health.

According to the general definition of input-output-outcome indicators presented above (Gudmundsson, 2007), the activity and root cause indicator dimensions would be defined as output indicators (land use, travel, vehicles), while both the output and outcome dimension relate to outcome indicators (emission, land take, effects on health).

Table 4.8. Illustrations of the framework Indicators of the Environmental Impacts of Transportation as presented by EPA.

Dimensions	*Root cause indicator*	*Activity indicator*	*Output indicator*	*Outcome indicator*
Categories	Land use (including demographics and geographic issues) Economics	Infrastructure construction and maintenance Vehicle and parts manufactured Travel Vehicle maintenance and support Disposal of vehicles and parts	Habitat change/land take Emission Ambient levels Exposure to pollutants	Effects on habitat change Effects of pollutant emission

SHIFT

Through the SHIFT initiative a framework was developed that is divided into three dimensions; enablers; transport and system services; results and impacts, see table 5.9 (Neergaard, Rye, & Vleugels, 2011).

Process indicators focus on the management of the transportation system and how environmental strategies and finance are integrated to achieve sustainability goals. The outputs focus on the components that makes up the current transportation system such as speed limits, infrastructure of different modes, travel, travel information and vehicle fleet composition. The outcomes take into account the impacts the transportation system has on the society, e.g. health issues and safety.

Table 4.9. SHIFT

Dimensions	*Process: Enablers*	*Output: Transport and system*	*Outcome: Result and impact*
Categories	Knowledge of society and user needs Vision, strategy and leadership Personnel and resources Finance for ecomobility Public participation Monitoring, evaluation and review	Accessibility to services Planning of new city areas Car free and low speed zones Information systems and MM MM services supporting ecomobility Parking policy and traffic restraint measures Accessibility for people with reduced mobility Walking infrastructure Cycling infrastructure Coverage of PT network Speed Affordability Simplicity – ease of use Green vehicles	Modal split PT trips per capita Safety overall Safety – vulnerable road users Energy efficiency Greenhouse gases Local air quality

Transport and Environment Reporting Mechanism

The two main dimensions of the TERM framework are: determinants of the transport and environment system; transport and environmental performance (European Commission, 2000). In relevance to the *input-output-outcome* framework determinants of the transport and environment system includes the outcome indicators and transport and environmental performance consists of output indicators, see table 5.10. In the TERM framework process indicators are incorporated within the output dimension.

Similarly to the SHIFT framework the output dimension consists of components that describes the state of the transportation system, such as infrastructure, travel demand and affordability while the outcome dimension measures the environmental consequences of the transportation sector.

Table 4.10. TERM

Dimensions	*Outputs: Determinants of the transport/environment system*	*Outcome: Transport and environmental performance*
Categories	Transport demand and intensity Land use and access to basic services Transport supply Price signals Technology and utilization efficiency Management integration	Environmental consequences of transport

4.3 Discussion and summary of reviewed schemes

The discussion is divided into two parts: the first part revolves around the initiative review while the second part presents the ideas that were discussed during the workshop.

4.3.1 Initiative review discussion

Similarly to the definition of sustainable transportation, a deduction that becomes evident when overseeing the reviewed initiatives is that no standard framework for sustainable transport analysis currently exists. However, an agreement present in a majority of the frameworks reviewed is that sustainable transportation frameworks should, at least, include measurements of impact on the three cornerstones: the economy, the environment and the social wellbeing of a city's inhabitants, a perspective supported in a study by Jeon and Amekudzi, (2005).

As stated the consensus is to include economic, social and environmental aspects when measuring sustainability of transportation. Hence the TBL frameworks and adjustment of TBL frameworks is a good example where these aspects are highlighted. In the TBL approach the focus is to overview the impacts certain activities has on the sustainability of a certain system under consideration. A downside to this method is that the aspects under consideration (economic, social, environmental) often overlap with the others and as a result the division of indicators/categories becomes complex. The initiative review strengthens this viewpoint, as the division of indicators did not match throughout the TBL frameworks, see chapter 4.2.1. This was particularly evident regarding the categorisation of economic and social indicators. In example in

Litman's *comprehensive sustainable transportation indicators* the accessibility category is included within the economic dimension, while in JRC's *Indicators to Assess Sustainability of Transport Activities* puts accessibility and mobility within the social dimension. Another potential drawback with the TBL framework is that the negative impacts that we want to reduce (environmental impacts, fatalities) are distributed among the different dimensions.

Input-output-outcome and the *PSR* frameworks, both described as linkage-based frameworks by Amekudzi and Jeon tries to catch a full range of indicators that produces particular disorders affecting the sustainability, the impacts of these disorders, and counteractive actions that improves the situation. In contrast to the TBL frameworks these approaches highlights the linkage between impacts/outcomes (fatalities, noise level) and the transport system activities (infrastructure, travel intensities). A potential drawback are that these framework approaches could be difficult to understand for someone that has limited knowledge about the topic, as the TBL approach is to a greater extent used in the field of sustainable development. However, even though the TBL is a common approach, it does not necessarily mean that it is the most suitable.

The *main category framework* is used in seven of the fifteen initiatives and show large variations of its composition. Unlike the four other identified framework types, it does not follow a well-known structure for its categories and within this group there are large differences. Therefore it is vital that the topics are properly named and follows a focus level that is not too large or too detailed. A well-balanced main category framework with relevant topics and focus level can be a comprehensive and user-friendly tool to use. Another strong point for the main category frameworks is the adaptability, since they are not subjected to preconceived categorisations.

4.3.2 Workshop discussion

During the workshop, see chapter 3.1, one discussed topic was; Who should be the target group of the program? Two interesting alternatives were discussed:

Alternative 1. A guiding tool

> The model is intended for the municipalities to use as a simple guiding tool in which their progress towards sustainable transportation is assessed and presented. With this approach the intended users are the municipalities and the model should be adjusted accordingly to municipalities needs.

Alternative 2. A ranking tool

> The model is intended as a municipality-ranking tool in order to distinguish how municipalities' effort to achieve a sustainable transport system compares. This approach should be viewed as a competition in which a scoring system is needed to rank municipalities against each other. With this approach the public is the main target group.

It was concluded that the later of the two targets was preferable, since with this approach the model could contribute with something new for the market. Namely, a ranking tool that can draw the public's attention. An advantage of using the ranking tool alternative is that it would place the user of the transport system in focus by making the users aware of how sustainable the transport system actually is. A disadvantage of using the guiding tool alternative is that it would require a shift in focus towards management and process indicators to a larger extent in order to be of rele-

vance for a municipality. An additional disadvantage is that these types of guiding tools already exist for municipalities to use.

The key purpose of the workshop however was to establish an initial framework. The participating members pointed out an important notion that the selection of framework type is closely related to the intended target group of the model.

All members that took part of the workshop agreed upon that the two TBL approaches were too general; they were therefore neglected. Deciding either a linkage-base approach or a main category approach would prove to be a hard choice. Pros and cons were discussed lengthily, most of which has already been discussed in previous chapter, see chapter 4.3.1. However, the determining factors were flexibility and simplicity. The main category approach was said to hold the advantage regarding both of these factors, thus the suggested framework approach was the main category one.

The final part of the workshop revolved around which of the seven main category initiatives that was most suitable going forward. It was concluded that a framework that is already recognised on the market would have hold a clear advantage as people can relate to it and credibility issues may be less of a problem. The framework selection is presented in the next chapter.

5 Framework selection

This chapter clarifies the framework selection and the selection of categories in order to build a unique model that draws experience from the field of transportation. Knowledge obtained from the review and workshop that was previously discussed, was used as input for the selection.

5.1 Choosing the TRAST framework

With consideration of the performed initiative review and the workshop conducted with experts, an indicator framework was selected. The framework that was preferred for this study was the structure found in TRAST, in particular its related TRAST aspects. The seven TRAST aspects are:

- *City Characteristics* – Aspects that describe the city or municipality in terms of population and area, indicators will not affect overall score.
- *Traffic System* – Aspects that regard the current infrastructure of the municipality.
- *Volumes of Traffic* – Aspects that regard the traffic flows and characteristics.
- *Accessibility* – Aspects that regard the accessibility of the city infrastructure and public transport.
- *Security* – Aspects that regard how secure the users of the transport system feels.
- *Traffic Safety* – Aspect that regard how safe the transport system is in terms of human casualties.
- *Environmental Impact* – Aspects that regard the impacts the traffic system have on the environment.

The reason for selecting the TRAST aspects is that they are widely recognised and established in the field of traffic planning in Sweden and the credibility increases by using a structure that is already in use. As mentioned in the previous chapter, see chapter 4.3, a major advantage of selecting an existing framework is that professionals recognise it, which is the case for TRAST on the Swedish market.

No further emphasis has been laid on the structure of the sub-categories for each main category of the TRAST model that have been analysed in this study.

5.2 Should the TRAST framework be complemented?

Valuable input from frameworks, other than the selected TRAST approach, should not be neglected as they may contribute to enhancing the model. To avoid such shortcoming, all of the indicators presented in reviewed initiatives have been categorised. It should however be mentioned that hereafter, dimensional aspects are disregarded since TRAST is a main category framework and an inclusion of dimensions would counteract that approach.

The categorisation did not draw its inspiration from the TRAST framework, instead it was a stand-alone operation where categories was chosen in order to (a) include all indicators from reviewed initiatives (required a level of freedom in the category selection, this would be limited if the TRAST categories where applied) and (b) include major categories that was addressed by the initiatives. In summary, this chapter will

evaluate the suitability of the different categories in relevance to the stated limitations of this study and by doing so it is possible to decide which categories should or should not be included in the final framework.

As stated the categorisation borrows from reviewed initiatives, trying to address major topics. However, at times indicators overlap thus making them difficult to place within a single category, at those occasions the knowledge of the writers worked as the deciding factor.

Appendix 2 contains a compilation of all the categories that the indicators were assigned to. The main purpose of usage and a short description of the indicator content are clarified for each category. This work approach was derived from the SHIFT program that performed a similar category summary.

Table 5.1. concludes 24 categories that was used in sorting the indicators and how frequently present each subject were in the different programs. The initial sorting included all 525 indicators gathered from the reviewed initiatives, the full listing can be found in *appendix 3*. The reoccurrence of different categories is unbalanced; some are frequently used by the initiatives while others are less common.

Table 5.1. Categorisation of indicators and summary of the initiatives use of the categories. The marking (x) indicates if an initiative had indicators measuring the category or not, the (x) marking equals that it was measured. The numbers (1-15) in the head of the table represents one of the reviewed initiatives, see footnote.

Category	1[1]	2[1]	3[1]	4[1]	5[1]	6[1]	7[1]	8[1]	9[1]	10	11	12	13	14	15	Count
Accessibility	X		X	X	X	X		X	X	X	X	X	X	X		12
Accessibility for disabled	X				X	X		X		X	X			X	X	8
Affordability	X		X	X	X	X			X	X	X	X	X		X	11
Air emissions	X		X	X	X	X				X	X	X	X	X	X	11
Demography and geography					X									X	X	3
Energy and resource efficiency			X	X		X			X	X	X		X	X		8
Habitat loss				X	X	X										3
Hazardous waste (non air related)	X			X	X	X						X				5
Health					X	X						X	X			4
Implementation and monitoring				X		X	X									3
Information and communication	X			X	X		X	X	X	X	X		X			9
Infrastructure and land take	X		X		X	X		X	X	X	X		X	X	X	11
Liveability	X		X													2
Management and policy	X	X				X	X	X	X	X	X	X	X			10
Modal split	X		X	X	X				X	X		X		X	X	9
Noise pollution			X	X	X	X						X	X	X		7
Parking							X	X		X				X		4
Safety	X		X	X		X		X	X	X	X	X	X	X	X	12
Security			X													1
Taxation & subsidies				X		X			X		X		X			5
Traffic volumes and mobility				X	X	X		X	X	X		X	X	X	X	10

[1] ***1.*** *Litman/Comprehensive Sustainable Transportation Indicators* ***2.*** *Swedish Society for Nature Conservation/Gröna Bilister (Swedish for Green Drivers)* ***3.*** *Lund University/HASTA* ***4.*** *OECD/Indicators for the Integration of Environmental Concerns Into Transport Policies* ***5.*** *EPA, BTA and DOT/Indicators of the Environmental impacts of transportation* ***6.*** *IES and JRC/Indicators to Assess Sustainability of Transport Activities* ***7.*** *Cykelfrämjandet (Transl: Promotion of Cycling)/Kommunvelometern (Swedish for Municipality velometer)* ***8.*** *Non-motorized transport performance indicator* ***9.*** *The World Bank/Performance Indicators for Transport* ***10.*** *IEE/SHIFT* ***11.*** *Siemens AG/Siemens Complete Mobility Index* ***12.*** */STPI* ***13.*** *EEA/TERM* ***14.*** *Swedish Transport Administration/TRAST* ***15.*** *EC/Urban Transport Benchmarking*

Category	1[1]	2[1]	3[1]	4[1]	5[1]	6[1]	7[1]	8[1]	9[1]	10	11	12	13	14	15	Count
Transport cost/gain				X	X	X	X	X	X	X		X	X		X	10
Travel behaviour	X				X	X		X					X		X	6
Vehicle fleet				X	X	X			X	X		X	X	X	X	9

Since the use of different categories in measuring sustainability is strongly connected to the limitations and aims, a number of the categories can be eliminated accordingly. To achieve this, the 24 categories were divided into three groups:

Group A contains categories that should be included in the model. The categories in this group have been commonly applied in earlier initiatives, stressing their importance, and do not conflict with the aim and limitations of this study.

Group B consists of categories that may be included if the accessibility do not hinder data gathering, which would complicate the model. These categories can be less founded in the field of sustainable transportation, but must not conflict with the aim and limitations.

Group C including categories that will be eliminated from further study. The categories may or may not be commonly implemented in other sustainability studies and are eliminated because they do not agree with the aim and limitations.

The result from the elimination have been gathered in table 5.2. 10 categories were subjected to group A, 4 to group B and 10 to group C.

Table 5.2. Grouping of categories according to relevance. Were group A must be present, group B can be included and group C will not be included.

Group A	Group B	Group C
Accessibility	Accessibility for disabled	Habitat loss
Affordability	Noise pollution	Hazardous waste (non air related)
Air emission	Parking	Health
Demography and Geography	Travel behaviour	Implementation and monitoring
Energy and resource efficiency		Information and communication
Infrastructure and land take		Liveability
Modal split		Management and policy
Safety		Security
Traffic volume and mobility		Taxation and subsidies
Vehicle fleet		Transport cost/gains

As stated, the categories presented in *Group A* are categories commonly used in earlier sustainability initiatives, the level of use in this group is 9-12 out of 15 initiative. One exception is demography and geography, only applied in 3 of the 15 initiatives. However as demographical and geographical data are essential inputs for the interpretation of results when evaluation municipalities the category was also included in *Group A.*

The level of use in *Group B* is less common, 4-8 out of 15 possible initiatives. The categories are viewed as suitable in the context of the study.

Group C consists of the neglected categories, either the categories were found to not match the limitations set for the model or the categories were neglected because they were not established by the reviewed initiatives. A limitation of this study was that the

model is; *directed towards the current physical transportation system and therefore, will not investigate the municipality's management of economic issues and work concerning sustainability*.

As a result the following categories were eliminated from further inclusion; implementation and monitoring, information and communication, management and policy, taxation and subsidies, transport cost/gains. The categories neglected because they were less established were: Habitat loss, hazardous waste, health, liveability and security, 4 or less initiative used those categories.

5.3 Model suggestion

In chapter 5.2, 10 out of 24 categories were eliminated leaving 14 categories of interest. These were matched with the chosen TRAST framework, chapter 5.1, to the extent it was possible, see table 5.3. One of the original TRAST aspect (security) has been disregarded. The reason behind this adjustment is stated previously, see table 5.2 in chapter 5.2.

Table 5.3. Matching TRAST aspects with categories of interest.

TRAST aspects: Sorting of main categories
City Characteristics - Demography and geography
Traffic System - Infrastructure and land take - Parking
Traffic Volume - Modal Split - Traffic volume and mobility - Travel behaviour - Vehicle fleet
Accessibility - Accessibility - Accessibility for disabled - Affordability
~~*Security*~~
Traffic safety - Safety
Environmental impacts - Air emission - Energy and resource efficiency - Noise pollution

In table 5.3., both TRAST aspects and categories represent generalised subjects and it is difficult to distinguish what the intended measurement is. In order to specify the content for each TRAST aspect, the categories have been divided into subcategories that can be measured by a limited number of indicators. The result of this selection can be seen in table 5.5.

One distinction that can be seen in table 5.4 was that the original TRAST-aspect, *city characteristics*, has been separated from the remaining aspects. The cause for this is that indicators that match *city characteristics* do not measure sustainability; instead they represent factual information about a municipality such as population data, areal data. However *city characteristics* is still included as it indicates size and form of a municipality, as well as enables comparison made per capita, per area, per density.

Table 5.4. Clarification for the colour scheme applied in table 5.5.

Factual TRAST aspect	TRAST aspect
Subcategory	Subcategory
Previous main category	

Table 5.5

1. City Characteristics	
Sub Category	**Old main category**
Population Area Density Employment Income	Demography and geography

2. Traffic System	
Sub Category	**Old main category**
Length of infrastructure, different modes Land take by infrastructure Infrastructural quality Infrastructural services Green infrastructure	Infrastructure
Parking access Parking charge	Parking
3. Volume of Traffic	
Modal comparison	Modal Split
Journey length Velocity Traffic volume Congestion	Traffic Volume and Mobility
Occupancy	Travel Behaviour
Vehicle amounts Vehicle per capita Manufacture and waste Age of vehicle Vehicle emission standard: Renewable or not	Vehicle fleet
4. Accessibility	
Journey time Journey ratio Access to basic needs (distance and time) Transit stops	Accessibility
Transit adaption to disabled	Accessibility for disabled
Ratio: Travel cost/income Cost of transport: Total costs or per capita cost	Affordability
5. Traffic Safety	
Fatalities, injuries and risk Vulnerable road users	Safety
6. Environmental Impacts	
Per capita release Annual or daily release Exposure to and exceedance of air emission standards Emission trend	Air emission
Energy consumption Fuel consumption Use of renewable energy/fuels Resource management	Energy and Resource Efficiency
Exposure to noise	Noise Pollution

The subcategories presented in table 5.5 should be viewed as **potential** subcategories. However, further evaluation of indicator accessibility and indicator overlaps may change the content to some extent. This is evaluated further in the next chapter, chapter 6.

6 Selection of indicators

The final step before a test of the model is performed is the selection of indicators. The six TRAST aspects will not be changed hereafter and will all be included in the final model. However, out of the 41 subcategories identified, table 5.5, only the most important should be incorporated. A high amount of indicators would result in a model that is difficult to implement because the activity of gathering data would be time consuming, something that should be avoided when the objective is to supply an easily applicable model[2].

To obtain a set of relevant indicators lists that matched the sub-categories. A categorisation of all indicators was performed; see *appendix III*. Thereafter unsuitable indicators were excluded.

Each list contained a number of indicators that reflect similar topics, e.g. *traffic accidents resulting in fatalities* and *traffic accidents resulting in severely injured* are two unique indicators that reflect the same transport issue, by grouping these as one indicator *traffic accidents resulting in death or severely injured*, the selection is narrowed down to a limited number of indicators instead of large number. After the "indicator grouping" was achieved indicators were selected and implemented into the model if they fulfilled most or all of the following criteria's:

- Data should be easily-obtained
- Indicators should describe sustainable transport topics as precisely as possible
- Indicators should describe phenomenon of interest rather generally, not too detailed
- Indicators should be present in several of the different programs
- One indicator per subcategory is preferable

A few sub-categories that are more or less relevant and commonly present in the different programs have been removed completely in this stage, mainly since several sub-categories overlap and aspects would be accounted for twice if they were to be included, e.g. energy consumption, fuel consumption and use of renewable fuels/energy are represented by the sub-category Vehicle fleet with the indicator Share of green vehicles and with carbon dioxide emissions per capita. Indicators that would be ideal to include but due to difficulties of obtaining data have been removed, for example congestion levels, exposure to and exceedance of air emission standards and average vehicle velocities have been discarded since the data is unattainable.

The indicators had the data accessibility evaluated, see appendix x. This chapter will only present the ones that were selected for the finalised model and the focus is to explain the indicators purpose.

6.1 City Characteristics

As previously stated the indicators included in city characteristics will be used as input for other indicators and to distinguish the type of city being examined. Six indicators have been included in the category, seen in table 6.1.

Table 6.1. Final indicator selection concerning city characteristics.

City Characteristics				
Nr	**Subcategory**	**Nr**	**Indicator**	**Interpretation**

[2] Workshop

1.1.	Population	1.1.1	*Number of municipality inhabitants*	Only used as an input value
		1.1.2	Night and daytime population	Only used as an input value
1.2.	Area	1.2.1	*Municipality land area*	Only used as an input value
		1.2.2	Urban area	Only used as an input value
1.3.	Density	1.3.1	*Inhabitants per square meter*	Only used as an input value
1.4.	Income	1.4.1	*Median income per capita*	Only used as an input value

Population

The population indicator enables values per capita to be calculated, which gives opportunity to compare municipalities with each other. The Swedish national statistic organisation, Statistics Sweden (SCB in Swedish), keeps record of population growth both locally and nationally and the data is available for the public.

Values for night and daytime population of workforce have been added to give a simple measure of how the traffic flows are directed to and from the city.

Area

Area data enables municipality comparisons to be measured in square meter or square kilometre. As the study focuses on land based travel the municipality area does not contain area of water masses. Data is open to the public through SCB.

Density

The values for density have been added by dividing population with land area. It is used to give a simple measure for how urbanised the municipality is.

Income

Data on income enables affordability comparisons in the context of transportation. In this model the median income have been chosen as input the value. Median income, and not average income, is by certain statisticians viewed as a better indicator since it avoids being affected by extreme low and high values, which is the case for average income (U.S Census Bureau, 2003).

6.2 Traffic System

The traffic system supplies the users, inhabitants, with the means, infrastructure, that enables movement within the municipality. There is a need for the traffic system to be wide covering, enabling movement for all. At the same time, the traffic system should prioritise environmental-friendly alternatives for traveling and make effective use of the space available. Indicators measuring the traffic system are viewable in table 6.2.

Table 6.2. Final list of indicators that regards the traffic system.

Traffic System				
Nr	**Subcategory**	**Nr**	**Indicator**	**Interpretation**
2.1.	Length of infra-structure	2.1.1	*Length of road infrastructure per capita*	Less is better
		2.1.2	*Length of pedestrian infrastructure per capita*	More is better
		2.1.3	*Length of bicycling infrastructure per capita*	More is better
2.3.	Parking charge	2e	*Maximum hourly parking charge in central area of the municipality*	More is better

Length of infrastructure

Indicators measuring infrastructural length are commonly used in sustainability studies, since it gives a measure of how much land that is occupied by transport (Toth-Szabo & Várhelyi, 2011). However, since the size and number of inhabitants in a municipality puts certain demands on the quantity of infrastructural services, comparisons needs to be performed in regards to per capita or as a ratio. It should be noted as well that densely populated areas of a certain area receive less length of infrastructure per capita in comparison to a scarcely populated area of the same size. The following indicators will be included in this category:

- Length of road infrastructure, measured per capita
- Length of pedestrian infrastructure, measured per capita
- Length of bicycle infrastructure, measured per capita

Access to proper data for infrastructural length measures is limited and these indicators have been difficult to obtain, however it is an important topic and therefore have been included in the model for possible future analysis. Values that have been added are collected from the investigation performed in the Municipality Velometer.

Parking charge

Research has found correlation between sustainable cities and cities that have restrictive parking policies (SHIFT, 2012). A potential way for measuring parking policies is to look at the hourly parking charge, especially in the central area since it draws a large number of travellers. If the hourly charge for parking the car is high, the potential outcome is that travellers chose alternative travel options that are sustainable to a higher extent.

This indicator consists of the maximum hourly charge for parking in the municipality's central area, measured in SEK. Data is available through official webpages of the municipalities.

6.3 Traffic volume

Traffic volumes or number of trips can describe movements within the traffic system. In order to reach a sustainable transport system the travel behaviour should change in order to make sure that resource efficient and environmental-friendly options are prioritised. A shift from travel by car to public transport, walking and bicycling contribute to improved sustainability, including improving the technical aspects related to motorised transport, i.e. use of green cars, see table 6.3.

Table 6.3. Final selection of indicators that regards traffic volume.

Traffic volume				
Nr	**Subcategory**	**Nr**	**Indicator**	**Interpretation**
3.1	Modal split	3.1.1	*Share of the total number of trips, by the municipalities inhabitants, that are performed using a sustainable mode (pedestrian, bike or PT)*	*More is better*
3.2.	Journey length	3.2.1	*Share of the total distance travelled, by the municipalities inhabitants, that are performed using a sustainable mode (pedestrian, bike or PT)*	*More is better*
3.5.	Car occupancy	3.5.1	*Car occupancy*	*Less is better*
3.6	Vehicle fleet	3.6.1	*Number of inhabitant per registered car*	*More is better*
		3.6.2	*Share of green cars of the total number of registered vehicles*	*More is better*

Modal split

Assessing the modal split enables an evaluation on how the travel policies of a municipality impacts the inhabitants travel behaviour (SHIFT, 2012). The modal split is the percentage of travellers that use a particular type of transportation. Four modes of transport are included in this study: car, public transit, bicycle and pedestrian, where a low percentage of car travel is preferable since, for example, congestion and emission levels will decrease (TDM Encyclopedia, 2012). Data concerning modal split is gathered through national travel behaviour studies, RVU[3].

Journey length

The annual per capita passenger-km by car is a description of the travel behaviour of city inhabitants as well as the geographic shape of the city (SHIFT, 2012). The indicator helps measure the goal to decrease travel by car and increase travel by sustainable options. The data is obtained from national travel behaviour studies.

Car occupancy

Increased car occupancy is beneficial as it makes travel more efficient (TDM Encyclopedia, 2012). Here the occupancy is calculated with the use of four inputs: average annual journey length per car, average annual journey length per capita, population of municipality and number of cars in the vehicle fleet.

Occupancy formula:

$$Occupancy = \frac{anual\ total\ personkm\ by\ car}{annual\ total\ car-km} = \frac{municipality\ population \times annual\ average\ travel\ distance\ by\ car\ per\ capita}{number\ of\ registered\ cars \times annual\ average\ travel\ distance\ per\ car}$$

A high ratio is desirable as that indicates a high car occupancy ratio. The data is collected from Statistics Sweden.

Vehicle fleet

The vehicle fleet composition is used to indicate the car dependency of a municipality. Data on green vehicle usage indicates attitudes to environmental transportation. Two indicators are used in this subcategory:

[3] RVU (short for Resvaneundersökning) is the Swedish term for travel studies analysing travel patterns of transport users.

- Registered vehicle per capita
- Share of green vehicles of the total vehicle fleet

Data can be obtained through the statistical database *Trafikanalys*[4].

6.4 Accessibility

The shift from mobility-based transport planning towards accessibility-based planning is a cornerstone in order to obtain sustainable transportation, since the transport system should be accessible to all users (Litman, 2012). It has both an economic and a social dimension, since access for goods and people to work places and industrial activities is important in an economic perspective while being able to reach sites and activities for individuals is important in a social perspective (EC, 2004).

Table 6.4. Final selection of indicators that regards accessibility.

Accessibility				
Nr	**Subcategory**	**Nr**	**Indicator**	**Interpretation**
4.1	Journey ratio	4.1.1	*Travel ratio comparison between car travel time and PT travel time. Three large living areas outside the city centre are used as start point. The central station and the largest hospital are used as end point.*	*Less is better*
4.2	Access to basic services	4.2.1	*Share of workplaces that have access to a public transport stop within 1 km*	*More is better*
		4.2.2	*Share of population that lives within 1 km of a grocery store*	*More is better*
4.3.	PT adaption for disabled	4.3.1	*Share of PT vehicles that have low floor*	*More is better*
		4.3.2	*Share of PT vehicles that have audiovisual information system*	*More is better*
4.4.	Affordability	4.4.1	*Cost of monthly network-wide PT pass as the percentage of median gross monthly income*	*Less is better*

Journey ratio

The travel ratio of public transportation in comparison to travel by car enables an evaluation of how attractive the public transport system is in relation to travel by car, since time savings is essential for travellers when choosing travel mode (Quarmby, 1967).

As data concerning travel ratio is difficult to collect, a simplified method has been used. To measure the journey ratio the travel time between two points (A and B) needs to be measured for two modes (car and public transit) and then compared in relation to each other.

The two endpoints are the central station and the largest hospital of each municipality, since they attract many people. The origin of these trips will start in the centre of three city districts, which will in total yield six trips, of which the average ratio is calculated. The city districts are determined by identifying the five highest populated city districts and choosing the three that are the furthest away from the central station. The reason for this is that some distance is required in order to gain accurate results and the central station were in all cases located in one of the highest populated areas and would receive a distance of 0 meters. The travel times have been collected from Google Maps and the city districts of interest are identified from administrative maps

[4] Trafikanalys is a Swedish government owned organisation that supplies data about transportation.

from webpages of the municipalities. Five minutes have been added to the car time to reflect the time it takes to walk to the car and the time it takes to pay for the parking (Lunds Kommun, 2009).

Access to basic services

This sub-category is divided into two indicators:

- Share of workplaces that have access to a public transport stop within 1 km
- Share of population that lives within 1 km of a grocery store

These indicators are part of political transport goals set by the Swedish parliament in 2009 and the result has been presented by the statistical database *Trafikanalys* on an annually basis since then (Trafikanalys, 2013).

Transit adaption for disabled

The transport system must ensure equity for all its users in order to achieve sustainable transportation, therefore the public transport system must adapt its vehicles and stops for disabled people (OECD, 1996). This sub-category is divided into two indicators that both can yield maximum five points, with share of low floors on buses and audio-visual information to aid the users.

Affordability

Affordability refers to the ability for users to pay for the services the transport system offers, where a higher amount of users being able to pay is preferable (EPA, 2011). The data for median monthly income is gathered from Statistics Sweden and the cost for monthly network-wide public transport pass is gathered from the webpages of the bus companies.

6.5 Traffic Safety

In accordance with the European Council's definition of sustainable transportation, the traffic system should provide safety for its intended users, thus the traffic systems functionality and usability should provide a safe system, see the indicator measuring traffic safety in table 6.5.

Table 6.5. Final selection of indicators that regards traffic safety.

Traffic safety				
Nr	**Subcategory**	**Nr**	**Indicator**	**Interpretation**
5.1.	Traffic accidents resulting in severe injury or death	5b	*Traffic accidents resulting in death of serious injury per year and 100 000 inhabitants*	*Less is better*

Traffic accidents resulting in injury

The indicator measure the safety level related to the transport system of the municipality. Number of fatalities and seriously injured travellers is measured per year and 100 000 inhabitants. Values for fatalities and severely injured have been extracted from documents on the webpages of the municipalities.

The Swedish Transport Administration defines traffic accident, (MSB, n.d.); three aspects has to be fulfilled for an accident to be identified as a traffic accident:

- It has to occur on areas that are identified as being part of the road network.

- It has to occur in traffic, defined by two parameters: movement within the road network and including conflict between person and vehicle.
- The accident should involve a defined level of damage.

6.6 Environmental Impact

Transports impact the environment negatively in a number of ways, with greenhouse gases that deteriorate the climate, particulates and noise pollution that affect human health (EC, 2004). This study has selected three indicators that take into account three of these different impacts, see table 6.6. The goal for a sustainable transportation system, from an environmental viewpoint, is to *limits emissions and waste within the planet's ability to absorb them.*

Table 6.6. Final selection of indicators that regards environmental impacts.

Environmental impact				
Nr	**Subcategory**	**Nr**	**Indicator**	**Interpretation**
6.1.	Air emission	6.1.1	Annual CO2 emissions from private vehicles per capita	Less is better
		6.1.2	Annual PM10 emissions from private vehicles per km^2 of urban region	Less is better
6.2.	Exposure to noise	6.2.1	Portion of population exposed to traffic noise >55db L_{den}*	Less is better

*L_{den} – Weighted average daily sound level with reduced values for evening with 5 dB and 10 dB for night.

Air emission

Two indicators have been selected to measure how the transport sector impact air quality:

- Annual CO_2 emissions from private vehicles per capita
- Annual PM_{10} emissions from private vehicles per km^2 of urban region

The first indicator, CO^2 emissions per capita, is a measure of the regional and global impact the transportation system contributes to, since CO^2 is an important greenhouse gas. Within the transport sector passenger vehicles and light-duty trucks is estimated to account for half of the GHG release (EPA, 2013).

The second indicator, PM_{10} emissions per km^2 of urban area, measures the local effects to human health from transportation. "*Increased levels of fine particles in the air as a result of anthropogenic particulate air pollution is consistently and independently related to the most serious effects, including lung cancer and other cardiopulmonary mortality."* (Cohen, 2005)

Both of these indicators have been collected through the national emissions database.

Exposure to noise

Transport noise originating from the movement of transport vehicles affects human health, i.e. increases the risk of heart disease (Rodrigue, 2013). The indicator is measured as; the number of inhabitants per 100 000, that is subjected to a noise level L_{DEN} above 55 dB(A), according to the definition from the European Council that calculates a weighted average sound level where the evening level is reduced by 5 and the night level by 10 (EC, 2002). The data have been collected from documents on the webpages of the municipalities.

7 Model testing

This chapter includes a pilot test of the model on a selection of Swedish municipalities, which will be used to determine if adjustments must be made. The Municipality selection describes what criteria that must be fulfilled for the municipalities and why the specific municipalities have been chosen. In Model results the in-data gathered will be inserted in to the model in order to analyse the results. If the model needs adjustments or if the results are satisfying, this will be discussed in the Recommendations section.

7.1 Municipality selection

As a first step to assess the accuracy of the designed model, a number of municipalities was selected in order to test the model and analyse the results. The selection have primarily been based on population size, whereas a larger population is preferable since the travel demand of a municipality increases with increased population size, resulting in larger impacts from transportation. A secondary reason of selecting a larger municipality was that data gathering was become easier if the municipality is larger[5]. In addition to a selection based on population size, the municipalities have been chosen after geographic and demographic location in Sweden to include the majority of the country (SCB, 2013). The four municipalities that have been selected are listed below:

- Gothenburg 526 000 inhabitants
- Lund 113 000 inhabitants
- Umeå 117 000 inhabitants
- Västerås 140 000 inhabitants

With Gothenburg and Lund representing the western and southern parts of Sweden respectively and Umeå representing the northern parts, the central part are represented by Västerås. However it is important to point out that this first pilot test focuses primarily on obtaining an accurate model rather than analysing the results for each municipality, meaning that this initial selection of municipalities should not be given too much consideration since the model should investigate all larger municipalities in its final stage.

An additional reason for choosing the municipality of Lund, is its participation in EcoMobility SHIFT where the transport system have been analysed and benchmarked, making it possible to calibrate the model with a known reference point. A comparison will be made between results from the model and the results from the SHIFT model to analyse similarities and differences.

During the previously conducted workshop, see chapter 4.3.2., it was concluded that the three largest municipalities in Sweden: Stockholm, Gothenburg and Malmö, are not as relevant to investigate since these municipalities have previously performed similar studies and are well investigated. Therefore the focus has been laid on larger municipalities excluding the three largest ones, which would be the most preferable municipality group to investigate. In contrast to this, Gothenburg was selected in the initial pilot test, primarily to investigate how one of the largest municipalities will perform in the model and to identify differences in the results.

[5] In this report a municipality that is considered large has a population of more than 50 000 inhabitants.

7.2 Scoring

In order to be able to compare the sustainability status of the traffic systems of the municipalities with each other, a method for scoring is essential. The ideal scenario would be to have different levels for each indicator that would yield a certain amount of points if that level were to be reached. However that would require extensive amount of research and as a result, that approach was abandoned.

In this study a relational approach was used to score the municipalities. The municipality that achieved the best value for a certain indicator was given 100 percent, meanwhile the remaining municipalities got a relative percentage relating to the best value.

The method used for calculating percentages is illustrated in table 7.1. Indicators where more is better e.g. *Share of workplaces that have access to a public transport stop within 1 km* was calculated according to the formula seen in the middle column.

Indicators were less is better e.g. *Annual CO2 emissions from private vehicles per capita* was calculated as seen in the column on the right, table 7.1. Again, it is important to point out that maximum score for an indicator does not necessarily imply that it is a preferable value, since the scoring is relative and not absolute.

Table 7.1. Calculating the score.

Value (unit not relevant)	Relation (more is better)	Relation (less is better)
2	$\frac{2}{12} \approx 17\%$	$\frac{1}{\frac{2}{2}} = 100\%$
5	$\frac{5}{12} \approx 42\%$	$\frac{1}{\frac{5}{2}} = 40\%$
9	$\frac{9}{12} = 75\%$	$\frac{1}{\frac{9}{2}} \approx 22\%$
12	12/12=100%	$\frac{1}{\frac{12}{2}} \approx 17\%$

7.3 Weighting of results

To include the fact that not all indicators in the model contribute equally to achieving a sustainable traffic system, each indicator have been assigned a maximum value of a set amount of points to illustrate this, also known as a weighted score. A weighted score is achieved when different indicators or categories in the model are given lower of higher degree of importance, i.e. a good result for indicator *A* is viewed as more important than a good result for indicator *B*. Thus, a weighted result highlights the important indicators, categories or aspects within the model.

The weighting of the score founded on the weighting method used in Eco-Mobility SHIFT, see appendix X, since out of the reviewed programs its performed indicator weighting was the most suitable and comprehendible (SHIFT, 2012). The maximum points for each indicator was multiplied with the percentage for each indicator, which contributed to the total score, see example in table 7.2.

Table 7.2. Example how a weighted score is calculated

Municipality	Indicator value (no unit)	Percentage	Maximum score	Achieved score (no unit)
Göteborg	10	80%	10	8

The weighted score that was assigned for the TRAST aspects, subcategories and indicators, are illustrated in table 7.3.

Table 7.3. Weighted score.

TRAST aspect	TRAST aspect: Score	Subcategory	Subcategory: Score	Indicator	Indicator: Score
City Characteristics	**0**	Population	**0**	*Number of municipality inhabitants*	**0**
				Night and daytime population	**0**
		Area	**0**	*Municipality land area*	**0**
				Urban area	**0**
		Density	**0**	*Inhabitants per km2*	**0**
		Income	**0**	*Income /Average income per capita*	**0**
Traffic system	**40**	Length of infrastructure	**30**	*Length of road network per capita*	**10**
				Length of pedestrian network per capita	**10**
				Length of bicycling network per capita	**10**
		Parking charge	**10**	*Maximum parking charge in central zone of the municipality*	**10**
Traffic volume	**60**	Modal comparison	**15**	*Share of the total number of trips, by the municipalities inhabitants, that are performed using a sustainable mode (pedestrian, bike or PT)*	**15**
		Journey length	**15**	*Share of the total distance travelled, by the municipalities inhabitants, that are performed using a sustainable mode (pedestrian, bike or PT)*	**15**
		Occupancy	**10**	*Car occupancy*	**10**
		Vehicle fleet	**20**	*Number of inhabitant per registered car*	**10**
				Share green vehicles out of the total number of registered vehicle that meets the emission requirements	**10**
Accessibility	**50**	Car/PT journey ratio	**10**	*Travel ratio comparison between car travel time and PT travel time. Three large living areas outside the city centre is used as start point. The central station and the largest hospital is used as end point.*	**10**
		Access to basic services	**20**	*Share of workplaces that have access to a public transport stop within 1 km*	**10**
				Share of population that lives within 1 km of a grocery store	**10**
		Transit adaption to disabled	**10**	*Share of public transportation vehicles that have low floor*	**5**
				Audio or visual information	**5**
		Affordability	**10**	*Cost of monthly network-wide PT ticket as the percentage of median gross monthly income*	**10**
Traffic safety	**10**	Traffic accidents resulting in injury	**10**	*Traffic accidents resulting in death of serious injury per year and 100 000 inhabitants*	**10**
Environmental impacts	**30**	Air emission	**20**	*Annual CO2 emissions per capita*	**10**
				Annual PM10/NO2? emissions per km2 of urban region	**10**

TRAST aspect	TRAST aspect: Score	Subcategory	Subcategory: Score	Indicator	Indicator: Score
		Exposure to noise	**10**	*Portion of population exposed to high levels of traffic noise >55/65 db*	**10**

7.4 Interpretation of results

As stated, each municipality's indicator measure will be compared to the value of the best result for every indicator, meaning that the best indicators as a group will make out a fictive best-in-class municipality that the municipalities are compared to. This will give a measure of what is achievable since the maximum values are gathered from the participating municipalities.

The final score will be a percentage of this fictive best-in-class municipality, with the maximum score of 190 points. It will be possible to identify strengths and weaknesses of each TRAST aspect, with tables displaying TRAST aspects individually.

7.5 Results

The following chapters include the results from the model testing performed on the four pilot municipalities. One aspect regarding the results has to be clarified; the data availability was low at times and as a result the municipality of Uppsala, that was originally supposed to be included as part of the analysis, had to be excluded. However, the data that was gathered from Uppsala is still included in the appendix x.

7.5.1 Compiled results

The final result concludes that Gothenburg performed best in the pilot testing of the model; closely followed by Lund in the second place, see *figure 7.1*. Somewhat detached, point-wise, from the best scoring municipalities are Umeå and Västerås in the third and fourth spot respectively. The top placed municipality Gothenburg was able to gather 152 points, while the bottom placed municipality Västerås gathered 131 points total, a difference of 21 points.

The maximum score, seen in *figure 7.1*, is 190 points, however during the pilot test the potential was lower. The TRAST aspect *Traffic system* had two indicators missing (pedestrian and road length of infrastructure) due to lack of data. The 20 points that were subjected to these two indicators was therefore set as 0 and consequently the true "achievable score" in the pilot testing were in fact 170 points, and not 190 points.

As the table indicates most points is found within TRAST aspects; *Traffic volume* and *Accessibility*; noticeable is that both Gothenburg and Lund shows respectable number in these areas. The largest diversities point-wise, can be seen for *Environmental impacts*, were Lund's score almost doubles that of Västerås.

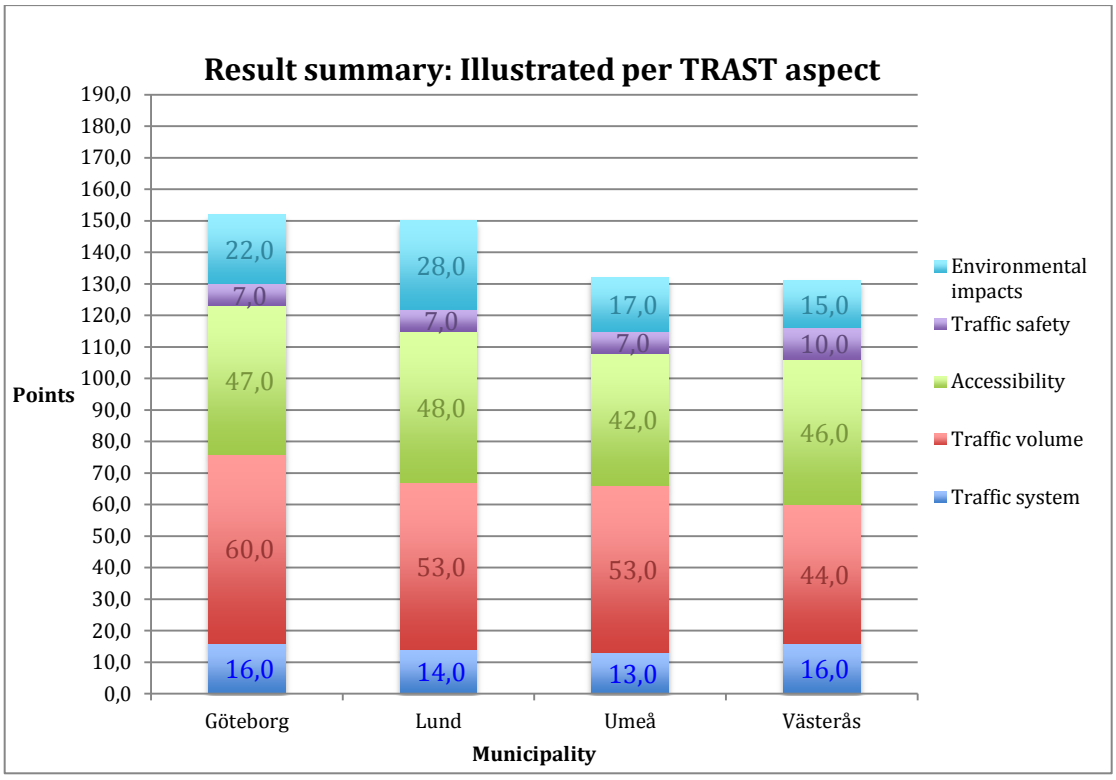

Figure 7.1. Compiled result from the pilot testing of the municipalities. Result is illustrated for the five TRAST aspects.

7.5.2 City characteristics

City characteristic is, as stated, a descriptive and input oriented TRAST aspect. Hence, it was disallowed from the scoring system. The result from city characteristics is not presented here, but can be found in *appendix IV*, together with all input data for the municipalities.

7.5.3 Traffic system

Gothenburg and Västerås share the best result of 16 points for the *Traffic system* aspect, see *figure 7.2*. Lund and Umeå follows closely scoring 14 and 13 points respectively.

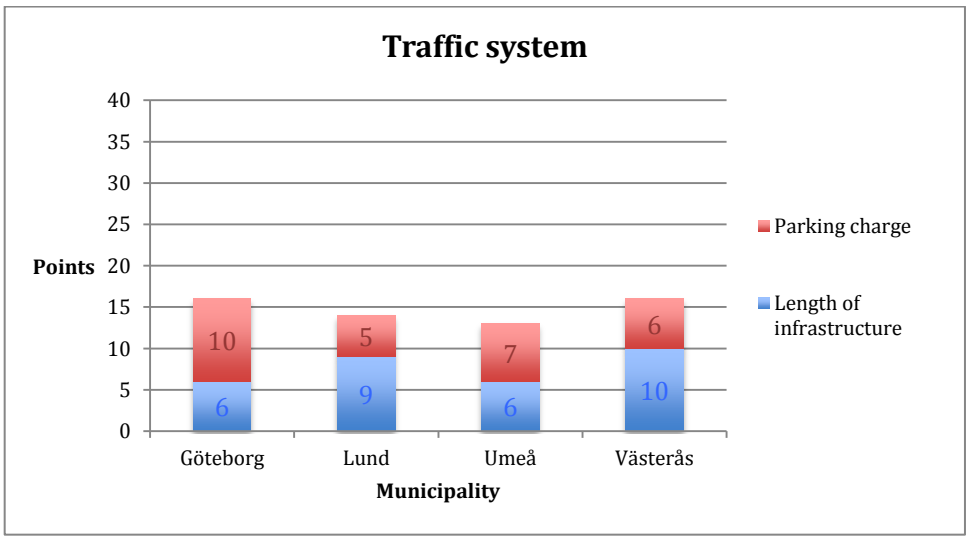

Figure 7.2. Scoring of the subcategories included in traffic system.

Traffic system was measured using four indicators that enabled a 40 point total. However, data concerning *length of road infrastructure per capita* and *length of pedestrian infrastructure per capita* was not found in this evaluation and those indicators were therefore given a score of 0 points. In addition missing from the data was Umeå's data about *length of bicycle infrastructure per capita*, Umeå was given the minimum value of xx m/capita that was the length found in Gothenburg. The minimum score was chosen to avoid underestimation of Umeå's score.

7.5.4 Traffic volume

Gothenburg was the best scoring municipality regarding *Traffic volume;* the municipality gained 60 points, which the maximum point total achievable for *Traffic volume*. Second tiers were Lund and Umeå at 52 and 53 respectively, see *figure 7.3*. In last place Västerås was somewhat detached at only 44 points in total. Västerås had poor numbers regarding its vehicle fleet and journey length; meaning a high ratio of cars per capita, having few green cars and travelling a large share of the per capita distance with unsustainable travel modes.

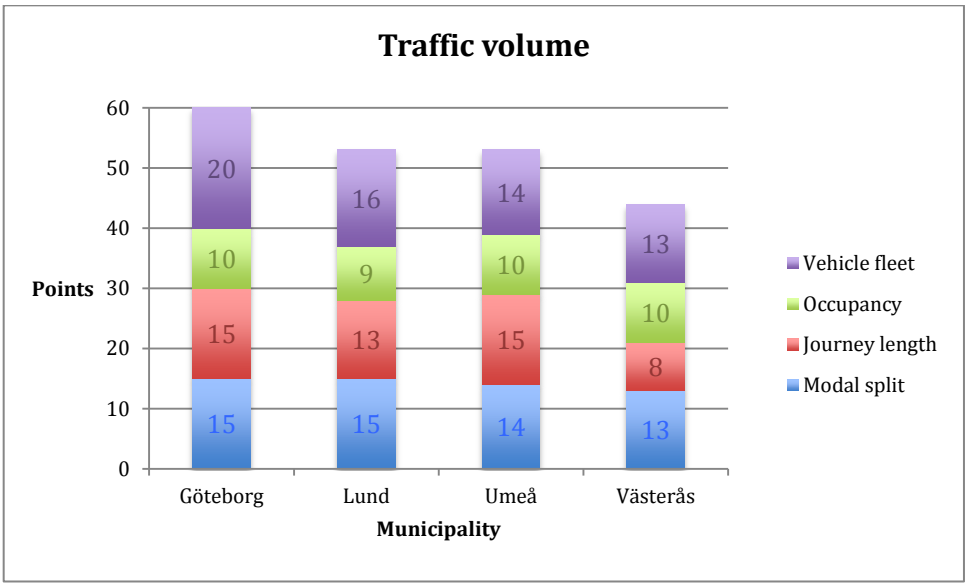

Figure 7.3. Scoring of the subcategories included in traffic volume

Traffic volume is the aspect that has the highest scoring potential with 60 points.

7.5.5 Accessibility

Lund had the highest score for the *Accessibility* aspect, scoring 48 points out of the maximum score of 50 points, see *figure 7.4*. Göteborg and Västerås had similar results as second tiers, scoring 47 and 46 points respectively, while Umeå scored the lowest at 42 points. All pilot municipalities scored high in *Affordability* and *PT adaption for disabled*, however Umeå hade slightly worse results in comparison to competing municipalities in the *Access to basic services* and *Car/PT time ratio* subcategories.

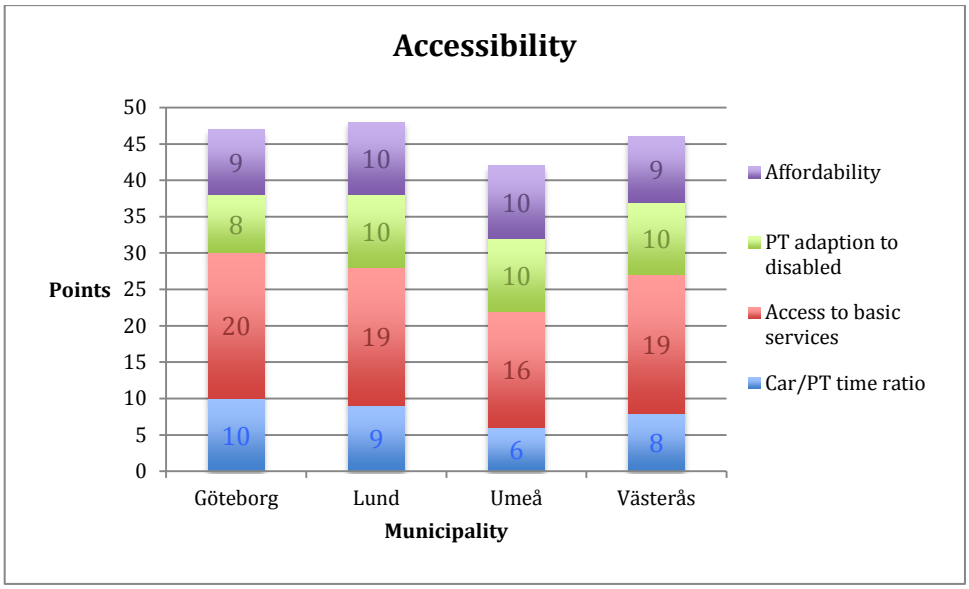

Figure 7.4. Scoring of the subcategories included in accessibility.

7.5.6 Traffic safety

Västerås had the highest score regarding *Traffic safety* giving the maximum score 10 points, see *figure 7.5*. Gothenburg, Lund and Umeå had comparative values and all were given the score of 7 points. For comparison, Västerås had 25 accidents resulting in severe injury or death, while Gothenburg, Lund and Umeå spanned 34 to 38 accidents resulting in sever injury or death, Gothenburg having the highest amount.

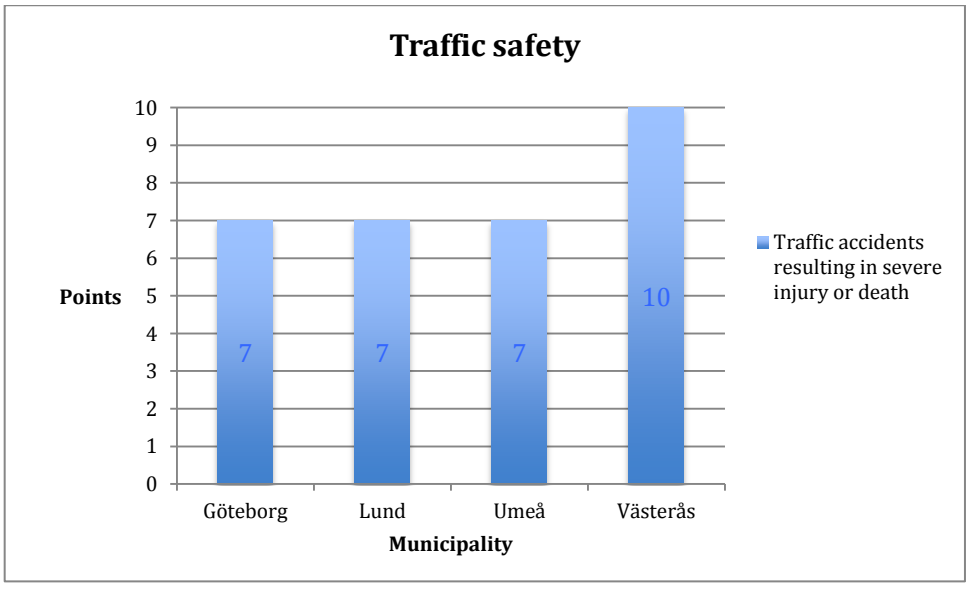

Figure 7.5. Scoring of the subcategories included in traffic safety.

There are certain uncertainties connected to the data gathering of traffic accidents, i.e. there is no easily accessible statistical database that is shared for all the municipalities and the annual follow-up differs among the municipalities. In addition the classification of injuries that are viewed as severe is not transparent, which could lead to misleading results.

7.5.7 Environmental impacts

Lund had the highest score for *Environmental impacts*, achieving 28 points of a maximum 30 points, see *figure 7.6*. Gothenburg finished in second place with 22 points, while Umeå and Västerås were somewhat detached at 17 and 15 respectively. Environmental impacts is the aspect that has the largest difference percentage wise between the highest and lowest score, Lund having almost twice the point total in comparison to Västerås.

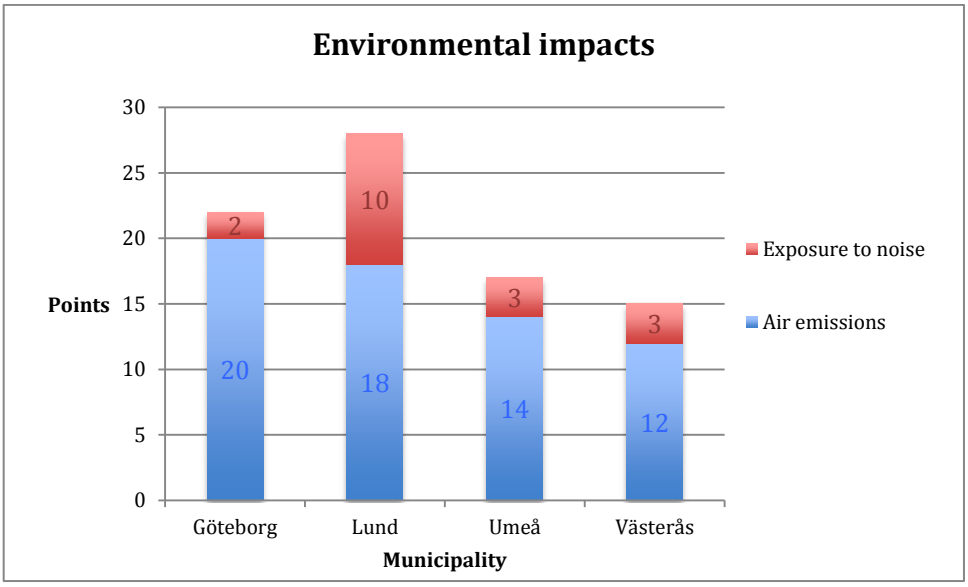

Figure 7.6. Scoring of the subcategories included in environmental impacts.

While the data gathering for the *air emission* subcategory is taken from a shared source, the data regarding *exposure to noise* is not. This is a question mark since the process of how these measuring were performed lacks transparency.

8 Discussion and recommendations

The discussion and recommendation have been divided to address three matters. First follows a discussion regarding the result of the model testing, highlighting concerns that became apparent when the test was performed. The second discussion subject concerns the overall model approach and how the result was evaluated….

8.1 Results from testing

The general output gained from the testing was illustrated for each TRAST aspect, some concerns regarding the result was made apparent while the data was gathered and put into the model. The following discussion will highlight these concerns for all TRAST aspects.

While *city characteristics* had no impact on the final score, the indicator themselves matters. An interesting question is: Is it possible to compare a city of 500 thousands inhabitants to one of 100 thousands inhabitants? For example when comparing *length of bicycle infrastructure per capita* Gothenburg scores the worst out of the municipalities, however does this mean that the bicycle network of Gothenburg is less than the competing municipalities or is it rather a consequence of Gothenburg having a higher population density which enables people to share bicycle paths to a higher degree than the other municipalities. Similar concerns can be lifted for other indicators as well.

The results found for *traffic systems* were imperfect due to lack of data. Especially hard to gather was data concerning infrastructural lengths. There is no publicly open database that supplies these data, however infrastructural measures are gathered within the municipalities. The knowledge that municipalities do gather those essential data inputs should be taken into account, one alternative is to involve the municipalities in the data gathering, i.e. by the use of a questionnaire. Here employees from each municipality could be asked to fill in important data gaps.

Gathering data for the TRAST aspect *traffic volume* was possible to a higher degree than for *traffic system*. However, for the indicator *occupancy* a simple formula was used to calculate the result. One issue using this approach was that the inputs for the calculations were gathered from a number of sources. This could increase the likelihood of errors occurring.

The indicator *journey ratio* used to measure *accessibility* is difficult to validate since the production of the results were based on a small number of data inputs. However, since the process of producing these results were time consuming a small sample size were viewed as better in relation to no result at all. The method however should be overlooked going forward, i.e. the method do not take into account the distance between starting point and end point of the evaluated stretches, which may affect the final outcome. Also missing from the evaluation was the trip frequency of the public transportation system, which is a vital attraction when an inhabitant chooses between the modes car and public transport.

Similarly to *traffic system*, the data related to *traffic safety* were difficult to gather. Especially current data was problematic to get hold of; consequently some of the results were not up to date while being put into the model. Another issue was the transparency of how a severe traffic accident is classified. If municipalities have different classification systems the result is not comparable. In addition, since accident data fluctuate from year to year the ideal data would be a average over a period of time,

however since the data accessibility was low this was not possible, which lowers the quality of the inputs. Data on *traffic safety* could, similarly to *traffic system*, be gathered directly from the municipalities through a questionnaire. Here the municipalities could also be given the chance to comment on the classification system used for accidents.

Data concerning *environmental impacts* had some issues, i.e. the noise exposure data from Lund, the municipality that achieved the best score, is potentially measure in a different way than the rest of the municipalities. Göteborg, Västerås and Umeå states that the measurement was performed as L_{den} while Lund does not. If Lund's measurement method does not match the other municipalities' method the result should be re-evaluated. The fact that Lund's performance was, by a wide margin, better than the other municipalities rises suspicion. Regarding air emissions the biggest concern is subjected to the indicator that concerns PM10 emission. The emission levels were compared per square km of urban region, how this effects the result should be reviewed further in the future.

An overall concern that is connected to the results is that the year for which data was obtained varies quite significantly. In this study, no specific data year has been set as a requirement, since the accessibility of the data have been a central focus point. However, ideally the data input would be drawn from the same year, as results change year to year depending on the efforts put in by the municipalities. If achieved it would be easy to analyse result trends, comparing previous rankings to later ones.

The accessibility and availability of data have been the denominating factor that has limited the design of the model the most, since the data must be available for every municipality in order for the results to be comparable. To improve the model in terms of data gathering and reliability, a possible solution could be to send out surveys for municipalities to fill in the data that have been difficult to collect. A sent out survey would be a simple implementation that would not require significant effort by the municipalities. Primarily this refers to the indicators that describe the traffic system in terms of infrastructure lengths and traffic safety in terms of fatalities or severely injured caused by traffic.

8.2 Model approach

At present it is difficult to distinguish the validity of the gained result from the pilot testing, since there are no authentic values to compare the result against. One potential concern is the number of indicators that make up the model: Is 19 indicators in fact too few to give an overall indication of the sustainability of a municipality's passenger transportation system. Then again this is a discussion on how advance the model can be and still be viewed as easily adaptable. If too many indicators were to be included the data gathering would grow rapidly and the adaptability would suffer.

To be able to evaluate validity the result from the pilot testing, the outcomes should be compared to the results gained from more advanced programs, such as SHIFT. However, this EU-founded programs are currently being launched and only a few selected municipalities around the EU have been analysed as of yet. However if a number of Swedish municipalities were to be analysed by these programs in the future, the results could then easily be compared and additional conclusions could be drawn.

One interesting comparison that is possible at this stage is the one with Kommunvelometern. Kommunvelometern has evaluated a number of municipalities' sustainability performance, focusing only on bicycling. Three out of four municipalities that was

included in this pilot testing has also been analysed in Kommunvelometern and what is interesting is that Gothenburg and Lund that got a high score in the pilot testing also scored high in Kommunvelometern's study. Meanwhile Västerås scored significantly less, also matching the outcomes establish by the model testing. If this is an indication that the model can rank the sustainability level of the municipalities can be disputed, at the least it does not undermine the result.

The sample size of the study can be discussed as only five municipalities have been analysed in the test of the model. The accuracy of the model's result is heavily influenced by the performance of the best in-class values for every indicator. If more municipalities would participate there would be a more accurate distribution of the results compared to the best-in-class value for each indicator and the high and low values of the study would better indicate the best and worst scores for each indicator.

The number of indicators each TRAST aspect involves has affected the final results since nearly all indicators are worth ten points each. This has resulted in difference in point distribution among the TRAST aspects. For instance *accessibility* which is a rather general topic that has six indicators resulting in 50 points, while *traffic safety* which is more specific only have one indicator that gives maximum ten points. However the distribution of points have been designed for indicators since the weighted score for all contribute to the final percentage regardless of which TRAST aspect the indicator matches. Since the selection of subcategories and indicators are largely based on how common they are in other sustainability initiatives, the hope is that the most important indicators and TRAST aspects are highlighted as a result of the selection.

By choosing the TRAST framework approach, the other approaches were neglected. However if possible a mix of framework approaches may contribute to a model that is more comprehendible. One approach that could be implemented fairly easily is the *IOO* framework, since the TRAST aspects can already be divided as either an input, output or outcome aspects. *City characteristics* and *traffic system* matches the definition for inputs, *traffic volume* and *accessibility* matches the definition of outputs, while *traffic safety* and *environmental impacts* matches the definition of outcomes. By relating the TRAST aspects to the *IOO* framework the model highlights the function different indicators has in the traffic network.

8.3 Scoring method

At present, an indicator that receives the highest score for a specific indicator does not implicitly mean that it is a preferable value, only that it is better in comparison to other municipalities. A potential improvement of the model would be to conduct an absolute comparison rather than a relative comparison. The function of the absolute comparison is that set key values for each indicator represents the required result that needs to be reached for an indicator value to be viewed as good. Another advantage with an absolute scoring method is that it enables conclusion regarding the municipalities' results being sustainable or not. The initial objective of this study was to present a model that could measure the sustainability but such in detail evaluation of every single indicator was too advanced to achieve at this early stage of the model.

Since with an absolute comparison, it is possible to determine at what level sustainability is achieved, a further model development could be to include different certificates that is awarded to municipalities that have performed well in the testing. With certificates, for example Gold, Silver and Bronze, awarded for achieving different

sustainability levels municipalities could highlight their progress of having a sustainable transport system. Handing out certificates is also known as benchmarking of the result. A benchmarking system could also become an encouragement for municipalities to score high in the program. Kommunvelometern is a good program example where the result is available to the public and therefore puts pressure on municipalities that score badly in the program

8.4 Summary of recommendations

- Data gathering by direct contact with the municipalities, e.g. a questionnaire
- Make a more extensive model testing, including a larger number of municipalities
- Compare the results to results from more advanced models
- Enable an absolute comparison of the results instead of a relative comparison
- Benchmark result by handing out certificates to municipalities that have reached certain scores
- Observe databases that are not free of charge to see if more advance data can be assembled
- Combine the TRAST framework with the IOO framework to further highlight the indicators and how they function in traffic system

9 Conclusion

This study set out to build a model that could measure the sustainability achieved within the passenger transport system. The model should be a simplified one; meaning that data gathering and number of indicators should be kept to a minimum. The question was:

- Is it possible to build a robust model, or prototype of a model, that could succeed on does requests?

As a first prototype, the model that has been presented in this study can rank the municipalities' performance in relative terms. However, the current scoring system has to be changed, if the goal is to measure the sustainability level that each municipality's passenger transportations system has achieved in absolute terms. Going forward, the recommendation is that absolute values are evaluated and incorporated into the model.

The robustness of the model was hard to validate. Currently no similar analysis has been performed and therefore no comparison of the result can be made to existing data. Another issue about the sturdiness of the model was concerns the number of indicators; is nineteen indicators enough to give a good indication of such an advance system? Ideally the results can be compared to more advance models in the future, drawing new conclusions on the matter.

The accessibility and availability of data have been the denominating factor that has limited the design of the model the most, since the data must be available for every municipality in order for the results to be comparable. The work method to gather data should be altered going forward. Two alternatives should be overseen:

- Questionnaires is sent out to municipalities to gather data that is otherwise difficult to collect
- Value the data that is accessible thorough databases that are not closed to the public. Reliable data would greatly contribute to enhancing the model.

The indicator selection can be altered if needed. However, in this study the idea was that the most common indicators should be used.

10 Bibliography

Banister, D., Stead, D., Steen, P., & Åkerman, J. (2000). *European transport policy and sustainable mobility.* London: E & FN Spon.

Broken, J., Ceuster, G., Burgess, A., & Herbruggen, B. v. (2005). *Annex XXVII of ASSESS.* EC.

Bureau of Infrastructure. (2012). *Traffic Growth: Modelling a Global Phenomenon.* Canberra: Department of Infrastructure and Transport.

Department of transportation. (2008). *Transport statistics Great Britain.* Department of transportation.

Dobranskyte-Niskota et al. (2007). *Indicators to Assess Sustainability of Transport Activities: Review of the Existing Transport Sustainability Indicators Initiatives and Development of an Indicator Set to Assess Transport Sustainability Performance.* Luxembourg: Joint Reseach Centre.

EC. (2002). *DIRECTIVE 2002/49/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 June 2002 relating to the assessment and management of environmental noise.* THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION,.

EC. (2004). *Operationalising Sustainable Transport and Mobility: The System Diagram and Indicators.* Directorate General for Energy and Transport.

EC. (2009). *Transport and the Environment.* Belgium: European Comission.

EPA. (2011). *GUIDE TO SUSTAINABLE TRANSPORTATION PERFORMANCE MEASURES.* Pittsburgh: ICF International.

EPA. (1996). *Indicators of the Environmental Impacts of Transportation: Highway, Rail, Aviation, and Maritime Transport.* Policy, Planning, and Evaluation. United States Environmental Protection Agency.

EPA. (2013, 04 22). *www.epa.gov*. Retrieved 05 10, 2013 from http://www.epa.gov/climatechange/ghgemissions/sources/transportation.html

European Comission. (2012b). *What are the consequences of climate change?* Retrieved 01 30, 2013 from CLIMATE ACTION: http://ec.europa.eu/clima/policies/brief/consequences/index_en.htm

European Comission. (2012a). *What's causing climate change?* Retrieved 01 30, 2013 from CLIMATE ACTION: http://ec.europa.eu/clima/policies/brief/causes/index_en.htm

European Commission. (2000). *Transport and environment: Statistics for the Transport and Environment Reporting Mechanism (TERM) for the European Union.* Luxembourg: Office for Official Publications of the European Communities.

FAO. (1999). *www.fao.org*. Retrieved 02 25, 2013 from Food and Agriculture Organization of the United Nations: http://www.fao.org/ag/againfo/programmes/en/lead/toolbox/Refer/EnvIndi.htm#psr

Gemzøe, L. (2011). *Menneskevenlige, bæredygtige byer.* Mölndal: Gehl Architects.

Gilbert, R., & Tanguay, H. (2000). *SUSTAINABLE TRANSPORTATION PERFORMANCE INDICATORS PROJECT: BRIEF REVIEW OF SOME RELEVANT*

WORLDWIDE ACTIVITY AND DEVELOPMENT OF AN INITIAL LONG LIST OF INDICATORS. The Centre for Sustainable Transportation. Ontario, Canada: Environment Canada and Transport Canada.

Gröna Bilister. (2012). *Gröna Bilisters Kommunranking 2012: Poängsättningsmall.* Stockholm: Gröna Bilister.

Gudmundsson, H. (2007). *Sustainable Mobility and incremental change – some building blocks for IMPACT.* Danish Transport Research Institute.

Gudmunsson, H. (2008). *Sustaianble Mobility and incremental change- Some building blocks for IMPACT.* TransportMistra.

Gudmunsson, H., & Joumard, R. (2010). *Indicators of environmental sustainability in transport.* Lyngby: Technical University of Denmark, Dept of Transport.

Johansson, R., Nilsson, L., & Wendl, B. (2011). *Trast-guiden: Arbetsprocess för kommunens trafikstrategi.* Stockholm: Sveriges Kommuner och Landsting, Trafikverket.

Litman, T. (2006). Issues in sustainable transportation. Victoria: Victoria Transport Policy Institute,.

Litman, T. (2006). *Issues in sustainable transportation.* Victoria: Victoria Transport Policy Institute,.

Litman, T. (2006). *Issues in sustanable transportation.* Victoria: Victoria policy transport institute.

Litman, T. (2012). *Well Measured - Developing Indicators for Sustainable and Liveable Transport Planning.*

Lucas, K., & Markovich, J. (2011). *The Social and Distributional Impacts of Transport: A Literature Review.* Oxford: University of Axford.

Lunds Kommun. (2009). *resejamforaren.* Retrieved 05 11, 2013 from http://kartor.lund.se/resejamforaren/start.htm

Mattsson, C. (2011). *Cykelfrämjandets Kommunvelometer 2011: En granskning och jämförelse av kommunernas satsningar på att öka cykling och göra cykling säkrare och mer attraktivt.* Koucky & Partners AB. Cykelfrämjandet.

MSB. (n.d.). *Samhällets kostnader för vägtrafikolyckor: Beräkningar.* MSB.

Neergaard, K., Rye, T., & Vleugels, I. (2011). *Definition of EcoMobility criteria for labelling and setting up of Quality Management System: Task 3.1 -Review of current labelling and quality management schemes.* EcoMobility SHIFT.

Notteboom, T., & Rodrigue, J. P. (2013). *The Geography of Transport Systems.* New York: Routledge.

OECD. (2002). *Guidelines towards Environmentally Sustainable Transport.* Paris: OECD.

OECD. (1999). *INDICATORS FOR THE INTEGRATION OF ENVIRONMENTAL CONCERNS INTO TRANSPORT POLICIES.* Organisation for Economic Co-operation and Development. Paris: OECD.

OECD. (2010). *Reducing transport greenhouse gas emission: Trends & Data.* Leipzig: International Transport Forum.

OECD. (1996). *Towards Sustainable Transportation.* Vancouver.

Office of the Auditor General of Canada. (2003). *Road transportation in urban areas: Accountability for reducing green house gases.* Ottawa: Minister of Public Works and Government Services of Canada.

Quarmby, D. (1967). *Choice of journey mode for the travel to work: Some findings.* Leeds: University of Leeds.

Roberts, S., & Taylor, N. (2004). *Review of the Common Indicators from the Urban Transport Benchmarking Initiative.* Directorate General for Energy and Transport. European Commission.

Rodrigue, J.-P. (2013). *The Geography of Transportation Systems* (Third edition ed.). New York, U.S.: Routledge.

Roughton, C., Hengel, D., & Weigand, L. (2012). *CREATING WALKABLE + BIKEABLE COMMUNITIES: A user guide to developing pedestrian and bicycle master plans.* Center for Transportation Studies. Oregon: Portland State University.

SCB. (2013, 02 20). *www.scb.se*. Retrieved 05 20, 2013 from www.scb.se/pages/tableandchart____350652.aspx

SHIFT. (2012). *Indicator Description.* ICLEI.

Siemens. (2009). *Sustainable Urban Infrastructure: Vienna Edition – Role Model for Complete Mobility.* Industry Sector, Mobility Division. Wünsch, Neumarkt: Siemens AG.

TDM Encyclopedia. (2010, Feb 17). (Victoria Transport Policy Institute) Retrieved Mars 10, 2013 from http://www.vtpi.org/tdm/tdm67.htm

TDM Encyclopedia. (2012, 02 22). *Carsharing Vehicle Rental Services That Substitute for Private Vehicle Ownership*. Retrieved 04 27, 2013 from http://www.vtpi.org/tdm/tdm7.htm

The Centre for Sustainable Transportation. (2002). *Definition and vision of sustainable transportation.* Mississauga.

Toth-Szabo, Z., & Várhelyi, A. (2011). *Measuring sustainability of transport in the city – development of an indicator-set.* Traffic & Roads, Department of Technology and Society. Lund: Lund University.

Trafikanalys. (2013, 4). *www.trafa.se*. Retrieved 5 2, 2013 from http://www.trafa.se/sv/malportal/Transportpolitiska-mal/

UBC. (2011, Feb 16). *The University of British Columbia*. Retrieved Feb 24, 2013 from http://transportation.ubc.ca/transportation-office/sustainable-transportation/

Wee, B. v., Boon, W., & Geurs, K. (2009). *Social Impacts of Transport: Literature Review and the State of the Practice of Transport Appraisal in the Netherlands and the United Kingdom.* Bilthoven: Routledge.

Victoria Transport Policy Institute. (2011). *Sustainable Transportation and TDM*. Retrieved 01 30, 2013 from TDM Encyclopedia: http://www.vtpi.org/tdm/tdm67.htm

World Commision On Environment and Development. (1987). *Our Common Future.* Oxford: Oxford University Press.

World Commission on Environment and Development. (1987). *Our Common Future aka. Brundtland Report.* Oxford: Oxford University Press .

APPENDIX I

- Review of schemes relevant to sustainable transportation/mobility

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The review each sustainable transportation scheme includes:

- Framework and indicator presentation, illustrated through tables;
- Focus of framework/kinds of indicator;
- Short explanation of the aim and background of each scheme;
- Information regarding founding organisation and workgroup;
- Reference to source material;

Presented in alphabetical order, the review includes the following schemes:

1. Comprehensive Sustainable Transportation Indicators
2. Gröna Bilister (Swedish for Green Drivers)
3. HASTA
4. Indicators for the Integration of Environmental Concerns Into Transport Policies
5. Indicators of the Environmental impacts of transportation
6. Indicators to Assess Sustainability of Transport Activities
7. Kommunvelometern (Swedish for Municipality velometer)
8. Non-motorized transport performance indicator
9. Performance Indicators for Transport
10. SHIFT
11. Siemens Complete Mobility Index
12. STPI
13. TERM
14. TRAST
15. Urban Transport Benchmarking Index

1 Comprehensive Sustainable Transportation Indicators

Scheme name:
Comprehensive Sustainable Transportation Indicators
Reference:
Issues in sustainable transportation - Todd Litman (2006)
Initiators:
Todd Litman, Victoria Transport Policy Institute

Aim and Objective
The indicators recommended by Litman are a suggestion of indicators to measure sustainable mobility as comprehensively as possible, taking into account all sustainability goals and objectives regarding transportation.
Background
Litman is the founder and executive director of Victoria Transport Policy Institute, a Canadian independent research organisation that works with developing innovative solutions to issues in transportation.
Description
The Comprehensive Sustainable Transportation Indicator framework uses the triple-bottom line approach.
Benchmarking
The indicator framework is only a suggestion and therefore does not use benchmarking.

Table 10.1

Category	Indicator	Direction
Economic		
Accessibility - commuting	Average commute travel time	Less is better
Accessibility - land use mix	Number of job opportunities and commercial services within 30-minute travel distance of residents	More is better
Accessibility - smart growth	Implementation of policy and planning practices that lead to more accessible, clustered, mixed, multi-modal development	More is better
Transport diversity	Mode split: portion of travel made by walking, cycling, rideshare, public transit and telework	More is better
Affordability	Portion of household expenditures devoted to transport by 20% lowest-income households	Less is better
Facility costs	Per capita expenditures on roads, traffic services and parking facilities	Less is better
Freight efficiency	Speed and affordability of freight and commercial transport	More is better
Planning	Degree to which transport institutions reflect least-cost planning and investment practices	More is better
Social		
Safety	Per capita crash disabilities and fatalities	Less is better
Health and fitness	Percentage of population that regularly walks and cycles	More is better
Community liveability	Degree to which transport activities increase community liveability	More is better
Equity - fairness	Degree to which prices reflect full costs unless a subsidy is specifically justified	More is better
Equity - non-drivers	Quality of accessibility and transport services for non-drivers	More is better
Equity - disabilities	Quality of transport facilities and services for people with disabilities	More is better
Non-motorised transport planning	Degree to which impacts on non-motorised transport are considered in transportation modelling and planning	More is better
Citizen involvement	Public involvement in transport planning process	More is better
Environment		
Climate change emissions	Per capita fossil fuel consumption, and emissions of CO2 and other climate change emissions	Less is better
Other air pollutions	Per capita emissions of conventional air pollutants	Less is better
Noise pollution	Portion of population exposed to high levels of traffic noise	Less is better
Water pollution	Per capita vehicle fluid losses	Less is better
Land use impacts	Per capita land devoted to transportation facilities	Less is better
Habitat protection	Preservation of wildlife habitat	More is better

Resource efficiency	Non-renewable resource consumption in the production and use of vehicles and transport facilities	Less is better

2 Green Motorists

Scheme name - Gröna Bilister
Reference
Gröna Bilister Poänsättningsmall 2012
Initiators
Gröna Bilister
Aim and Objective
The municipality ranking of Gröna bilister (transl: Green car drivers) is a nationwide assessment of the progress towards reducing the environmental effects from car use in municipalities. The purpose of the municipality ranking is to encourage municipalities into greater efforts in the shift towards sustainability and give them the opportunity to compare with other municipalities. This comparison will highlight municipalities with good results that will function as an inspiration for other municipalities to follow.
Background
The organisation Gröna bilister, founded in 1994 with support from the Swedish Society for Nature Conservation (Naturskyddsföreningen) and World Wildlife Fund WWF, works with making the development of car-traffic environmentally friendly. The organisation have identified three needs in order to achieve an environmentally friendly car traffic:

- The need to change from fossil fuels to renewable fuels with less impact on the climate
- The need of more energy efficient transports regardless of fuel type
- The need to reduce the total transport volume

The municipality ranking have been funded by the Swedish Transport Administration (Trafikverket).
Description
The framework is mode-specific since it only focuses on the car transport of a municipality and the topics in the framework are of the main category theme. The maximum score is 100 points divided into seven different categories, spanning from 28 to two points.
Benchmarking
The tool uses benchmarking.

Table 10.2

Dimension	Category	Indicator
Cars of the municipality	The car park of the municipality	Average fossil carbon dioxide emissions per kilometre from the registered private car vehicles of the municipality [g/km]
	Procurement requirements for cars of the municipality	Requirements on green car at purchase or leasing (4 p), Procurement policy priorities renewable fuels or electricity (1 p), Other environment-related requirements are made according to the procurement criteria of the council of environment guidance (Miljöstyrningsrådet) at the level "Advance"(2 p), The requirements above include both municipality and municipal companies (1 p)
The car usage of the municipality-employed	Requirements to drive renewable	For municipal cars that can be run on one or more renewable fuels the requirement is that at least 50-70 % of the mileage is run on any of these fuels
	Sustainability requirements on fuels	The municipality requests or demands environmental and social sustainability beyond legal requirements (1 p), The requirements include both renewable and fossil fuels (1 p), The municipality possesses electric cars and make sure these are run on environmentally certified electricity (1 p)
	Energy consumption	Display of declining energy usage in their cars by comparison between the second last and the last year where statistics are available (2 p), Compilation of statistics is performed for earlier mentioned indicator but the energy usage is rising (1 p), The actual energy consumption per mileage is 6 kWh or less (2 p), Compilation of statistics is performed for earlier mentioned indicators but exceeds 6 kWh (1 p)

	Travel policy	The municipality has a travel policy with clear priority towards 1) bicycle and walking, 2) telephone or video conference, 3) Rail bound public transport (1 p), A travel policy of this kind is applied on all departments (1 p)
	Virtual meetings	The municipality offers opportunities for video conferences or virtual meetings and have held these the last year
	Company car pool	There is a company car pool (1 p), Access to the company car pool exists at more than one department (1 p), With a central booking system (1 p), All municipal car pools only contains green cars (1 p)
	Economic driving	Any part of the personnel have undergone education in economic driving the last two years (1 p), A larger program for education in economic driving have been conducted the last two years or are under progress (1 p)
	ISA: Intelligent systems for automatic speed adaptability	Intelligent support for adaption of speed (ISA) have been used in a pilot project or have been installed permanently in a number of vehicles
	Climate compensation	The municipality climate compensate its road trips (1 p), It is in accordance with the recommendations of the Energy Authority (Energimyndigheten) (1 p)
	Company bicycles	There is access to a larger company bicycle pool with a central booking system
	Own car while working	It is prohibited to use a private car on duty
	Benefit cars	The municipality offers no benefit cars or only benefit cars that are green cars
Procured transportation services	Passenger transport	100 % green vehicles is required of all passenger transports (12 p), Control towards green cars is paired with requirements that at least 50 % of the mileage is run on renewable fuels or electricity (2 p), Active control towards that contractors should use green cars that can be run on renewable fuels (1 p)
	Other transports	The municipality actively controls towards that green cars should be used on other missions that includes transports
Car-usage of the public	Parking benefits	The municipality offers free parking only for cars that can be run on a renewable fuel of electricity and accepts several fuels of that kind (4 p), For a car that can be run on a renewable fuel it is required that at least 50 % of the mileage is run on a fuel of that kind (1 p)
	Public car pools	Access to the carpool exists for the public (2 p), The municipality allows the public access to cars in evenings and weekends from an internal municipal pool in cooperation with an external party (1 p), The municipality actively works for the car pool business to be initiated or expanded (1 p)
	Ridesharing and commuting	The municipality facilitates car sharing and commuting
Access to renewable fuels	Refuelling opportunities	Public refuelling places exist for two or more renewable fuels (4 p), More than one public place exist for more of these fuels (2 p), Public charging stations for electricity cars exist (2 p)
	Production of renewable fuels	The municipality contributes to production of a renewable fuel within the boundaries of the municipality or in the vicinity, or contributes to an initiated production project
	Waste digestion	The municipality collects organic domestic waste for digestion to biogas for vehicle use (2 p), The municipality collects organic waste from other activities for digestion to biogas for vehicle use (1 p)
New car sales	New car sales	The share of green cars in the new car sale is larger than 50 % (2 p), The average carbon dioxide emissions are less than 120 g/km (2 p)
Air quality	Air quality	The environmental quality standards for NO2 regarding hourly, daily and yearly mean values are met (1 p), The environmental quality standards for particles PM10 regarding daily and yearly mean values are met (1 p)

3 HASTA

Scheme name
HASTA
Reference
Measuring Sustainability. Toth-Szabo (2011)
Initiator
Transport and Roads, Department of Technology and Society, Faculty of Engineering at Lund University

Aim and Objective
The aim of the tool developed by HASTA is to aid municipalities to make progress towards sustainability at present and to construct a policy that motivates investments for sustainability today and in the near future. The purpose is to achieve a balance between the three dimensions of sustainability, obtained by the priorities the municipalities make, thus giving a municipality that is both sustainable and attractive. This is done by utilising sustainability indicators, defined by HASTA, that are both relevant and measurable in order to describe the different dimensions of the sustainable and attractive city. The results from the visualisation tool applied on the municipalities makes it possible to evaluate, monitor and compare the sustainability level regarding transportation of each municipality; as well it clarifies development trends and identifies strengths and weaknesses.
Background
HASTA (Hållbar Attraktiv Stad, transl: Sustainable Attractive City) is a framework project performed by Transport and Roads, the Department of Technology and Society, the Faculty of Engineering at Lund University. It focuses its research on different aspects of the city, such as safety, accessibility, environment and security. The vision of HASTA for the sustainable and attractive city is that it satisfies the different needs for its population, without jeopardising the needs of future populations. The framework project is funded by Vinnova the Swedish Governmental Agency for Innovation Systems, SKL (Sveriges Kommuner och Landsting, transl: Swedish Association of Local Authorities and Regions) and the Swedish Transport Administration.
Description
HASTA uses the triple-bottom line approach completely when categorising its indicators, in addition with seven sub-categories. The indicators are ranked hierarchically after what type they are, from highest to lowest: outcome, output and input. The tool includes subjective indicators from user surveys with equally important significance as the objective measureable indicators.
Benchmarking
Benchmarking is performed individually for each municipality with the desired value as 100 percent.

Table 10.3

Category	Indicators	Unit
ECONOMY		
Efficiency	Annual tonne-km on the municipalise road network per average annual cost for the network	Tonne-km/SEK
	Annual number of public transport passenger-km within the municipality per average annual cost for the PT traffic system of the municipality	PT passenger-km/SEK
	Share of businesses and public organisations that are pleased with the transport system	%
Accessibility (Industry)	Quota of average travel time between sustainable transport modes and car to/from work for the work-able population	%

	Share of work-able population that is pleased with the transport system regarding travels to and from work	%
SOCIAL		
Accessibility (Individual)	Share of person-km with sustainable transport modes of total number travels	%
	Share of the population that is pleased with the transport system regarding non-work related travels	%
Safety	Risk of personal injuries	Severely and fatally injured per 1000 inhabitants
	Share of populations that feels safe in the traffic (free from accident risk)	%
Liveability	Share reported assaults that occurred in the transport system per year per person-km	Reported assaults/million person-km
	Share of population that feels safe from assaults in the transport system	%
	Share of children that travels to school with other transport modes than car	%
	Share of population that is pleased with the transport-related public spaces regarding convenience, cleanness and aesthetics	%
ENVIRONMENTAL		
Emissions	Annual carbon-dioxide emissions from traffic	Tonne/inhabitant
	Share of population that does not feel bothered by traffic-related air pollutions close to their homes	%
	Share of population that lives in an area where outdoor noise does not exceed 55 dbA	%
	Share of population that does not feel bothered by traffic-related noise close to their homes	%
Resource usage	Land usage for the road and transport network of the municipality of the total area of the municipality	%
	Share of population that thinks that the transport-related areas are appropriate in relation to the total area of the municipality	%
	Share of renewable amount of energy of the total annual sold amount of energy for transport in the municipality	%
	Share of population that thinks it is affordable to use renewable fuels	%

4 Indicators for the Integration of Environmental Concerns Into Transport Policies

Scheme name:
Indicators for the Integration of Environmental Concerns Into Transport Policies
Reference:
OECD 1999 – Indicators for the Integration of Environmental Concerns Into Transport Policies
Initiators:
Organisation for Economic Co-operation and Development (OECD)

Aim and objectives
The purpose of the indicator framework from OECD is to highlight and encourage the integration of environmental issues and concerns in the transport policy process and decision-making. The indicator set should fulfil these objectives as well:

- *Highlight the interface between transport activities and environmental issues, and identify how different driving forces and policy instruments interact and affect the environmental impacts of transport; and*
- *Provide a basis for monitoring the integration of environmental concerns into transport policies.*

Background
The indicator program is a part of the OECD work program regarding environmental indicators. It is continuing on previous works performed by OECD, in particular by updating the OECD Environment Monograph Indicators for the Integration of Environmental Concerns into Transport Policies from 1993.
Description
The indicator program uses the adjusted Triple-bottom line approach with three dimensions named; Sectorial trends and Environmental significance, Interaction with the Environment and Economic and Policy aspects.
Benchmarking
The tool does not use benchmarking.

Table 10.4

Category	Indicator
Sectorial trends and environmental significance	
Overall traffic trends and modal split	Passenger transport trends by mode
	Freight transport trends by mode
	Road traffic trends and densities
	Trends of airport traffic
Infrastructure	Capital expenditure by mode
	Road network length and density
	Rail network length and density
Vehicles and mobile equipment	Road vehicle stocks
	Structure of road vehicle fleet
	Private car ownership
Energy use	Final energy consumption by the transport sector
	Consumption of road fuels
Interactions with the environment	
Land use	Change in land use by transport infrastructure
	Access to basic services
Air Pollution	Transport emissions and emission intensities
	Population exposed to air pollution from transport
Water pollution	Oil released from marine transport
Noise	Population exposed to transport noise >=65db(A)

Waste	Transport-related waste and related recovery rates
	Hazardous waste imported or exported
Risk and Safety	Road traffic fatalities
	Hazardous material transported by mode
Economic & policy aspects	
Environmental damage	Environmental damage relating to transport
	Social cost of transport
Environmental expenditure	Total expenditure on pollution prevention and clean-up
	R&D expenditure on "eco-vehicles"
	R&D expenditure on clean transport fuels
Taxation and subsidies	Direct subsidies to transport
	Total economic subsidies to transport
	Relative taxation of vehicles and vehicle use
Price structures	Structure of road fuel prices
	Trends in public transport prices
Trade and environment	Indicators to be developed (e.g. trends in international transport of goods, relative importance of cross-border vs. Domestic transport)

5 Indicators of the Environmental Impacts of Transportation

Scheme name: Indicators of the Environmental impacts of transportation
Reference: http://ntl.bts.gov/lib/6000/6300/6333/indicall.pdf

Initiators

This study was part of a series of reports on the subject of transportation and its connection to the environment, which was issued by the Office of Policy, Planning and Evaluation. The workgroup consisting of collaboration between the United States Environmental Protection Agency (EPA), Bureau of Transportation Statistics (BTA) and the Department of Transportation (DOT).

Aim

The aim was to *develop environmental indicators for the transportation sector*, see the developed indicator framework in table 10.5.

Description

The work presented by EPA takes into account all four primary modes for transportation: Road, Air, Maritime and Rail. The report strive was to supply a logical framework; identify and categorise the environmental impacts of transportation; develop indicators; quantification of the impacts and assess the gaps in data as well as recommendation for further studies.

Indicator framework and focus

Usage of a three level analysis: 4 general dimension, 13 categories and 50+ indicators. The study's framework focuses on outcome and output indicators. Process related indicators have not been included.

The indicator list includes no qualitative indicators and is all things considered a quantitative study.

Benchmarking

No labelling or scoring is discussed.

Table 10.5

CATEGORISATION	INDICATORS
ROOT CAUSE INDICATORS	
LAND USE (Including demographics and geographic issues)	Population growth rate.
	Density (commercial, residential, or mixed; per square mile or zone mile).
	Transit access.
	Pedestrian environment factors (level of pedestrian accessibility).
	Bike friendliness (including climate, terrain, safety issues, etc.)
ECONOMICS	Cost of travel by various modes.
	Income.
	Attitudes about environmental protection, transit etc.
	Knowledge/level of information regarding transportation costs (internal and environmental) and travel alternatives.
ACTIVITY INDICATORS	
INFRASTRUCTURE CONSTRUCTION AND MAINTENANCE	Number of lane miles constructed annually.
	Percentage of roads that are paved/unpaved.
	Number of transit stations.
	Quantity of deciding compounds applied
VEHICLE AND PARTS MANUFACTURED	Number of vehicles manufactured
	Number of railcars purchased by transit agencies
	Number of new aircraft delivered
	Number of registered vehicles
TRAVEL	Vehicle-miles travelled (VMT) (or VMT per capita)
	Passenger-miles travelled (PMT) (or PMT per capita)
	Number of trips
	Average vehicle occupancy (AVO)
	Modal split (percentage using transit, walking, driving alone, etc.)

	Speeds (peak and off-peak)
	Acceleration, stops, etc.
	Congestion levels (e.g., share of travel in level of service "F", number of delay hours)
	Gallons of fuel used (or average MPG for a given city or year)
VEHICLE MAINTENANCE AND SUPPORT	Number of cleaning or refuelling stations/terminals
	Number of active petroleum underground storage tanks
DISPOSAL OF VEHICLES AND PARTS	Number of vehicles scrapped
	Number of used tires landfilled
	Percentage of mass landfilled or recycled
OUTPUT INDICATORS	
HABITAT CHANGES/LAND TAKEN	Acres of various types of land disrupted or divided by roads, by type of land, including changes in habitat fragmentation caused by transportation (e.g., number and size of parcels of forest or other ecosystem)
	Acres of various types of land destroyed, accounting for mitigation/restoration (e.g., classified by summarized wetland functions and values)
	Number of threatened/endangered species in affected areas
EMISSION	Tons emitted by mode, location, and chemical
	Levels of noise pollution
	Number of vehicles in use violating emissions standards
AMBIENT LEVELS	Parts per million of pollutant in ambient atmosphere, by location and chemical, for various averaging times
	Number or percentage of areas in nonattainment of Federal air quality standards
	Stream miles not meeting designated uses
EXPOSURE TO POLLUTANTS	Number of people living in nonattainment areas
	Estimated amount of exposure in ppm-hours or other units
	Population near hazardous waste sites
	Population downstream of areas with water quality problems or drinking affected water
OUTCOME INDICATORS	
EFFECTS OF HABITAT CHANGE	Changes in abundance of various species caused by transportation
	Changes in species diversity caused by transportation
	Other detailed measures of: Fishery impacts, Forestry impacts, Agricultural impacts, Avian species impacts
EFFECTS OF POLLUTANT EMISSIONS	Expected (estimated) number of cases of a given health effect (e.g., cancer cases) attributable to transportation emissions
	Percentage of all cases thought to be caused by transportation
	Risk level (i.e. probability that an individual will be affected)
	Dollar costs of health or welfare impacts (e.g., dollars of textile damage from corrosive air pollution)
	Person-days in exceedance of ambient standard (this is a measure of ambient levels but is also an indicator of their effects)

6 Indicators to Assess Sustainability of Transport Activities

Scheme name: Indicators to Assess Sustainability of Transport Activities

Reference:

Step 1:
http://publications.jrc.ec.europa.eu/repository/bitstream/111111111/10416/1/indicators%20report_green%20template.pdf

Step 2:
http://publications.jrc.ec.europa.eu/repository/bitstream/111111111/802/1/sust_transp_ind_report_final.pdf

Initiators:

The institute for environment and sustainability (IES), a scientific institute within the European Commission's Joint Research Centre (JRC), set up the scheme. IES main function is to supply scientific and technical backing concerning environmental issues in a global and European context.

Aim:

The study was performed in two steps. The first step focusing on the development of an indicator framework and indicator sets to measure the sustainability of transportation systems, see indicator framework in table 4. The second was to assess the results to enable scoring/labelling of the included indicator sets.

Description:

Step 1: To supply a framework and indicator listing by reviewing international and European initiatives in sustainable transportation.

Step 2: Is a further development of step 1. The focus was to gather data for evaluation and development of a benchmarking system called SysTrans Index.

Indicator framework and focus

The framework is a development on the triple bottom line concept with the addition of the Technical and Operational dimension and the Institutional dimension. The study is performed in three levels the first described above and includes 5 general dimensions; the second level includes 17 categories and the final level includes the 50+ (56) indicators.

Benchmarking

No labelling or scoring is discussed.

Table 10.6

Category	Indicator
ECONOMIC	
Transport demand and intensity	Volume of transport relative to GDP (passenger-km/tonne-km)
	Road transport (passenger-km/tonne-km)
	Railway transport (passenger-km/tonne-km)
	Maritime transport for goods and passengers (passenger-km/tonne-km)
	Inland waterway transport (passenger-km/tonne-km)
	Air transport (passenger-km/tonne-km)
	Intermodal transport (passenger-km/tonne-km)
Transport cost and prices	Total per capita transport expenditures (parking, road and transport service)
	Motor vehicle fuel prices and taxes
	Direct user cost by mode (passenger transport)
	External cost of transport activities (congestion, emission cost, safety cost) by transport mode (freight and passenger)
	Internalization of costs (implementation of economic policy tools with a direct link with the marginal external costs of the use of different transport modes)
	Subsidies to transport
	Taxation of vehicles and vehicle use
	% of GDP contributed by transport
	Investment in transport infrastructure (per capita by mode/as share of GDP)

Infrastructure	Road quality (paved roads, fair/good quality)
	Total length of roads in km by mode
	Density of infrastructure (km/km2)
SOCIAL	
Accessibility and mobility	Average passenger journey time
	Average passenger journey length per mode
	Quality of transport for disadvantaged people (disabled, low income, children)
	Mobility (daily or annual person-mile and trips by income group)
	Volume of passengers
Risk and safety	Person killed in traffic accidents (number of fatalities per 1000 vehicle km and per million inhabitants
	Traffic accidents involving injury (number of injuries per 1000 vehicle km and per million inhabitants)
Health impacts	Population exposed to and annoyed by traffic noise, by noise category and by mode associated with health and other effects
	Cases of chronicle respiratory diseases, cancer, headaches. Respiratory restricted activity days and premature deaths due to motor vehicle pollution
Affordability	Private car ownership
	Affordability (proportion of households income devoted to transport)
Employment	Contribute of transport sector (by mode) to employment growth
ENVIRONMENTAL	
Transport emission	NOx emission (per capita)
	VOCs emission (per capita)
	PM10 and PM25 emission (per capita)
	SOx emission (per capita)
	O2 concentration (per capita)
	CO2 emission (per capita)
	N2O emission (per capita)
	CH4 emission (per capita)
Energy efficiency	Energy consumption by transport mode (tonne-oil equivalent per vehicle km)
	Fuel consumption (vehicle-km by mode)
Impact on environmental resources	Habitat and ecosystem disruption
	Land take by transport infrastructure modes
Environmental risks and damages	Polluting accidents (land, air, water)
	Hazardous materials transported by mode
Renewables	Use of renewable energy sources (numbers of alternative fuelled vehicles) - use of biofuels
TECHNICAL AND OPERATIONAL	
Occupancy of transportation	Occupancy rate of passenger vehicles
	Load factors for freight transport (LDV, HDV)
Technology status	Average age of vehicle fleet
	Size of vehicle fleet (vehicle per million inhabitants)
	Proportion of vehicle fleet meeting certain air emission standards (Euro IV, euro V etc.)
INSTITUTIONAL	
Measure to improve transport sustainability	R&D expenditures on "eco vehicles" and clean transport fuels
	Total expenditure on pollution prevention and clean-up
	Measures taken to improve public transport
Institutional development	Uptake of strategic environmental assessment in the transport sector

7 Kommunvelometern

Scheme name:
Kommunvelometern
Reference:
Cykelfrämjandets Kommunvelometer - Cykelfrämjandet (2011)
Initiators:
Koucky and Partners AB by order of Cykelfrämjandet (Transl: Promotion of Cycling).
Aim and objective
The aim of Kommunvelometern (Transl: The Municipality Velometer) have been to measure and distribute actions taken by municipalities that favours cycling and make comparisons possible over time. The idea is to make the review a tool to highlight the significance of the bicycle, nationally and globally, and contribute to improve the conditions to cycle in Sweden. The purpose of the review is to objectively compare the work done by the municipalities for cycling and easily highlight strengths and weaknesses over time in their work.
Background
The program is designed by Koucky and Partners AB by order of Cykelfrämjandet, an organisation with the following aims:

- To be a nationwide organisation for cyclists
- Utilise the interests of all cyclists that use the cycle for communication, tourism, recreation or exercise
- Cooperate with the bicycle industry to help it develop good and cost-efficient bicycles
- Cooperate with organisations that acts within the traffic area for bicycle-adapted legislation
- Better traffic environment and less impact on the climate

Description
The tool is based on a web-based survey for each municipality to answer annually, divided into six different categories where each category can give maximum ten points. The indicator framework is a mode-specific main category themed framework.
Benchmarking
The Municipality Velometer uses benchmarking.

Table 10.7

Category	Indicator	Unit
Consisting infrastructure	Total length bicycle path	m/capita
Investments infrastructure/maintenance	Total investments infrastructure and maintenance 2010	SEK/capita
	Total investments infrastructure and maintenance 2011	SEK/capita
	Total personal resources	Employments/capita
Investments information/marketing	Investments information campaigns 2010	SEK/capita
	Investments information campaigns 2011	SEK/capita
	Personal resources information/campaigns	Employments/capita
	Share signposted bicycle paths	% of total length bicycle path
Activities 2010	Number of activities	-
Bicycle politics	Political goals	Yes/No
	Time-bound goals	Yes/No
	Measurable goals	Yes/No
	Follow-up of goals by board	Yes/No
	Cycle strategy adopted	Yes/No
	Bicycle Plan last 5 years	Yes/No
	Funds for Bicycle plan	Yes/No

	Bicycle parking number	Yes/No
	Implementation of planning document	Yes/No
	Current maintenance plan	Yes/No
	Active bicycle politics as employer	Yes/No
Follow-up and measurement	Flow measurements performed 2010	Yes/No
	Number of measurement points	Measurement frequency
	Travel survey last 5 years	Yes/No
	Satisfaction survey last 5 years	Yes/No
	Cooperation with cyclists	Yes/No
	Financial statements for bicycle (or BYPAD)	Yes/No

8 Non-motorised Transport Performance Indicators

Scheme name: Non-motorized transport performance indicators
Reference:
http://www.pdx.edu/ibpi/sites/www.pdx.edu.ibpi/files/IBPI%20Master%20Plan%20Handbook%20FINAL%20(7.27.12).pdf
Initiator: Nohad. A. Toulan School of Urban Studies & Planning: Initiative for Bicycle and Pedestrian Innovation, Portland State University in partnership with Alta Planning + Design.
Aim and objective: The tool was prepared as a guidebook designed to help communities strategically plan for bicycle and pedestrian transportation.
Background: The organisation Initiative for Bicycle and Pedestrian Innovation aims to advance bicycling and walking as integral elements of the transportation system.
Description: The indicator list is an example list of what should be measured to evaluate progress. It uses the Main Category framework with four categories.
Benchmarking: The program does not use benchmarking.

Table 10.8

Listing of Indicators	
Infrastructure	
Total miles of bikeways	Percentage of roadways with sidewalks
Miles of bikeways catering to each type of bicyclist	Number of miles of sidewalk infill per year
Percentage of households within one quarter mile (400 m) of a bicycle facility	Percentage of intersections up to current ADA standard
Percentage of buses equipped with bicycle racks	Number of transit stops with pedestrian amenities
Percentage of transit stops with bicycle parking or secure bicycle parking	Percentage of new development meeting pedestrian standard
Percentage of new developments that include secure bicycle parking or other end-of-trip facilities	Number of bridges with dedicated bicycle and pedestrian facilities
Number of bicycles parking spaces	Number of miles of trails/multi-use paths
Programs	
Percentage of schools served by Safe Routes to School Program	Attendance at Ciclovia or Open events
Number of safety training offered per year	Number of households participating in individualized marketing programs
Number of enforced efforts per year	Mode shift resulting from individualized marketing program
Use and Safety	
Mode share for work trips	Percentage of bicyclists that are women, youth or seniors
Mode share for all trips	Average trip distance across all modes
Number of walking and bicycling trips per day along key corridors	Number of trips made by bike share
Bicycle and pedestrian crash rate	
Public opinion	
Percentage of satisfied with the safety and comfort of existing bicycle and pedestrian facilities	Percentage of residents interested in walking and bicycling more frequently

9 Performance Indicators for Transport

Scheme name: Performance Indicators for Transport
Reference: http://www.worldbank.org/transport/transportresults/documents/users-guide.pdf
Initiator: Transport and Urban department, The World Bank
Aim and Objective: The indicator list is a part of an Users Guide for member countries and key partners of the World Bank to better understand the significance of the transport sector and its impacts on social and economic development.
Background: As a result to overcome declining quality of transport sector data and revitalise focus on infrastructure the World Bank developed the Infrastructure Action Plan in 2003. One part of the action plan was the assessment tool REDI, Recent Economic Developments in Infrastructure. Its focus was to analyse the infrastructure sector as a whole or as individual sub-sectors.
Description: The indicator framework is a Main Category framework with nine categories, where each indicator is categorised after mode. The framework is designed after data availability where Access, Affordability, Quality – Technical Dimension and Efficiency – Financial Cost are called "snapshot set" due to quicker results while the remaining five main categories are called "comprehensive set" since the data is more difficult to obtain.
Benchmarking: The tool does not use benchmarking.

Table 10.9

Mode	Indicator	Unit
ACCESS		
Roads	Access to all-season road by rural population	% of pop.
Roads	Average distance to nearest transport stop for urban population	km
Roads	Average distance to nearest transport stop for rural population	km
Roads	Road density in terms of population	km/1000 pop.
Roads	Road density in terms of land area	km/1000km2
Rail	Rail line density in term of land area	km/1000km2
Rail	Rail line density in terms of population	km/1000 pop.
Roads	Motorized road vehicles ownership in rural areas: Private cars	% of rural households
Roads	Motorized road vehicles ownership in rural areas: Motorcycles	% of rural households
Roads	Non-motorized road vehicles ownership in rural areas: Bicycles	% of rural households
Urban	Motorized road vehicles ownership in urban areas: Motorcycles	% of urban households
Urban	Motorized road vehicles ownership in urban areas: Private cars	% of urban households
Urban	Non-motorized road vehicles ownership in urban areas: Bicycles	% of urban households
Roads	Non-motorized road vehicles ownership: Bicycles	% of urban households
Air	Aircraft departures	thousands
AFFORDABILITY		
Road	Motor vehicle fuel prices: Gasoline (Super/regular)	US$/litre
Road	Motor vehicle fuel prices: Gas/Diesel Oil	US$/litre
Urban	Spending on transport services by urban households	% of expenditure
Rural	Spending on transport services by rural households	% of expenditure
Rail	Average rail tariff: Passenger	US$/Passenger-km
Rail	Average rail tariff: Freight	US$/Tonne-km
Roads	Road user charges as share of total road expenditure	%
Ports	Port handling cost: containers	US$/TEU
Ports	Port handling cost: containers	US$/Ton
QUALITY (Technical dimension)		
Roads	Paved roads	% of total
Roads	Roads in fair/good condition	% of total
Rail	Rail traffic density	traffic units/km
Rail	Route length of multi-tracked rail lines	% of total rout-km
Rail	Rail service frequency	Passenger train-km/route-km
Roads	Fatalities in road motor vehicle accidents in terms of vehicles	Fatalities/10000 veh.
Roads	Fatalities in road motor vehicle accidents in terms of population	Fatalities/10000 pop.

Urban	Urban transport modes	% of work trips
Ports	Seaport traffic: Containers	
Ports	Seaport traffic: General cargo	
Rail	Rail share of passenger domestic travel	%
Roads	Road share of passenger domestic travel	%
Water	Inland and coastal shipping share of passenger domestic travel	%
Air	Air share of passenger domestic travel	%
Rail	Rail share of total freight domestic carriage	%
Roads	Road share of total freight domestic carriage	%
Water	Inland and coastal shipping share of total freight domestic travel	%
Air	Air share of total freight domestic carriage	%
QUALITY (Perception)		
All	Average total time travelling by rural households	min/day
All	Average total time travelling by urban households	min/day
Urban	Travel time to work in main cities	min/one-way trip
Roads	Commercial perception of services delivered by road department/public work	-
Rail	Commercial perception of railway services	-
Air	Commercial perception of air transport services	-
Ports	Commercial perception of port facilities and inland waterways	-
Ports	Cargo handling services: Market openness	-
EFFICIENCY (Cost)		
Ports	Shipping cost	Ratio
Rail	Railway employee productivity	annual out-put/employee
EFFICIENCY (Economic)		
Roads	Road transport system technical efficiency	US$/km
FISCAL COST		
Roads	Road expenditure as share of GDP	%
Roads	External founds as share of total road expenditure	%
Roads	Actual to require road maintenance expenditure	%
FINANCIAL AUTONOMY		
Roads	Expenditure on owning and operating vehicles	US$
INSTITUTIONAL DEVELOPMENT		
Roads	National roads boards exists and reports	Y/N
Roads	Private sector representatives from majority of national road boards	Y/N
Roads	Main (National) road agency operating with annual report published	Y/N
Roads	Main (National) road agency publishing technical and financial audits	Y/N
Roads	National road safety action plan	Y/N
Roads	Social assessment of road project management	Y/N
All	Gender assessment	Y/N
All	Access for all	Y/N
All	Planning	Y/N
Roads	Environmental assessment of road project mainstreamed	Y/N
Roads	Communicable disease control	Y/N
All	Competitive private sector participation in transport services	Y/N
All	Core labour standards	Y/N
All	Health and safety	Y/N

10 SHIFT

Scheme name: SHIFT
Reference: Technical brochure – SHIFT ICLEI (2011)
Initiators: Global Alliance for Eco-Mobility
Aim and Objective: Eco-Mobility SHIFT aims at creating a certification scheme to assess and help improve local governments' sustainable transport policies.
Background: The Eco-Mobility SHIFT project that finished in May 2013 was co-funded by the European Agency for Competitiveness and Innovation and consisted of eight partners: ICLEI – Local Governments for Sustainability, Edinburgh Napier University, Mobiel 21, Traject, Trivector Traffic, I-CE – Interface for Cycling Expertise, Municipality of Burgas and Municipality of Miskolc.
Description: The indicator framework is a Linkage-based framework, divided into three indicator types; Enablers, Output and outcome indicators.
Benchmarking: The program uses benchmarking.

Table 10.10

Category	Indicator	Points
Process: Enablers		
Knowledge of society and user needs	Evaluation of city's measures to gather information regarding future needs.	10
Vision, strategy and leadership	Whether the city has an ecomobility strategy (i.e. SUMP) and sufficient leadership to support it (i.e. political support).	30
Personnel and resources	Level of staff and resources available to implement SUMP or similar strategy plan	10
Finance for ecomobility	Proportion of the total transportation budget spent on walking, bike, PT or reduction measures for motor traffic.	20
Public participation	Involvement of citizens and stakeholders through consultation and participation.	10
Monitoring, evaluation and review	Evaluation of the city's follow-up work on what it has done and improving on it.	10
Output: Transport and system services		
Accessibility to services	Avg. linear distance of citizens to a public primary school	20
Planning of new city areas	Extent to which new city areas are planned to reduce the need of travel by car and to facilitate alternative modes	15
Car free and low speed zones	Percentage of city's streets and squares that are: car free or have speed limit below 30 km/h	10
Information systems and MM	Advice on ecomobility modes: Information, campaign, travel planning websites etc.	10
MM services supporting ecomobility	Availability of high quality services supporting ecomobility: bike or car sharing, teleworking, carpooling etc.	10
Parking policy and traffic restraint measures	Percentage of inner-city parking space with hourly charge, time-limited stay or other traffic restraints (congestion fee)	?
Accessibility for people with reduced mobility	Adaption of public space, PT stops and vehicles to meet needs of people with reduced mobility	10
Walking infrastructure	Quality of walking network: safe, accessible, comfortable, signed, pedestrian priority and low waiting	10
Cycling infrastructure	Percentage of urban roads with speed limits >50km/h where measures for good cycling conditions are implemented.	10
Other cycling conditions	Quality of cycling network: safe, accessible, comfortable, signed, limit longer routes, parking conditions	10
Coverage of PT network	Percentage of citizens living within 500 m of bus stop, 1 km of tram/subway stop or 2 km of a rail stop with service interval during peak period of less than 15 min .	10
Speed	Ratio between peak hour journey time (including waiting and finding parking space) for car travel and PT travel for 5 common trips (i.e. Residential-city centre/residential-residential)	10
Affordability	Cost of monthly network-wide PT ticket as the percentage of median gross monthly income.	
Simplicity – ease of use	Expert opinion on the PT system ease of use i.e. ticket include switch between modes, information at stops, ease of understanding system	10
Green vehicles	Percentage of vehicles with more than four wheels that are low emission < 100 gCO2/km	10
Outcome: Results and impacts		
Modal split	Modal split for all trips by city residents (percentage)	30
PT trips per capita	PT trips on the city's PT system divided by the population	10
Safety overall	Traffic accidents resulting in death of serious injury per year and 100 000 in-	10

	habitants	
Safety – vulnerable road users	Safety for vulnerable road users according to accident exposure in comparison to driving	10
Energy efficiency	Transportation final energy consumption per capita for city inhabitants	10
Greenhouse gases	GHG emission from transport sector per capita in tonnes of CO2 equivalent per person per year of city inhabitants	10
Local air quality	Daily exceedance of EU air quality standard for cities (PM10 and NOx)	10

11 Siemens Complete Mobility Index

Scheme name:
Siemens Complete Mobility Index
Reference:
Sustainable urban infrastructure - Siemens 2009 PDF
Initiators:
Siemens AG
Aim and Objective
Siemens CMI aims to evaluate the sustainable mobility level of a city and compare it with best practices. Siemens have listed five objectives that they want to achieve:

- *Efficient management of growing traffic volumes*
- *Optimisation of modal split: providing the right transport mode for each purpose and making efficient use of the strengths of each transport mode*
- *Optimum coordination of rail, car, aircraft and ship transport modes, and intelligent interlinking with modern information and communications technologies*
- *Central collection and sharing of technological know-how*
- *Environmental protection*

http://www.siemens.co.uk/pool/about_us/businesses/industry/t24_sustainable_transport_gordon_wakeford.pdf
Background
Siemens presented CMI in 2008 using 11 qualitative and quantitative indicators, later 15, using data from International Association of Public Transport's Millennium Cities Data-base from 1995, later updated with values from 2009. The Complete Mobility concept aims at identifying a process for developing a transport system, including passenger and freight transport, which is as efficient, sustainable and user-oriented as possible (Vienna-raporten).
Description
Siemens CMI uses the adjusted triple-bottom line approach with three main dimensions, User- oriented, Efficiency and Sustainability, similar to the strict bottom-line approach with user-oriented and Efficiency related to Social and Economic dimensions respectively. The 15 indicators are divided into qualitative and quantitative groups as well.
Benchmarking
Siemens Complete Mobility Index uses benchmarking, every indicator is given a value from one to six.

Table 10.11

Category	Indicators
User focus	
Public transport level of service	Level of organisational, regulatory and modal integration which enhances user experience, service efficiency and urban management
Transport information and payment systems	Implementation of customer facing tools for journey planning and payment to support both trip decision making and city objectives
Affordability	Average cost of travel as a percentage of household income
Reliability of rail services	Reliability of rail journey time
Accessibility	Percentage of stations with disabled access
Efficiency	
Transport management, control & security	Uptake of urban traffic control and security systems and their application which provide infrastructure for proactive management of mobility
Air transport	Level of connectivity of national and international air travel and integration of airport facilities with urban infrastructure

Sea transport	Level of connectivity of national and international sea travel and integration of port facilities with urban infrastructure
Road infrastructure	Optimised provision of road space per 1000 population
Cost of transport provision/unit GDP	Cost of transport provision from the community
Performance of road network	Average journey time on road network
Sustainability	
Accidents	Rate of fatal accidents from transport
Energy use intensity	Level of energy use intensity from transport
Pollution	Level of emissions arising as a consequence of transport
Dedicated cycle lanes	Level of provision of dedicated cycle lanes

12 STPI

Scheme name: STPI
Reference:
http://richardgilbert.ca/Files/2003/Sustainable%20Transportation%20Performance%20Inidicators%20(for%20TRB).pdf
Initiators: The Centre for Sustainable Transportation
Aim and objectives:
The Centre for sustainable transportation conclude year 1996 that the STPI should produce: "quantifiable performance measurements, based on the vision and definition, that can be used to track progress toward sustainability"
Benchmarking:
Unknown

Table 10.12. STPI indicator listing.

Category	Indicators		
Framework	Initial STPI	Short-term additions	Long-term additions
Environmental and health consequences of transport	- Use of fossil fuels energy for all transport. - GHG emission for all transport. - Index of emission of air pollutants from road transport. - Index of road injuries and fatalities.	- Air quality - Waste from road transport. - Discharge into water. Land use for transport. - Proximity of infrastructure to sensitive areas and ecosystems.	-Noise - Effect on human health. - Effect on ecosystem - Effects on health.
Transport activity	- Total motorized movement of people. - Total motorized movement of freight. - Share of passenger travel not by land-based PT. - Movement of light-duty passenger vehicles.	- Utilization of passenger vehicles - Urban automobile vehicle-km - Travel by non-motorized models in urban areas - Journey-to-work modal share	- Urban and intercity person-km - Freight modal participation - Utilization of freight vehicles
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 (percentage walking to work/ jobs 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 share by urban zone
Supply of transport infrastructure and services	- Length of paved roads	-Length of sustainable infrastructure - Transit seat-km per capita.	- Congestion index
Transport expenditure and pricing	- Index of relative household transport cost - Index of relative cost of urban transport.	-Percent of net government transport expenditures spent on ground-based PT system.	- Transport related user charge - Expenditures by businesses on transportation
Technology adaption	- Index of energy intensity of car and trucks - Index of emission intensity of the road-vehicle fleet	- Percentage of alternative fuel vehicles in the fleet	- Percentage of passenger-km and tonne-km fuelled by renewable energy - Percentages of labour force regularly telecommuting
Implementation and monitoring		- Number of sustainable transport indicators regularly updated and widely reported - Public support for initiatives to achieve sustainable transportation	- Number of urban regions where planning and delivery of transport and related land use matters have a single authority

13 TERM

Scheme name: TERM
Reference: *PDF: Transport at a crossroads TERM 2008*
Initiators:
The European Environmental Agency (EEA) initiated the Transport and Environment Reporting Mechanism (TERM) in 1998 under influences from the European transport minister.
Aim and objectives:
"*To monitor the progress and effectiveness of transport and environment integration strategies through the environmental performance of transport"*
http://www.rscproject.org/indicators/index.php?page=eea-2
The TERM scheme addresses seven issues within the transportation sector:

1. Freight transport and modal split
2. Passenger transport and modal split
3. Greenhouse gas emissions from the transport sector
4. Local emissions and air quality
5. Transport fuel developments
6. Transport noise
7. Need for demand management

Description
TERM indicators covers vital characteristics of the transport and environment system, using the DPSIR framework It represents a long-term vision of the indicators that are preferably needed to answer environmental concerns connected to the transport sector.
Benchmarking
Monitor the environmental progress over time concerning the programs indicators. Comparisons of annual result.

Table 10.13. The indicator framework for the TERM-scheme, (2002).

Group	Indicators
Transport and Environment Performance	
Environmental consequences of transport	Transport final energy consumption and primary energy consumption, and share of total (fossil, nuclear, renewable) by mode
	Transport emission and share in total emission for CO2,NOx ,VOCs , PM10, SOx, by mode
	Exceedance of air quality objectives
	Exposure to annoyance by traffic noise
	Infrastructure influence on the ecosystem and habitats ("fragmentation") and proximity of transport infrastructure to designated sites
	Land take by transport infrastructure
	Number of transport accidents, fatalities, injured, polluting accidents (land, air and maritime)
Determinants of the transport/environment system	
Transport demand and intensity	*Passenger transport/Freight transport (see below):*
	Total passengers/total tonnes
	Total passenger-km/total tonne-km
	Passenger-km per capita/tonne-km per capita
	Passenger-km per GDP/tonne-km per GDP
Land use and access to basic services	Average passenger journey time and length per mode, purpose (community, shopping leisure) and territory (urban/rural)
	Access to transport services e.g.: motor vehicles per household, proportion of households located within 500 m of PT stop

Transport supply	Length of transport by mode and by type of infrastructure (e.g. Motorway, national road, municipal road etc.)
	Investment in transport infrastructure/capita and by mode
Price signals	**Real passenger and freight transport price by mode**
	Fuel prices
	Taxes
	Subsidies
	Expenditure for personal mobility per person and income group
Technology and utilization efficiency	Energy efficiency for passenger and freight transport (per pass-km and per tonne-km and by mode)
	Emission per pass-km and emission per tonne-km for CO2, NOx, NM, VOCs, PM10, SOx, by mode
	Occupancy rate of passenger vehicles
	Load factor for road freight transport (LDV,HDV)
	Uptake of cleaner (unleaded petrol, electric, alternative fuels) and alternative fuelled vehicles
	Vehicle fleet size and average age
Management integration	Number of member states that implement an integrated transport strategy
	Number of member states with national transport and environment monitoring systems
	Uptake of strategic environmental assessment in the transport sector
	Uptake of environmental management systems by transport companies
	Public awareness and behaviour

**The bolded indicators where marked as important by the scheme authors.*

14 TRAST

Scheme Name
TRAST
Reference
Trast guiden - Sveriges Kommuner och Landsting (2011)
Initiator
Swedish Association of Local Authorities and Regions, Swedish Transport Administration
Aim and Objective
The aim and purpose of TRAST is to guide planners and decision makers to establish an individual municipal traffic strategy that will integrate traffic-related topics in the planning process and thus progress towards a sustainable transport system.
Background
TRAST (TRAfik för en Attraktiv Stad, transl: Traffic for an Attractive City) is developed by SKL, the Swedish Transport Administration in cooperation with the Swedish Energy Agency (Energimyndigheten) initially in 2004.
Description
TRAST is primarily used as a guideline for municipalities to use in order to implement a transport strategy, therefore the indicator aspect is not a central part of TRAST. The indicator sets are dependant and adapted after the special needs of each municipality. In this study the indicator list for the municipality of Eslöv have been selected since it is the indicator framework that is of most relevance for this study and not the individual indicators and they correspond to the most important aspects according to TRAST. The indicator framework for Eslöv uses the main category approach.
Benchmarking
The indicators are individually determined and correspond to goals set for a specific municipality, no other benchmarking is performed.

Category	Indicators
City Characteristics	
Functions	Square meters of city/inhabitants
	Square meters green area/inhabitants
Green Vegetation, streets	Share of network with parkways
Population	Number of inhabitants
Traffic System	
Standard of Traffic Network	Share of walking network with good surface coating standard
	Share of bicycle network with good surface coating standard
	Share of street network with good surface coating standard
Car Lots	Occupancy of parking lots near city centre
Occupancy Bicycle Lots	Occupancy of bicycle parking lots near city centre
Pedestrian Crossings	Number of pedestrian crossings
	Number of pedestrian crossings with traffic safety measure
	Average bus velocity
	Number of traffic lights with priority for bus traffic
	Number of PT lanes
Volume of Traffic	
Vehicles in traffic	Private cars in traffic per 1000 inhabitants
Traffic Volumes	Vehicle amounts (Outer)
	Vehicle amounts (Inner)
	Bicycle traffic amounts
Trips Public Transport	Number of trips per inhabitant with city bus per year
Mileage	Mileage car within municipality, vehicle km per inhabitant and year

Modal Split	Share of trips to city centre by walking within municipality
	Share of trips to city centre by bicycle within municipality
	Share of trips to city centre by bus within municipality
	Share of trips to city centre by car within municipality
School Trips	Share of children being taken to school by car
Accessibility	
Stops	Number of stops
	Number of stops completely adapted for disabled people
	Number of stops partly adapted for disabled people
	Travel time ratio
Security	
Security	Share of pedestrians that feel safe in traffic
	Share of bicyclists that feel safe in traffic
Traffic Safety	
Accident statistics	Number of killed per year
	Number of gravely injured per year
	Number of slightly injured per year
Velocities	Vehicle velocities (Outer)
	Vehicle velocities (Inner)
Usage of Bicycle Helmet	Share of bicyclists that use helmet
Environmental Impact	
Fuel consumption	Share alternative fuels
Emissions	Emissions of carbon dioxide per year
Noise	Number of real estates that are exposed to noise levels higher than 35 db(A) indoors

15 Urban Transport Benchmarking Index

Scheme name: Urban Transport Benchmarking Index
Reference: *PDF:* Urban Transport Benchmarking Index - 2004
Initiators: European Council

Aim and Objective

The purpose of the Urban Transport Benchmarking Initiative is to show that attractive, efficient local and regional transport systems is an important pillar for the European Union both in terms of economic development and in social cohesion. The aim of UTBI is to identify, compare and highlight best practices and interesting solutions of the different transport systems in Europe. It lists six objectives:

- *To select annually a group of participants representing local and regional urban transport stakeholders from 35-40 cities*
- *To agree a set of common performance indicators covering urban passenger and freight transport*
- *To undertake a comparative analysis across stakeholders*
- *To set up a maximum of 5 thematic working groups on topics agreed by the participants*
- *To organise site visits (3 per year) for the working groups through which to identify and study best practices*
- *To disseminate the results*

(http://www.transportbenchmarks.eu/transport/objectives.html)

Background

UTBI was initiated by the European Council in 2003 and finished in 2006, where it benchmarked transport systems of 45 different European cities. It was led by three different companies: Transport and Travel Research Ltd (TTR), The International Association of Public Transport (UITP) and the Regional Environmental Center for Central and Eastern Europe (REC). The exchange and promotion of best practices within urban transport is a key policy feature for the European Commission.

Description

UTBI uses the main category approach with the main headlines as; Region and city, Transport network, Fleet composition, Travel characteristics, Economy, Road Safety and Environment.

Benchmarking

Benchmarking is performed by best practice of the 45 investigated European cities.

Table 10.14

Category	Indicators
Region and city	
Area of region	Size of administrative area
Area of city	Size of urban administrative area
Population of region	Number of residents of the regional administrative area
Population of city	Number of residents of the urban administrative area
Geography	Description of key geographical features influencing transport
Transport network	
Cycle paths	Length of segregated, dedicated cycle paths in the administrative area
Public transport network	Length network by mode (bus/train/metro/tram)
Roads	Length of road network
Public transport priority	Length of bus lanes and segregated right of way for trams
Fleet composition	
Car ownership	Number of cars registered in the administrative area
Public transport fleet	Number of vehicles (by mode) operating in the administrative area
Accessibility	% of public transport vehicles with low floors, by mode
Travel characteristics	
Average speed (private transport)	Average speed of cars/motorcycles in peak hour

Average speed (public transport)	Average speed of buses/trains/metro vehicles/trams in peak hour
Service intervals	Typical service intervals of buses/trains/metro vehicles/trams in peak hour
Modal split	Total number of daily one-way journeys by mode in the administrative area
Vehicle occupancy	Average vehicle occupancy by mode (car/bus/train/metro/tram) in peak hour
Economy	
Cost of car use	Average cost to user of car use
Cost of public transport	Average cost to user of public transport by mode
Investment in public transport	Capital expenditure on public transport, by mode, averaged over the last 5 years
Investment in roads	Capital expenditure on roads, averaged over the last 5 years
Gross Domestic Product	GDP per head of population
Employment	% of resident population currently employed
Road Safety	
Traffic accidents	Number of injuries and deaths on the road network, per annum
Environment	
Air quality	Air quality by pollutant (NO2, SO2, Nox, VOC, particulates) per annum

APPENDIX II

- Categorisation of indicators listed in appendix 3, short purpose and description.

Table 10.15. Description and purpose for the categorisation of indicators.

Accessibility http://www.extension.org/pages/62111/what-are-the-differences-between-mobility-accessibility-and-connectivity-in-transportation-planning
Purpose: Accessibility in the context of transportation strives to reflect generalised costs (time, money, discomfort etc.) of reaching an activity/destination. If the accessibility of sustainable modes competes with unsustainable modes the chances of reaching sustainability improves. *Description:* To fit this study accessibility revolves around the time it takes to reach destinations, the comfort the transport mean supplies and the access inhabitants have to basic transport services. Emphasis is on comparing sustainable and unsustainable modes.
Accessibility for disabled
Purpose: The emission generated by traffic can affect the health of the inhabitants, especially in urban settings. *Description:* This category includes indicators measuring these affects, such as risk of illness or actual number of sickened.
Affordability http://www.vtpi.org/affordability.pdf
Purpose: Affordability in the context of transportation focuses on the potential inhabitants has to finance their transportation. *Description:* The category includes household expenditures on transportation, freight affordability and costs as well as cost comparisons between different modes.
Air emission http://people.hofstra.edu/geotrans/eng/ch8en/conc8en/ch8c1en.html
Purpose: Air emission in the form of gas and particulate matters emissions affects air quality causing damage to human health and climate change. *Description:* The category includes measures of the pollutant that have effect on the mentioned areas, i.e. CO2, NO2 etc. Emission intensity, total release and per capita emissions are generally applied to measure the pollutants.
Demography & geography
Purpose: The category enables interpretation of the result and is valuable when a comparison is made between municipalities of different size. *Description:* The category includes indicators that focus on population size and density (demography) as well as geographical measures of zone size. The indicators have no direct linkage to transport sustainability.
Energy & resource efficiency
Purpose: The transportation sector requires large amount of energy and resources and restrictions or implementations that limits the overall usage can help reduce the hazardous effects of transportation. *Description:* The category reflects the energy and resource efficiency of transportation. Vehicle energy use as well as the way a municipality take care of and supply resources is in focus. The category also includes financial inputs for R&D that aims to supply clean fuels and eco vehicles.

Equity

Purpose: As the transportation system is supposed to be accessible to all inhabitants, people with disabilities needs extra support.
Description: The category includes indicators focusing on these aspects such as; adaption of vehicles, transit stops and transport facilities to enhance access. The category is closely related to accessibility, but has been excluded to highlight its importance.

Habitat loss

Purpose: The alternation of the natural ecosystem in order to supply a transport network can affect the surrounding environment and therefore habitats.
Description: The category centres around the effects this brings upon the habitat by measuring the disruption, loss of life etc.

Implementation & monitoring

Purpose: The knowledge of "user needs" in transportation is important and requires transport management organisations to monitor the traffic. Knowledge helps in managing the transportation system when deciding the investments possible to improve transport sustainability.
Description: This category includes indicators on monitoring work and implementation that strive to increase sustainability.

Information & communication

Purpose: To communicate travel information to the population in regards to transportation services can enhance the impacts of such features (shift has ref). Another communicative gain is the importance of involving citizens in the planning process, this way problems can be foreseen and undermined.
Description: Researching the public opinion on transport services, commercial investments, travel-planning tools and meeting the public to hear ideas regarding transport.

Infrastructure and land take

Purpose: The infrastructure supplies the "landscape" in which we move and has to meet travel demands in order to be seen as functional. However the priority of expanding one mode of infrastructure in relation to another greatly affect possibilities for citizen's to travel.
Description: Includes different indicators that measure the physical presence of the infrastructure, i.e. road length and roads areal usage.

Liveability

http://en.wikipedia.org/wiki/Liveability#cite_note-DHG-1

Purpose: Liveability is a measure of the quality of life that is expressed by citizens. The term should not be confused with standard of living that more so reflect the income and housing standard. Liveability focus instead on the perceived well-being of individuals.
Description: The category includes measures that centre on the perceived comfort of the transportation system and how the transportation increases quality of life.

Management & policy

Purpose: In relation to information and communication, management and policy that addresses sustainability by helping inhabitants living a life
Description: The category touches on a large amount of subjects but focuses on the goals, management methods and policies implemented by the municipality.

Modal split

Purpose: Measuring the impact the transportation network has on the travel behaviour.

Description: Includes different modes share of the travel volumes.
Mobility & transport volume http://www.oregon.gov/ODOT/SUS/Pages/accessibility_mobility.aspx
Purpose: Mobility refers to physical movement, and addresses movement within all different travel modes. In general, increased mobility increases access. All else being equal, the more you can travel the more destinations you can reach. *Description:* Mobility is measured through distance and speed. Transport volume is measured in daily travel, passenger-km or tonne-km etc.
Noise environment http://people.hofstra.edu/geotrans/eng/ch8en/conc8en/ch8c1en.html
Purpose: Noise levels exceeding the certain limits affects the climate for inhabitants and impacts the physical and psychological wellbeing. *Description:* Measurements of both indoor and outdoor noise level as well as the annoyance this causes for inhabitants
Hazardous waste (non air related)
Purpose: Although the foremost impact transportation has on the environment is through GHG emissions and pollutants affecting the local air quality; other pollutants are released as well that contributes to environmental degradation. *Description:* The category includes pollution to water, waste of different kinds, releases of hazardous material etc.
Parking Shift
Purpose: Studies have showed that cities that implements restrictive parking policies often achieves well in transport sustainability evaluations. *Description:* Number of parking spots (car and bicycle) present and parking spots that have implemented hourly charge. Connectivity between bicycle parking and transit facilities.
Safety
Purpose: Identification of the city's transport safety. *Description:* Overall injuries and fatalities as a consequence of transport. Comparing risk levels of different modes of transport.
Security
Purpose: Evaluating the security of using the transport system. *Description:* Measurements of real security (number of assaults) and the perceived security (views of the users).
Taxation & subsidies
Purpose: The transport behaviour is closely related to the pricing and taxation of fuels and resources. Subsidies for environmental friendly options can also affect behaviour. *Description:* Indicators involving taxation and subsidies to transport.
Transport cost/gain
Purpose: Upholding a functional transportation system requires founding. New investments and maintenance are budgeted for on a yearly basis and divided among the different transport functions. The transport sector is also a large contributor to the economy. *Description:* Includes indicators measuring cost to maintain and expand the transportation network, budget allocation and financial gains as a consequence of transportation.
Travel behaviour
Purpose: Inhabitant's views on environmental issues and how they relate these issues

to transportation largely affects the potential for a sustainable shift. *Description:* Indicators that measure travel behaviour includes vehicle occupancy and public awareness/attitude about environmental protection.
Vehicle fleet
Purpose: Evaluation of vehicle fleet composition, which can work as an indirect measure of a city's car dependency and inhabitants attitudes to limiting motorized transport. *Description:* Number of vehicles (bike, car etc.) and amount per capita.

APPENDIX III
- Indicator list.

	Indicator	Mode	Category	Qualitative?
1	Number of job opportunities and commercial services within 30-	all	accessibility	
1	Average commute travel time	all	accessibility	
1	Quality of accessibility and transport services for non-drivers	all	accessibility	Qualitative
1	Portion of household expenditures devoted to transport by 20%	all	affordability	
1	Per capita expenditures on roads, traffic services and parking	all	affordability	
1	Degree to which prices reflect full costs unless a subsidy is	all	affordability	Qualitative
1	Speed and affordability of freight and commercial transport	freight	affordability	
1	Per capita fossil fuel consumption, and emissions of CO2 and	motorised	air emissions	
1	Per capita emissions of conventional air pollutants	motorised	air emissions	
1	Non-renewable resource consumption in the production and use	all	energy and resource	
1	Quality of transport facilities and services for people with disa-	all	Accessibility for	Qualitative
1	Public involvement in transport planning process	all	information and	Qualitative
1	Per capita land devoted to transportation facilities	all	infrastructure and	
1	Preservation of wildlife habitat	all	habitat loss	
1	Degree to which transport activities increase community livea-	all	liveability	Qualitative
1	Implementation of policy and planning practices that lead to	all	management and	Qualitative
1	Degree to which impacts on non-motorised transport are consid-	non-	management and	Qualitative
1	Degree to which transport institutions reflect least-cost planning	undef.	management and	
1	Mode split: portion of travel made by walking, cycling,	all	modal split	
1	Percentage of population that regularly walks and cycles	non-	modal split	
1	Portion of population exposed to high levels of traffic noise	motorised	noise pollution	
1	Per capita vehicle fluid losses	motorised	Hazardous waste	
1	Per capita crash disabilities and fatalities	all	safety	
2	The municipality has a travel policy with clear priority towards	undef.	management and	Qualitative
2	The municipality offers opportunities for video conferences or	undef.	management and	
2	There is access to a larger company bicycle pool with a central	bicycle	management and	
2	Average fossil carbon dioxide emissions per kilometre from the	car	management and	
2	The municipality requests or demands environmental and social	car	management and	
2	Requirements on green car at purchase or leasing (4 p), Pro-	car	management and	
2	For municipal cars that can be run on one or more renewable	car	management and	
2	Display of declining energy usage in their cars by comparison	car	management and	
2	Intelligent support for adaption of speed (ISA) have been used	car	management and	
2	Any part of the personnel have undergone education in econom-	car	management and	
2	It is prohibited to use a private car on duty	car	management and	
2	The municipality offers no benefit cars or only benefit cars that	car	management and	
2	100 % green vehicles is required of all passenger transports (12	car	management and	
2	The municipality actively controls towards that green cars	car	management and	
2	The municipality offers free parking only for cars that can be	car	management and	
2	Access to the carpool exists for the public (2 p), The municipali-	car	management and	
2	The municipality facilitates carsharing and commuting	car	management and	
2	The share of green cars in the new car sale is larger than 50 % (2	car	management and	
2	There is a company car pool (1 p), Access to the company car	car	management and	
2	The municipality climate compensate its road trips (1 p), It is in	motorised	management and	
2	Public refuelling places exist for two or more renewable fuels (4	motorised	management and	
2	The municipality contributes to production of a renewable fuel	motorised	management and	
2	The municipality collects organic domestic waste for digestion	motorised	management and	
2	The environmental quality standards for NO2 regarding hourly,	motorised	management and	
3	Quota of average travel time between sustainable transport	all	accessibility	
3	Share of work-able population that is pleased with the transport	all	accessibility	Qualitative
3	Share of the population that is pleased with the transport system	all	accessibility	Qualitative
3	Share of businesses and public organisations that are pleased	all	accessibility	Qualitative
3	Share of population that thinks it is affordable to use renewable	motorised	affordability	Qualitative
3	Annual carbon-dioxide emissions from traffic	motorised	air emissions	
3	Share of population that does not feel bothered by traffic-related	motorised	air emissions	Qualitative
3	Share of renewable amount of energy of the total annual sold	motorised	energy and resource	
3	Land usage for the road and transport network of the municipali-	all	infrastructure and	
3	Share of population that thinks that the transport-related areas	all	infrastructure and	Qualitative
3	Share of population that is pleased with the transport-related	all	liveability	Qualitative
3	Share of person-km with sustainable transport modes of total	all	modal split	
3	Share of children that travels to school with other transport	all	modal split	
3	Share of population that lives in an area where outdoor noise	motorised	noise pollution	

3	Share of population that does not feel bothered by traffic-related	motorised	noise pollution	Qualitative
3	Risk of personal injuries	all	safety	
3	Share of populations that feels safe in the traffic (free from	all	safety	
3	Share reported assaults that occured in the transport system per	all	security	Qualitative
3	Share of population that feels safe from assaults in the transport	all	security	Qualitative
3	Annual tonne-km on the municipalital road network per average	freight	transport cost/gains	
3	Annual number of public transport passenger-km within the	PT	transport cost/gains	
4	Access to basic services	all	accessibility	
4	Capital expenditure by mode	all	affordability	
4	Social cost of transport	all	affordability	
4	Trends in public transport prices	PT	affordability	
4	Transport emissions and emission intensities	motorised	air emissions	
4	Population exposed to air pollution from transport	motorised	air emissions	
4	Final energy consumption by the transport sector	all	energy and resource	
4	R&D expenditure on clean transport fuels	motorised	energy and resource	
4	R&D expenditure on "eco-vehicles"	motorised	energy and resource	
4	Consumption of road fuels	motorised	energy and resource	
4	Transport-related waste and related recovery rates	motorised	energy and resource	
4	Environmental damage relating to transport	all	habitat loss	
4	Indicators to be developed (e.g. trends in international transport	undef.	implementation and	
4	Rail network length and density	air, rail,	infrastructure and	
4	Road network length and density	all	infrastructure and	
4	Change in land use by transport infrastructure	all	infrastructure and	
4	Passenger transport trends by mode	all	modal split	
4	Freight transport trends by mode	freight	modal split	
4	Population exposed to transport noise >=65db(A)	motorised	noise pollution	
4	Oil released from marine transport	air, rail,	Hazardous waste	
4	Hazardous material transported by mode	all	Hazardous waste	
4	Hazardous waste imported or exported	motorised	Hazardous waste	
4	Road traffic fatalities	all	safety	
4	Direct subsidies to transport	all	taxation and subsi-	
4	Total economic subsidies to transport	all	taxation and subsi-	
4	Structure of road fuel prices	motorised	taxation and subsi-	
4	Relative taxation of vehicles and vehicle use	motorised	taxation and subsi-	
4	Trends of airport traffic	air, rail,	traffic volumes and	
4	Road traffic trends and densities	motorised	traffic volumes and	
4	Total expenditure on pollution prevention and clean-up	all	transport cost/gains	
4	Private car ownership	car	vehicle fleet	
4	Road vehicle stocks	motorised	vehicle fleet	
4	Structure of road vehicle fleet	motorised	vehicle fleet	
5	Transit access	all	accessibility	
5	Bike friendliness (including climate, terrain, safety issues, etc.)	bicycle	accessibility	qualitative
5	Pedestrian environment factors (level of pedestrian accessibil-	pedestrian	accessibility	qualitative
5	Number of transit stations	PT	accessibility	
5	Cost of travel by various modes.	all	affordability	
5	Income	undef.	affordability	
5	Number of people living in nonattainment areas	all	air emissions	
5	Tons emitted by mode, location, and chemical	motorised	air emissions	
5	Number of vehicles in use violating emissions standards	motorised	air emissions	
5	Parts per million of pollutant in ambient atmosphere, by location	motorised	air emissions	
5	Number or percentage of areas in nonattainment of Federal air	motorised	air emissions	
5	Estimated amount of exposure in ppm-hours or other units	motorised	air emissions	
5	Person-days in exceedance of ambient standard (this is a meas-	motorised	air emissions	
5	Stream miles not meeting designated uses	undef.	air emissions	
5	Density (commecial, residential, or mixed; per square mile or	undef.	demography and	
5	Population growth rate	undef.	demography and	
5	Gallons of fuel used (or average MPG for a given city or year)	motorised	energy and resource	
5	Number of used tires landfilled	motorised	energy and resource	
5	Percent of mass landfilled or recycled	motorised	energy and resource	
5	Acres of various types of land disrupted or divided by roads, by	all	habitat loss	
5	Acres of various types of land destroyed, accounting for mitiga-	all	habitat loss	
5	Number of threatened/endangered species in affected areas	all	habitat loss	
5	Changes in abundance of various species caused by transporta-	motorised	habitat loss	
5	Changes in species diversity caused by transportation	motorised	habitat loss	
5	Other detailed measures of: Fishery impacts, Forestry impacts,	undef.	habitat loss	
5	Expected (estimated) number of cases of a given health effect	motorised	health	
5	Percentage of all cases thought to be caused by transportation	motorised	health	
5	Risk level (i.e. probability that an individual will be affected)	motorised	health	
5	Knowledge/level of information regarding transportation costs	all	information and	qualitative
5	Number of cleaning or refueling stations/terminals	motorised	infrastructure and	

5	Number of active petroleum underground storage tanks	motorised	infrastructure and	
5	Number of lane miles constructed annually.	motorised	infrastructure and	
5	Percentage of roads that are paved/unpaved.	motorised	infrastructure and	
5	Quantity of deciding compounds applied	undef.	infrastructure and	
5	Modal split (percentage using transit, walking, driving alone,	all	modal split	
5	Levels of noise pollution	motorised	noise pollution	
5	Population near hazardous waste sites	undef.	Hazardous waste	
5	Population downstream of areas with water quality problems or	undef.	Hazardous waste	
5	Passenger-miles traveled (PMT) (or PMT per capita)	all	traffic volumes and	
5	Number of trips	all	traffic volumes and	
5	Vehicle-miles traveled (VMT) (or VMT per capita)	motorised	traffic volumes and	
5	Speeds (peak and off-peak)	motorised	traffic volumes and	
5	Acceleration, stops, etc.	motorised	traffic volumes and	
5	Congestion levels (e.g., share of travel in level of service “F”,	motorised	traffic volumes and	
5	Dollar costs of health or welfare impacts (e.g., dollars of textile	motorised	transport cost/gains	
5	Attitudes about environmental protection, transit etc.	all	travel behaviour	qualitative
5	Average vehicle occupancy (AVO)	motorised	travel behaviour	
5	Number of new aircraft delivered	air, rail,	vehicle fleet	
5	Number of railcars purchased by transit agencies	air, rail,	vehicle fleet	
5	Number of vehicles manufactured	motorised	vehicle fleet	
5	Number of registered vehicles	motorised	vehicle fleet	
5	Number of vehicles scrapped	motorised	vehicle fleet	
6	Average passenger journey time	all	accessibility	
6	Total per capita transport expenditures (parking, road and	all	affordability	
6	Direct user cost by mode (passenger transport)	all	affordability	
6	Affordability (proportion of households income devoted to	all	affordability	
6	Nox emission (per capita)	motorised	air emissions	
6	VOCs emission (per capita)	motorised	air emissions	
6	PM10 and PM25 emission (per capita)	motorised	air emissions	
6	Sox emission (per capita)	motorised	air emissions	
6	O2 concentration (per capita)	motorised	air emissions	
6	CO2 emission (per capita)	motorised	air emissions	
6	N2O emission (per capita)	motorised	air emissions	
6	CH4 emission (per capita)	motorised	air emissions	
6	R&D expendiures on "eco vehicles" and clean transport fuels	motorised	energy and resource	
6	Energy consumption by transport mode (tonne-oil equivalent	motorised	energy and resource	
6	Fuel consumption (vehicle-km by mode)	motorised	energy and resource	
6	Use of renewable energy sources (numbers of alternative fuelled	motorised	energy and resource	
6	Quality of transport for disadvantaged people (disabled, low	all	Accessibility for	Qualitative
6	Habitat and ecosystem disruption	all	habitat loss	
6	Polluting accidents (land, air, water)	motorised	Hazardous waste	
6	Cases of chronical respiratory diseases, cancer, headaches.	motorised	health	
6	Measures taken to improve public transport	all	implementation and	
6	Road quality (paved roads, fair/good quality)	all	infrastructure and	
6	Total length of roads in km by mode	all	infrastructure and	
6	Density of infrastructure (km/km2)	all	infrastructure and	
6	Land take by transport infrastructure modes	all	infrastructure and	
6	Uptake of strategic environmental assessment in the transport	all	management and	
6	Population exposed to and annoyed by traffic noise, by noise	motorised	noise pollution	qualitative
6	Hazardous materials transported by mode	motorised	Hazardous waste	
6	Person killed in traffic accidents (number of fatalities per 1000	all	safety	
6	Traffic accidents involving injury (number of injuries per 1000	all	safety	
6	Subsidies to transport	all	taxation and subsi-	
6	Motor vehicle fuel prices and taxes	car	taxation and subsi-	
6	Taxation of vehicles and vehicle use	motorised	taxation and subsi-	
6	Air transport (passenger-km/tonne-km)	air, rail,	traffic volumes and	
6	Maritime transport for goods and passengers (passenger-	air, rail,	traffic volumes and	
6	Inland waterway transport (passenger-km/tonne-km)	air, rail,	traffic volumes and	
6	Railway transport (passenger-km/tonne-km)	air, rail,	traffic volumes and	
6	Average passenger journey length per mode	all	traffic volumes and	
6	Mobility (daily or annual person-mile and trips by income	all	traffic volumes and	
6	Intermodal transport (passenger-km/tonne-km)	all	traffic volumes and	
6	Volume of passengers	all	traffic volumes and	
6	Load factors for freight transport (LDV, HDV)	freight	traffic volumes and	
6	Road transport (passenger-km/tonne-km)	motorised	traffic volumes and	
6	% of GDP contributed by transport	all	transport cost/gains	
6	Contribute of transport sector (by mode) to employment growth	all	transport cost/gains	
6	Total expenditure on pollution prevention and clean-up	all	transport cost/gains	
6	Investment in transport infrastructure (per capita by mode/as	all	transport cost/gains	
6	Volume of transport relative to GDP (passenger-km/tonne-km)	all	transport cost/gains	

6	External cost of transport activities (congestion, emission cost,	all	transport cost/gains	
6	Internalization of costs (implementation of economic policy	all	transport cost/gains	
6	Occupancy rate of passenger vehicles	motorised	travel behaviour	
6	Private car ownership	car	vehicle fleet	
6	Average age of vehicle fleet	motorised	vehicle fleet	
6	Size of vehicle fleet (vehicle per million inhabitants)	motorised	vehicle fleet	
6	Porpotion of vehicle fleet meeting certain air emission standards	motorised	vehicle fleet	
7	Number of activities	bicycle	implementation and	
7	Flow measurements performed 2010	bicycle	implementation and	
7	Number of measurement points	bicycle	implementation and	
7	Investments information campaigns 2010	bicycle	information and	
7	Investments information campaigns 2011	bicycle	information and	
7	Personal resources information/campaigns	bicycle	information and	
7	Cooperation with cyclists	bicycle	information and	
7	Total personal resources	bicycle	information and	
7	Share signposted bicycle paths	bicycle	infrastructure and	
7	Total length bicycle path	bicycle	infrastructure and	
7	Political goals	bicycle	management and	qualitative
7	Time-bound goals	bicycle	management and	qualitative
7	Measurable goals	bicycle	management and	
7	Follow-up of goals by board	bicycle	management and	
7	Cycle strategy adopted	bicycle	management and	
7	Bicycle Plan last 5 years	bicycle	management and	
7	Implementation of planning document	bicycle	management and	
7	Current maintenance plan	bicycle	management and	
7	Active bicycle politics as employer	bicycle	management and	
7	Travel survey last 5 years	bicycle	management and	
7	Satisfaction survey last 5 years	bicycle	management and	
7	Bicycle parking number	bicycle	parking	
7	Total investments infrastructure and maintenance 2010	bicycle	transport cost/gains	
7	Total investments infrastructure and maintenance 2011	bicycle	transport cost/gains	
7	Funds for Bicycle plan	bicycle	transport cost/gains	
7	Financial statements for bicycle (or BYPAD)	bicycle	transport cost/gains	
8	Percentage of households within one quater mile (400 m) of a	bicycle	accessibility	
8	Percentage of buses equipped with bicycle racks	bicycle	accessibility	
8	Percentage of bicyclists that are women, youth or seniors	non-	Accessibility for	
8	Number of safety training offered per year	all	information and	
8	Attendance at Ciclovia or Open events	non-	information and	
8	Number of households participating in individulized marketing	non-	information and	
8	Mode shift resulting from individualized marketing program	non-	information and	
8	Total miles of bikeways	bicycle	infrastructure and	
8	Miles of bikeways catering to each type of bicyclist	bicycle	infrastructure and	
8	Percentage of roadways with sidewalks	non-	infrastructure and	
8	Number of miles of sidewalk infill per year	non-	infrastructure and	
8	Number of bridges with dedicated bicycle and pedestrian facili-	non-	infrastructure and	
8	Number of miles of trails/multi-use paths	non-	infrastructure and	
8	Number of transit stops with pedestrian amenities	pedestrian	infrastructure and	
8	Percentage of new development meeting pedestrian standard	pedestrian	infrastructure and	
8	Percentage of schools served by Safe Routes to School Program	non-	management and	
8	Mode share for work trips	all	modal split	
8	Mode share for all trips	all	modal split	
8	Number of trips made by bike share	bicycle	modal split	
8	Percentage of transit stops with bicycle parking or secure bicy-	bicycle	parking	
8	Percentage of new developments that include secure bicycle	bicycle	parking	
8	Number of bicycles parking spaces	bicycle	parking	
8	Percentage of satisfied with the safety and comfort of existing	non-	safety	qualitative
8	Percentage of intersections up to current ADA standard	non-	safety	
8	Bicycle and pedestrian crash rate	non-	safety	
8	Average trip distance across all modes	all	traffic volumes and	
8	Number of walking and bicycling trips per day along key corri-	non-	traffic volumes and	
8	Number of enforced efforts per year	non-	transport cost/gains	
8	Percentage of residents interested in walking and bicycling more	non-	travel behaviour	qualitative
9	Aircraft departures	air, rail,	accessibility	
9	Rail line density in terms of population	air, rail,	accessibility	
9	Rail service frequency	air, rail,	accessibility	
9	Access to all-season road by rural population	all	accessibility	
9	Average total time travelling by rural households	all	accessibility	
9	Average total time travelling by urban households	all	accessibility	
9	Travel time to work in main cities	all	accessibility	
9	Urban transport modes	all	modal split	

9	Road density in terms of population	motorised	accessibility	
9	Average distance to nearest transport stop for urban population	PT	accessibility	
9	Average distance to nearest transport stop for rural population	PT	accessibility	
9	Port handling cost: containers	air, rail,	affordability	
9	Port handling cost: containers	air, rail,	affordability	
9	Average rail tariff: Passenger	air, rail,	affordability	
9	Spending on transport services by urban households	all	affordability	
9	Spending on transport services by rural households	all	affordability	
9	Average rail tariff: Freight	freight	affordability	
9	Shipping cost	freight	affordability	
9	Expenditure on owning and operating vehicles	motorised	affordability	
9	Railway employee productivity	air, rail,	energy and resource	qualitative
9	Road transport system technical efficiency	all	energy and resource	qualitative
9	Commercial perception of air transport services	air, rail,	information and	qualitative
9	Commercial perception of port facilities and inland waterways	air, rail,	information and	qualitative
9	Commercial perception of railway services	air, rail,	information and	qualitative
9	Commercial perception of services delivered by road depart-	all	information and	qualitative
9	Cargo handling services: Market openess	freight	information and	qualitative
9	Route length of multi-tracked rail lines	air, rail,	infrastructure and	
9	Rail line density in term of land area	air, rail,	infrastructure and	
9	Paved roads	all	infrastructure and	
9	Roads in fair/good condition	all	infrastructure and	
9	Road density in terms of land area	motorised	infrastructure and	
9	National roads boards exists and reports	undef.	management and	
9	Private sector representatives from majority of national road	undef.	management and	
9	Main (National) road agency operating with annual report pub-	undef.	management and	
9	Main (National) road agency publishing technical and financial	undef.	management and	
9	National road saftey action plan	all	management and	
9	Social assessment of road project management	undef.	management and	
9	Gender assessment	undef.	management and	
9	Access for all	all	management and	
9	Planning	all	management and	
9	Environmental assessment of road project mainstreamed	all	management and	
9	Communicable disease control	all	management and	
9	Competitive private sector participation in transport services	all	management and	
9	Core labour standards	all	management and	
9	Air share of passenger domestic travel	air, rail,	modal split	
9	Air share of total freight domestic carriage	air, rail,	modal split	
9	Inland and coastal shipping share of passenger domestic travel	air, rail,	modal split	
9	Inland and coastal shipping share of total freight domestic travel	air, rail,	modal split	
9	Rail share of passenger domestic travel	air, rail,	modal split	
9	Road share of passenger domestic travel	air, rail,	modal split	
9	Rail share of total freight domestic carriage	air, rail,	modal split	
9	Road share of total freight domestic carriage	freight	modal split	
9	Health and safety	all	safety	
9	Fatalities in road motor vehicle accidents in terms of vehicles	motorised	safety	
9	Fatalities in road motor vehicle accidents in terms of population	motorised	safety	
9	Motor vehicle fuel prices: Gasoline (Super/regular)	motorised	taxation and subsi-	
9	Motor vehicle fuel prices: Gas/Diesel Oil	motorised	taxation and subsi-	
9	Seaport traffic: Containers	air, rail,	traffic volumes and	
9	Seaport traffic: General cargo	air, rail,	traffic volumes and	
9	Rail traffic density	air, rail,	traffic volumes and	
9	Road user charges as share of total road expenditure	all	transport cost/gains	
9	Road expenditure as share of GDP	all	transport cost/gains	
9	External founds as share of total road expenditure	all	transport cost/gains	
9	Actual to require road maintenance expenditure	all	transport cost/gains	
9	Non-motorized road vehicles ownership in rural areas: Bicycles	bicycle	vehicle fleet	
9	Non-motorized road vehicles ownership in urban areas: Bicycles	bicycle	vehicle fleet	
9	Non-motorized road vehicles ownership: Bicycles	bicycle	vehicle fleet	
9	Motorized road vehicles ownership in rural areas: Private cars	car	vehicle fleet	
9	Motorized road vehicles ownership in urban areas: Private cars	car	vehicle fleet	
9	Motorized road vehicles ownership in rural areas: Motorcycles	car	vehicle fleet	
9	Motorized road vehicles ownership in urban areas: Motorcycles	car	vehicle fleet	
10	Avg. linear distance of citizens to a public primary school	all	accessibility	
10	Ratio between peak hour journey time (including waiting and	motorised	accessibility	
10	Percentage of citizens living within 500 m of buss stop, 1 km of	PT	accessibility	
10	Cost of montly network-wide PT ticket as the percentag of	PT	affordability	
10	GHG emission from transport sector per capita in tonnes of CO2	motorised	air emissions	
10	Daily exceedance of EU air quality standard for cities (PM10	motorised	air emissions	
10	Transportation final energy consumption per capita for city	motorised	energy and resource	

10	Adaption of public space, PT stops and vehicles to meet needs	all	Accessibility for	qualitative
10	Evaluation of ciy's measures to gather information regarding	all	information and	qualitative
10	Involvment of citizens and stakeholders through consultation	all	information and	qualitative
10	Advice on ecomobility modes: Information, campaign, travel	all	information and	qualitative
10	Expert opinion on the PT system ease of use i.e ticket include	PT	information and	qualitative
10	Percentage of city's streets and squares that are: car free or have	all	infrastructure and	
10	Qualiy of cycling network: safe, accessible, comfortable, signed,	bicycle	infrastructure and	qualitative
10	Quality of walking network: safe, accessible, comfortable,	pedestrian	infrastructure and	qualitative
10	Level of staff and resources available to implement SUMP or	all	management and	qualitative
10	Whether the city has an ecomobility strategy (i.e. SUMP) and	all	management and	qualitative
10	Evaluation of the city's follow-up work on what it has done and	all	management and	qualitative
10	Extent to which new city areas are planned to reduce the need of	all	management and	qualitative
10	Availability of high quality services supporting ecomobility:	all	management and	qualitative
10	Modal split for all trips by city residents (percentage)	all	modal split	
10	Percentage of inner-city parking space with hourly charge, time-	car	parking	
10	Traffic accidents resulting in death of serious injury per year and	all	safety	
10	Safety for vulnerable rooad users according to accident exposure	non-	safety	
10	Percentage of urban roads with speed limits >50km/h where	bicycle	traffic volumes and	
10	PT trips on the city's PT system divided by the population	PT	traffic volumes and	
10	Proportion of the total transportation budget spent on walking,	all	transport cost/gains	
10	Percentage of vehicles with more than four wheels that are low	motorised	vehicle fleet	
11	Level of connectivity of national and international air travel and	air, rail,	accessibility	
11	Level of connectivity of national and international sea travel and	air, rail,	accessibility	
11	Reliability of rail journey time	air, rail,	accessibility	
11	Average journey time on road network	motorised	accessibility	
11	Average cost of travel as a percentage of household income	all	affordability	
11	Level of emissions arising as a consequence of transport	motorised	air emissions	
11	Level of energy use intensity from transport	motorised	energy and resource	
11	Percentage of stations with disabled access	air, rail,	Accessibility for	
11	Implementation of customer facing tools for journey planning	all	information and	
11	Optimised provision of road space per 1000 population	all	infrastructure and	
11	Level of provision of dedicated cycle lanes	bicycle	infrastructure and	
11	Level of organisational, regulatory and modal integration which	all	management and	
11	Uptake of urban traffic control and security systems and their	all	management and	
11	Rate of fatal accidents from transport	all	safety	
11	Cost of transport provision from the community	all	taxation and subsi-	
12	Share of urban population and employment served by transit	PT	accessibility	
12	Index of relative household transport cost	all	affordability	
12	Index of relative cost of urban transport	all	affordability	
12	Transport-related user charge	all	affordability	
12	GHG emission for all transport	motorised	air emissions	
12	Index of emission of air pollutants from road transport	motorised	air emissions	
12	Air quality	motorised	air emissions	
12	Index of emission intensity of the road-vehicle fleet	motorised	air emissions	
12	Share of population and employment growth on already urban-	all	demography and	
12	Employment density by urban size, class and zone	undef.	demography and	
12	Use of fossil fuels energy for all transport	motorised	energy and resource	
12	Index of energy intensity of car and trucks	motorised	energy and resource	
12	Percentage of alternative fuel vehicles in the fleet	motorised	energy and resource	
12	Percentage of passenger-km and tonne-km fuelled by renewable	motorised	energy and resource	
12	Proximity of infrastructure to sensitive areas and ecosystems	all	habitat loss	
12	Effect on ecosystem	motorised	habitat loss	
12	Effect on human health	motorised	health	
12	Effects on health	motorised	health	
12	Number of sustainable transport indicators regularly updated	undef.	information and	
12	Public support for initiatives to achieve sustainable transporta-	all	information and	
12	Land use for transport	all	infrastructure and	
12	Urban land use per capita	all	infrastructure and	
12	Urban land use by class, size and zone	all	infrastructure and	
12	Length of paved roads	all	infrastructure and	
12	Lenght of sustainable infrastructure	all	infrastructure and	
12	Number of urban regions where planning and delivery of	undef.	management and	
12	Journey-to-work modal share	all	modal split	
12	Travel and modal share by urban zone	all	modal split	
12	Freight modal participation	freight	modal split	
12	Mixed use (percentage walking to work/jobs employed force)	pedestrian	modal split	
12	Share of passenger travel not by land-based PT	PT	modal split	
12	Noise	motorised	noise pollution	
12	Waste from road transport	motorised	Hazardous waste	
12	Discharge into water	motorised	Hazardous waste	

12	Index of road injuries and fatalities	all	safety
12	Urban and intercity person-km	all	traffic volumes and
12	Congestion index	all	traffic volumes and
12	Urban automobile vehicle-km	car	traffic volumes and
12	Total motorized movement of freight	freight	traffic volumes and
12	Total motorized movement of people	motorised	traffic volumes and
12	Movement of light-duty passenger vehicles	motorised	traffic volumes and
12	Travel by non-motorized models in urban areas	non-	traffic volumes and
12	Transit seat-km per capita	PT	traffic volumes and
12	Percent of net government transport expenditures spent on	all	transport cost/gains
12	Expenditures by businesses on transportation	all	transport cost/gains
12	Percentages of labour force regularly telecommuting	all	travel behaviour
12	Utilization of passenger vehicles	car	travel behaviour
12	Utilization of freight vehicles	freight	travel behaviour
13	Access to transport services e.g.: motor vehicles per household,	all	accessibility
13	Average passenger journey time and length per mode, purpose	all	accessibility
13	Real passenger and freight transport price by mode	all	affordability
13	Expendiure for personal mobility per person and income group	all	affordability
13	Transport emission and share in total emission for CO2,	motorised	air emissions
13	Exceedance of air quality objectives	motorised	air emissions
13	Emission per pass-km and emission per tonne-km for CO2,	motorised	air emissions
13	Transport final energy consumption and primary energy con-	all	energy and resource
13	Energy efficiency for passenger and freight transport (per pass-	motorised	energy and resource
13	Uptake of cleaner (unleaded petrol, electric, alternative fuels)	motorised	energy and resource
13	Infrastructure influence on the ecosystem and habitats ("frag-	all	infrastructure and
13	Land take by transport infrastructure	all	infrastructure and
13	Length of transport by mode and by type of infrastructure (e.g.	all	infrastructure and
13	Number of member states that implement an integrated transport	all	management and
13	number of member states with national transport and environ-	all	management and
13	Uptake of strategic environmental assessment in the transport	all	management and
13	Uptake of environmental management systems by transport	all	management and
13	Exposure to annoyance by traffic noise	motorised	noise pollution
13	Number of transport accidents, fatalities, injured, polluting	all	safety
13	Taxes	all	taxation and subsi-
13	Subsidies	all	taxation and subsi-
13	Fuel prices	motorised	taxation and subsi-
13	Private Total passengers	all	traffic volumes and
13	Private Total passenger-km	all	traffic volumes and
13	Private Passenger-km per capita	all	traffic volumes and
13	Private Passenger-km per GDP	all	traffic volumes and
13	Freight total tonnes	freight	traffic volumes and
13	Freight total tonnes-km	freight	traffic volumes and
13	Freight total tonnes-km per capita	freight	traffic volumes and
13	Freight total tonnes-km per GDP	freight	traffic volumes and
13	Load factor for road freight transport (LDV,HDV)	freight	traffic volumes and
13	Investment in transport infrastructure/capita and by mode	all	transport cost/gains
13	Public awareness and behaviour	all	travel behaviour
13	Occupancy rate of passenger vehicles	motorised	travel behaviour
13	Vehicle fleet size and average age	motorised	vehicle fleet
14	Travel time ratio	motorised	accessibility
14	Number of stops	PT	accessibility
14	Emissions of carbon dioxide per year	motorised	air emissions
14	Number of inhabitants	undef.	demography and
14	Squaremeters of city/inhabitants	undef.	demography and
14	Share alternative fuels	motorised	energy and resource
14	Number of stops completely adapted for disabled people	PT	Accessibility for
14	Number of stops partly adapted for disabled people	PT	Accessibility for
14	Share of bicycle network with good surface coating standard	bicycle	infrastructure and
14	Share of street network with good surface coating standard	motorised	infrastructure and
14	Share of walking network with good surface coating standard	pedestrian	infrastructure and
14	Number of pedestrian crossings	pedestrian	infrastructure and
14	Number of traffic lights with priority for bus traffic	PT	infrastructure and
14	Number of PT lanes	PT	infrastructure and
14	Squaremeters green area/inhabitants	undef.	infrastructure and
14	Share of network with parkways	undef.	infrastructure and
14	Share of trips to city centre by bicycle within municipality	bicycle	modal split
14	Share of trips to city centre by car within municipality	car	modal split
14	Share of children being taken to school by car	car	modal split
14	Share of trips to city centre by walking within municipality	pedestrian	modal split
14	Share of trips to city centre by bus within municipality	PT	modal split

14	Number of real estates that are exposed to noise levels higher	motorised	noise pollution	
14	Occupancy of bicycle parking lots near city centre	bicycle	parking	
14	Occupancy of parking lots near city centre	motorised	parking	
14	Number of killed per year	all	safety	
14	Number of gravely injured per year	all	safety	
14	Number of slightly injured per year	all	safety	
14	Share of bicyclists that feel safe in traffic	bicycle	safety	qualitative
14	Share of bicyclists that use helmet	bicycle	safety	
14	Number of pedestrian crossings with traffic safety measure	pedestrian	safety	
14	Share of pedestrians that feel safe in traffic	pedestrian	safety	qualitative
14	Bicycle traffic amounts	bicycle	traffic volumes and	
14	Mileage car within municipality, vehicle km per inhabitant and	car	traffic volumes and	
14	Vehicle velocities (Outer)	motorised	traffic volumes and	
14	Vehicle velocities (Inner)	motorised	traffic volumes and	
14	Average bus velocity	PT	traffic volumes and	
14	Number of trips per inhabitant with city bus per year	PT	traffic volumes and	
14	Private cars in traffic per 1000 inhabitants	car	vehicle fleet	
14	Vehicle amounts (Outer)	car	vehicle fleet	
14	Vehicle amounts (Inner)	car	vehicle fleet	
15	Average cost to user of car use	car	affordability	
15	Average cost to user of public transport by mode	PT	affordability	
15	Air quality by pollutant (NO2, SO2, Nox, VOC, particulates)	motorised	air emissions	
15	Size of administrative area	undef.	demography and	
15	Size of urban administrative area	undef.	demography and	
15	Number of residents of the regional administrative area	undef.	demography and	
15	Number of residents of the urban administrative area	undef.	demography and	
15	GDP per head of population	undef.	demography and	
15	% of resident population currently employed	undef.	demography and	
15	% of public transport vehicles with low floors, by mode	PT	Accessibility for	
15	Description of key geographical features influencing transport	all	infrastructure and	
15	Length of segregated, dedicated cycle paths in the administra-	bicycle	infrastructure and	
15	Length of road network	car	infrastructure and	
15	Length network by mode (bus/train/metro/tram)	PT	infrastructure and	
15	Length of bus lanes and segregated right of way for trams	PT	infrastructure and	
15	Total number of daily one-way journeys by mode in the admin-	all	modal split	
15	Number of injuries and deaths on the road network, per annum	all	safety	
15	Average speed of cars/motorcycles in peak hour	motorised	traffic volumes and	
15	Average speed of buses/trains/metro vehicles/trams in peak hour	PT	traffic volumes and	
15	Capital expenditure on roads, averaged over the last 5 years	motorised	transport cost/gains	
15	Capital expenditure on public transport, by mode, averaged over	PT	transport cost/gains	
15	Average vehicle occupancy by mode (car/bus/train/metro/tram)	motorised	travel behaviour	
15	Number of cars registrated in the administrative area	car	vehicle fleet	
15	Number of vehicles (by mode) operating in the administrative	motorised	vehicle fleet	
15	Typical service intervals of buses/trains/metro vehicles/trams in	PT	vehicle fleet	

APPENDIX IV
- Municipality results, given per indicator, subcategory and TRAST aspect

Municipality order for result:

- Göteborg
- Lund
- Umeå
- Uppsala
- Västerås

Table 10.16

GÖTEBORG KOMMUN

Subcategory	Indicator	Value	Unit	Year of data	Available at	Interpretation	Comments
City Characteristics							
Population	*Number of municipality inhabitants*	526 089,0	Inhabitants	2012	SCB: Befolkningsmängd	-	
	Night and daytime population					-	
Area	*Municipality land area*	447,8	km2	2012	SCB: Land- och vattenareal i kvadratkilometer efter region, arealtyp och tid	-	
	Urban area	203,7	km2	2012	SCB: Tätorter; arealer, befolkning	-	
Density	*Inhabitants per km2*	1 174,9	Inhabitants/km2	2012	-	-	Number of inhabitants/municipality land area
Income	*Income /Average income per capita*	229 684,0	SEK/year	2011	SCB: Inkomster och skatter	-	
Traffic System							
Length of infrastructure	*Length of road network per capita*	2,7	m per capita	2011	Statistisk årsbok Göteborg	less is better	
	Length of pedestrian network per capita					more is better	
	Length of bicycling network per capita	1,5	m per capita	2011		more is better	
Parking charge	*Maximum parking charge in central zone of the municipality*	30,0	SEK/hour	2013		more is better	
Traffic volume							
Modal comparison	*Share of the total number of trips, by the municipalities inhabitants, that are performed using a sustainable mode (pedestrian, bike or PT)*	52,1	%	2005	Trivector	more is better	
Journey length	*Share of the total distance travelled, by the municipalities inhabitants, that are performed using a sustainable mode (pedestrian, bike or PT)*	17,6	%	2005	Trivector	more is better	
Occupancy	*Car occupancy*	1,2	passengers per car	2012	SCB: Körsträcka, befolk., regi. bilar	more is better	
Vehicle fleet	*Number of inhabitant per registered car*	2,9	inhabitants/car	2012	Trafikanalys	more is better	
	Share green vehicles out of the total number of registered vehicle that meets the emission requirements	21,20	%	2012	Trafikanalys	more is better	

Accessibility							
Car/PT journey ratio	*Travel ratio comparison between car travel time and PT travel time. Three large living areas outside the city centre is used as start point. The central station and the largest hospital is used as end point.*	1,14	Ratio: car travel time/PT travel time			less is better	see separate calculation
Access to basic services	*Share of workplaces that have access to a public transport stop within 1 km*	95	%	2011	Trafikanalys	more is better	
	Share of population that lives within 1 km of a grocery store	69	%	2011	Trafikanalys	more is better	
Transit adaption to disabled	*Share of public transportation vehicles that have low floor*	75,20	%	2012	FRIDA: Västtrafik	more is better	Includes both trams and busses, LF1000, WC1030
	Audio or visual information	70,45	%	2012	FRIDA: Västtrafik	more is better	Includes both trams and busses
Affordability	*Cost of monthly network-wide PT ticket as the percentage of median gross monthly income*	2,6384	%	2013	Västtrafik: Periodkort	less is better	
Traffic safety							
Traffic accidents resulting in injury	*Traffic accidents resulting in death of serious injury per year and 100 000 inhabitants*	38	Accidents per 100 000 inhabitants	2009;2010	Göteborgs Stad: Statistik om trafiken i Göteborg	less is better	Average value of 2009 and 2010
Environmental impact							
Air emission	*Annual CO2 emissions per capita*	0,81	tonne per capita	2010	Länsstyrelsen: Nationella Emissionsdatabasen	less is better	Private cars, mopeds and motorcycles
	Annual PM10 emissions per km^2 of urban region	1,03	tonne per km2	2010	Länsstyrelsen: Nationella Emissionsdatabasen	less is better	Private cars, mopeds and motorcycles, wear from brakes and tyres, wear of road surface
Exposure to noise	*Portion of population exposed to high levels of traffic noise >55 db*	43,56	%	2007	Göteborg Stad: Bullerkartläggning	less is better	Population of 2007 is used

Table 10.17

LUNDS KOMMUN

Category/Subcategory	Indicator	Value	Unit	Year of data	Available at	Interpretation	Comment
City Characteristics							
Population	*Number of municipality inhabitants*	112 950,0	Number of inhabitants	2012	SCB: Befolkningsmängd	-	
	Night and daytime population					-	
Area	*Municipality land area*	427,2	km2	2012	SCB: Land- och vattenareal i kvadratkilometer efter region, arealtyp och tid	-	
	Urban area	25,8	km2	2012	SCB: Tätorter; arealer, befolkning	-	
Density	*Inhabitants per km2*	264,4	Inhabitants/km2	2012	-	-	Number of inhabitants/municipality land area
Income	*Income /Average income per capita*	221 099,0	SEK/year	2011	SCB: Inkomster och skatter	-	
Traffic System							

Length of infra-structure	*Length of road network per capita*					less is better	
	Length of pedestrian network per capita					more is better	
	Length of bicycling network per capita	2,2	m per capita	2011		more is better	
Parking charge	*Maximum parking charge in central zone of the municipality*	16,0	SEK/hour	2013	LK	more is better	
Traffic volume							
Modal comparison	*Share of the total number of trips, by the municipalities inhabitants, that are performed using a sustainable mode (pedestrian, bike or PT)*	52,6	%	2005	Trivector	more is better	
Journey length	*Share of the total distance travelled, by the municipalities inhabitants, that are performed using a sustainable mode (pedestrian, bike or PT)*	15,7	%	2005	Trivector	more is better	
Occupancy	*Car occupancy*	1,1	-	2012	SCB: Körsträcka, befolk., regi. bilar	less is better	
Vehicle fleet	*Number of inhabitant per registered car*	2,0	inhabitants/car	2012	Trafikanalys	more is better	
	Share green vehicles out of the total number of registered vehicle that meets the emission requirements	19,30	%	2012	Trafikanalys	more is better	
Accessibility							
Journey ratio	*Travel ratio comparison between car travel time and PT travel time. Three large living areas outside the city centre is used as start point. The central station and the largest hospital is used as end point.*	1,3				Less is better	
Access to basic services	*Share of workplaces that have access to a public transport stop within 1 km*	94	%	2011	Trafikanalys	more is better	
	Share of population that lives within 1 km of a grocery store	59	%	2011	Trafikanalys	more is better	
Transit adaption to disabled	*Share of public transportation vehicles that have low floor*	96,84	%	2012	FRIDA: Trafikområde Lund	more is better	WC:154,LF:153
	Audio or visual information	98,10	%	2012	FRIDA: Trafikområde Lund	more is better	
Affordability	*Cost of monthly network-wide PT ticket as the percentage of median gross monthly income*	2,4966	%	2013	Skånetrafiken: Jojo Period	less is better	
Traffic safety							
Traffic accidents resulting in injury	*Traffic accidents resulting in death of serious injury per year and 100 000 inhabitants*	36	Accidents per 100 000 inhabitants	2006 - 2010	Lunds Kommun: Trafikräkningar och trafikolyckor	less is better	Average value of 2006 to 2010
Environmental impact							
Air emission	*Annual CO2 emissions per capita*	0,82	tonne per capita	2010	Länsstyrelsen: Nationella Emissionsdatabasen	less is better	Private cars, mopeds and motorcycles
	Annual PM10 emissions per km2 of urban region	1,31	tonne per km2	2010	Länsstyrelsen: Nationella Emissionsdatabasen	less is better	Private cars, mopeds and motorcycles, wear from brakes and tyres, wear of road surface
Exposure to noise	*Portion of population exposed to high levels of traffic noise >55 db*	7,74	%	2011	Lund Kommun: Åtgärdsprogram mot buller	less is better	LEQ, not LDEN

Table 10.18

UMEÅ KOMMUN

Catego-ry/Subcategory	Indicator	Value	Unit	Year of data	Available at	Interpretation	Comments
City Characteris-tics							
Population	*Number of municipality inhabitants*	117 294,0	Number of inhabitants	2012	SCB: Befolk-ningsmängd	-	
	Night and daytime population					-	
Area	*Municipality land area*	2 316,6	km2	2012	SCB: Land- och vattena-real i kvadratkilometer efter region, arealtyp och tid	-	
	Urban area	34,2	km2	2012	SCB: Tätorter; arealer, befolkning	-	
Density	*Inhabitants per km2*	50,6	Inhabitants/km2	2012	-	-	Number of inhabit-ants/municipalit y land area
Income	*Income /Average income per capita*	239 120,0	SEK/year	2011	SCB: Inkomster och skatter	-	
Traffic System							
Length of infrastructure	*Length of road network per capita*					less is better	
	Length of pedestrian network per capita					more is better	
	Length of bicycling network per capita					more is better	
Parking charge	*Maximum parking charge in central zone of the municipali-ty*	20,0		2013		more is better	
Traffic volume							
Modal compari-son	*Share of the total number of trips, by the municipalities inhabitants, that are performed using a sustainable mode (pedestrian, bike or PT)*	49,4	%	2005	Trivector	more is better	
Journey length	*Share of the total distance travelled, by the municipalities inhabitants, that are performed using a sustainable mode (pedestrian, bike or PT)*	17,2	%	2005	Trivector	more is better	
Occupancy	*Car occupancy*	1,1	-	2012	SCB: Körsträcka, befolk., regi. bilar	less is better	
Vehicle fleet	*Number of inhabitant per registered car*	2,4	inhabitants/car	2012	Trafikanalys	more is better	
	Share green vehicles out of the total number of registered vehicle that meets the emission requirements	11,80	%	2012	Trafikanalys	more is better	
Accessibility							
Journey ratio	*Travel ratio comparison between car travel time and PT travel time. Three large living areas outside the city centre is used as start point. The central station and the largest hospital is used as end point.*	1,76					
Access to basic services	*Share of workplaces that have access to a public transport stop within 1 km*	80	%	2011	Trafikanalys	more is better	
	Share of population that lives within 1 km of a grocery store	55	%	2011	Trafikanalys	more is better	
Transit adaption to disabled	*Share of public transportation vehicles that have low floor*	100	%	2013	Mail Correspondence	more is better	
	Audio or visual information	100	%	2013	Mail Correspondence	more is better	

Affordability	*Cost of monthly network-wide PT ticket as the percentage of median gross monthly income*	2,4590	%	2013	Länstrafiken i Västerbotten: Ultra	less is better	
Traffic safety							
Traffic accidents resulting in injury	*Traffic accidents resulting in death of serious injury per year and 100 000 inhabitants*	34	Accidents per 100 000 inhabitants	2001-2005	Umeå Kommun: Trafiksäkerhetsprogammet	less is better	Values are old, for the whole region the number of accidents have decreased in the last year
Environmental impact							
Air emission	*Annual CO2 emissions per capita*	0,86	tonne per capita	2010	Länsstyrelsen: Nationella Emissionsdatabasen	less is better	Private cars, mopeds and motorcycles
	Annual PM10 emissions per km2 of urban region	2,23	tonne per km2	2010	Länsstyrelsen: Nationella Emissionsdatabasen	less is better	Private cars, mopeds and motorcycles, wear from brakes and tyres, wear of road surface
Exposure to noise	*Portion of population exposed to high levels of traffic noise >55 db*	26,51	%	2012	Umeå Kommun: Bullerkartläggning	less is better	

Table 10.19

UPPSALA KOMMUN

Category/Subcategory	Indicator	Value	Unit	Year of data	Available at	Interpretation	Comments
City Characteristics							
Population	*Number of municipality inhabitants*	202 625,0	Number of inhabitants	2012	SCB: Befolkningsmängd	-	
	Night and daytime population					-	
Area	*Municipality land area*	2 182,8	km2	2012	SCB: Land- och vattenareal i kvadratkilometer efter region, arealtyp och tid	-	
	Urban area	48,8	km2	2012	SCB: Tätorter; arealer, befolkning	-	
Density	*Inhabitants per km2*	92,8	Inhabitants/km2	2012	-	-	Number of inhabitants/municipality land area
Income	*Income /Average income per capita*	237 116,0	SEK/year	2011	SCB: Inkomster och skatter	-	
Traffic System							
Length of infrastructure	*Length of road network per capita*					less is better	
	Length of pedestrian network per capita					more is better	
	Length of bicycling network per capita					more is better	
Parking charge	*Maximum parking charge in central zone of the municipality*	25,0	SEK/hour		Municipality website	more is better	
Traffic volume							
Modal comparison	*Share of the total number of trips, by the municipalities inhabitants, that are performed using a sustainable mode (pedestrian, bike or PT)*	55,1	%	2005	Trivector	more is better	
Journey length	*Share of the total distance travelled, by the municipalities inhabitants, that are performed using a sustainable mode (pedestrian, bike or PT)*	16,7	%	2005	Trivector	more is better	

Occupancy	*Car occupancy*	1,1	-	2012	SCB: Körsträcka, befolk., regi. bilar	less is better	see calculation in seperate sheet
Vehicle fleet	*Number of inhabitant per registered car*	2,6	inhabitants/car	2012	Trafikanalys	more is better	
	Share green vehicles out of the total number of registered vehicle that meets the emission requirements	14,40	%	2012	Trafikanalys	more is better	
Accessibility							
Journey ratio	*Travel ratio comparison between car travel time and PT travel time. Three large living areas outside the city centre is used as start point. The central station and the largest hospital is used as end point.*	N/A	-	2013	Google maps,municipalities web page		see separat calculation sheet
Access to basic services	*Share of workplaces that have access to a public transport stop within 1 km*	88	%	2011	Trafikanalys	more is better	
	Share of population that lives within 1 km of a grocery store	63	%	2011	Trafikanalys	more is better	
Transit adaption to disabled	*Share of public transportation vehicles that have low floor*	N/A				more is better	
	Audio or visual information	N/A				more is better	
Affordability	*Cost of monthly network-wide PT ticket as the percentage of median gross monthly income*	3,9980	%	2013	UL: 30-dagarskort	less is better	Includes Knivsta Municipality
Traffic safety							
Traffic accidents resulting in injury	*Traffic accidents resulting in death of serious injury per year and 100 000 inhabitants*	39	Accidents per 100 000 inhabitants	2003-2013	Mail correspondence	less is better	
Environmental impact							
Air emission	*Annual CO2 emissions per capita*	0,91	tonne per capita	2010	Länsstyrelsen: Nationella Emissionsdatabasen	less is better	Private cars, mopeds and motorcycles
	Annual PM10 emissions per km2 of urban region	3,36	tonne per km2	2010	Länsstyrelsen: Nationella Emissionsdatabasen	less is better	Private cars, mopeds and motorcycles, wear from brakes and tyres, wear of road surface
Exposure to noise	*Portion of population exposed to high levels of traffic noise >55 db*	N/A	db	2012	Municipality web page	less is better	

Table 10.20

VÄSTERÅS KOMMUN

Catego-ry/Subcatagory	Indicator	Value	Unit	Year of data	Available at	Interpretation	Comments
City Characteris-tics							
Population	*Number of municipality inhabitants*	140 499,0	Number of inhabitants	2012	SCB: Befolkningsmängd	-	
	Night and daytime population					-	
Area	*Municipality land area*	957,9	km2	2012	SCB: Land- och vattenareal i kvadratkilometer efter region, arealtyp och tid	-	
	Urban area	52,9	km2	2012	SCB: Tätorter; arealer, befolkning	-	

Density	*Inhabitants per km2*	146,7	Inhabit-ants/km2	2012	-	-	Number of inhabit-ants/municipality land area
Income	*Income /Average income per capita*	239 970,0	SEK/year	2011	SCB: Inkomster och skatter	-	
Traffic System							
Length of infrastructure	*Length of road network per capita*					less is better	
	Length of pedestrian network per capita					more is better	
	Length of bicycling network per capita	2,5	capita	2011		more is better	
Parking charge	*Maximum parking charge in central zone of the municipality*	18,0	SEK/hour			more is better	The cost increase the second hour
Traffic volume							
Modal compari-son	*Share of the total number of trips, by the municipalities inhabitants, that are performed using a sustainable mode (pedestrian, bike or PT)*	46,1	%	2005	Trivector	more is better	
Journey length	*Share of the total distance travelled, by the municipalities inhabitants, that are performed using a sustainable mode (pedestrian, bike or PT)*	9,7	%	2005	Trivector	more is better	
Occupancy	*Car occupancy*	1,1	-	2012	SCB: Körsträcka, befolk., regi. bilar	less is better	
Vehicle fleet	*Number of inhabitant per registered car*	2,2	inhabitants/car	2012	Trafikanalys	more is better	
	Share green vehicles out of the total number of registered vehicle that meets the emission requirements	13,00	%	2012	Trafikanalys	more is better	
Accessibility							
Journey ratio	*Travel ratio comparison between car travel time and PT travel time. Three large living areas outside the city centre is used as start point. The central station and the largest hospital is used as end point.*	1,48					
Access to basic services	*Share of workplaces that have access to a public transport stop within 1 km*	91	%	2011	Trafikanalys	more is better	
	Share of population that lives within 1 km of a grocery store	63	%	2011	Trafikanalys	more is better	
Transit adaption to disabled	*Share of public transportation vehicles that have low floor*	93,6	%	2012	FRIDA: Depå Västerås	more is better	
	Audio or visual information	100	%	2012	FRIDA: Depå Västerås	more is better	
Affordability	*Cost of monthly network-wide PT ticket as the percentage of median gross monthly income*	2,7503	%	2013	Västmanlands lo-kaltrafik: Stadsbussen	less is better	
Traffic safety							
Traffic accidents resulting in injury	*Traffic accidents resulting in death of serious injury per year and 100 000 inhabitants*	25	Accidents per 100 000 inhabitants	2004	Västerås stad: Press release	less is better	Only one year, not an average value
Environmental impact							
Air emission	*Annual CO2 emissions per capita*	1,06	tonne per capita	2010	Länsstyrelsen: Nationel-la Emissionsdatabasen	less is better	Private cars, mopeds and motorcycles
	Annual PM10 emissions per km2 of urban region	2,45	tonne per km2	2010	Länsstyrelsen: Nationel-la Emissionsdatabasen	less is better	Private cars, mopeds and motorcycles, wear from brakes and tyres, wear of road surface
Exposure to noise	*Portion of population exposed to high levels of traffic noise >55 db*	30,00	%	2011	Västerås Kommun: Bullerkartläggning	less is better	

APPENDIX V
- Result summary and point calculation

Summary of gathered data for all municipalities, given per indicator:

Table 10.21

Indicator	Göteborg	Lund	Umeå	Uppsala	Väster-ås	Interpreta-tion	Unit
City Characteristics							
Number of municipality inhab-itants	526 089,0	112 950, 0	117 294, 0	202 625, 0	140 499, 0	-	Inhabitants
Night and daytime population	0,0	0,0	0,0	0,0	0,0	-	Inhabitants
Municipality land area	447,8	427,2	2 316,6	2 182,8	957,9	-	km2
Urban area	203,7	25,8	34,2	48,8	52,9	-	km2
Inhabitants per km2	1 174,9	264,4	50,6	92,8	146,7	-	Inhabit-ants/km2
Income /Average income per capita	229 684,0	221 099, 0	239 120, 0	237 116, 0	239 970, 0	-	SEK/year
Traffic system							
Length of road network per capita	2,7	0,0	0,0	0,0	0,0	less is better	m per capita
Length of pedestrian network per capita	0,0	0,0	0,0	0,0	0,0	more is better	m per capita
Length of bicycling network per capita	1,5	2,2	1,5*	1,8	2,5	more is better	m per capita
Maximum parking charge in central zone of the municipali-ty	30,0	16,0	20,0	25,0	18,0	more is better	SEK/hour
Traffic volume							
Share of the total number of trips, by the municipalities inhabitants, that are per-formed using a sustainable mode (pedestrian, bike or PT)	52,1	52,6	49,4	55,1	46,1	more is better	%
Share of the total distance travelled, by the municipalities inhabitants, that are per-formed using a sustainable mode (pedestrian, bike or PT)	17,6	15,7	17,2	16,7	9,7	more is better	%
Car occupancy	1,16	1,05	1,12	1,14	1,12	less is better	passengers per car
Number of inhabitant per registered car	2,9	2,0	2,4	2,6	2,2	more is better	inhabit-ants/car
Share green vehicles out of the total number of registered vehicle that meets the emission requirements	21,20	19,30	11,80	14,40	13,00	more is better	%
Accessibility							
Travel ratio comparison be-tween car travel time and PT travel time. Three large living areas outside the city centre is used as start point. The central station and the largest hospital is used as end point.	1,14	1,3	1,76	N/A	1,48	less is better	Ratio: car travel time/PT travel time
Share of workplaces that have access to a public transport stop within 1 km	95	94	80	88	91	more is better	%
Share of population that lives within 1 km of a grocery store	69	59	55	63	63	more is better	%
Share of public transportation vehicles that have low floor	75,20	96,84	100	N/A	93,6	more is better	%
Audio or visual information	70,45	98,10	100	N/A	100	more is better	%

Cost of monthly network-wide PT ticket as the percentage of median gross monthly income	2,6	2,5	2,5	4,0	2,8	less is better	%
Traffic safety							
Traffic accidents resulting in death of serious injury per year and 100 000 inhabitants	38	36	34	39	25	less is better	Accidents per 100 000 inhabitants
Environmental impacts							
Annual CO2 emissions per capita	0,81	0,82	0,86	0,91	1,06	less is better	tonne per capita
Annual PM10 emissions per km2 of urban region	1,03	1,31	2,23	3,36	2,45	less is better	tonne per km2
Portion of population exposed to high levels of traffic noise >55 db	43,56	7,74	26,51	N/A	30,00	less is better	%

* The red typing indicates that the value has not been found and that the worst value of the assessed municipalities has been used.

Percentage scoring, given per indicator:

Table 10.22

Indicator	Göteborg	Lund	Umeå	Uppsala	Västerås
Traffic System, average:	79%	71%	67%	77%	80%
Length of road network per capita					
Length of pedestrian network per capita					
Length of bicycling network per capita	58%	88%	58%	70%	100%
Maximum parking charge in central zone of the municipality	100%	53%	67%	83%	60%
Traffic volume, average:	100%	88%	85%	91%	75%
Share of the total number of trips, by the municipalities inhabitants, that are performed using a sustainable mode (pedestrian, bike or PT)	99%	100%	94%	105%	88%
Share of the total distance travelled, by the municipalities inhabitants, that are performed using a sustainable mode (pedestrian, bike or PT)	100%	89%	98%	95%	55%
Car occupancy	100%	91%	96%	98%	97%
Number of inhabitant per registered car	100%	68%	81%	88%	75%
Share green vehicles out of the total number of registered vehicle that meets the emission requirements	100%	91%	56%	68%	61%
Accessibility, average:	90%	94%	88%	82%	91%
Travel ratio comparison between car travel time and PT travel time. Three large living areas outside the city centre is used as start point. The central station and the largest hospital is used as end point.	100%	88%	65%	N/A	77%
Share of workplaces that have access to a public transport stop within 1 km	100%	99%	84%	93%	96%
Share of population that lives within 1 km of a grocery store	100%	86%	80%	91%	91%
Share of public transportation that are wheelchair adapted or low floor	75%	97%	100%	N/A	94%
Audio or visual information	70%	98%	100%	N/A	100%

Cost of monthly network-wide PT ticket as the percentage of median gross monthly income	93%	98%	100%	62%	89%
Traffic safety, average:	66%	69%	73%	65%	100%
Traffic accidents resulting in death of serious injury per year and 100 000 inhabitants	66%	69%	73%	65%	100%
Environmental impact, average:	73%	93%	57%	60%	48%
Annual CO2 emissions per capita	100%	99%	95%	89%	77%
Annual PM10 emissions per km^2 of urban region	100%	79%	46%	31%	42%
Portion of population exposed to high levels of traffic noise >55db	18%	100%	29%	N/A	26%

Point scoring, given per indicator:

Table 10.23

		Municipality scoring			
Indicator	**Potential indicator score**	**Göteborg**	**Lund**	**Umeå**	**Västerås**
Traffic System					
Length of road network per capita	10	0	0	0	0
Length of pedestrian network per capita	10	0	0	0	0
Length of bicycling network per capita	10	6	9	6	10
Maximum parking charge in central zone of the municipality	10	10	5	7	6
Traffic volume					
Share of the total number of trips, by the municipalities inhabitants, that are performed using a sustainable mode (pedestrian, bike or PT)	15	15	15	14	13
Share of the total distance travelled, by the municipalities inhabitants, that are performed using a sustainable mode (pedestrian, bike or PT)	15	15	13	15	8
Car occupancy	10	10	9	10	10
Number of inhabitant per registered car	10	10	7	8	7
Share green vehicles out of the total number of registered vehicle that meets the emission requirements	10	10	9	6	6
Accessibility					
Travel ratio comparison between car travel time and PT travel time. Three large living areas outside the city centre is used as start point. The central station and the largest hospital is used as end point.	10	10	9	6	8
Share of workplaces that have access to a public transport stop within 1 km	10	10	10	8	10
Share of population that lives within 1 km of a grocery store	10	10	9	8	9
Share of public transportation that are wheelchair adapted or low floor	5	4	5	5	5
Audio or visual information	5	4	5	5	5
Cost of monthly network-wide PT ticket as the percentage of median gross monthly income	10	9	10	10	9
Traffic safety					
Traffic accidents resulting in death of serious injury per year and 100 000 inhabitants.	10	7	7	7	10

Environmental impact					
Annual CO2 emissions per capita	10	10	10	9	8
Annual PM10 emissions per km2 of urban region	10	10	8	5	4
Portion of population exposed to high levels of traffic noise >55 db.	10	2	10	3	3

Percentage scoring, given per subcategory:

Table 10.24

Subcategory	Göteborg	Lund	Umeå	Västerås
Traffic System				
Length of infrastructure	0%	0%	0%	0%
	0%	0%	0%	0%
	58%	88%	58%	100%
Parking charge	100%	53%	67%	60%
Traffic volume				
Modal comparison	99%	100%	94%	88%
Journey length	100%	89%	98%	55%
Occupancy	100%	91%	96%	97%
Vehicle fleet	100%	68%	81%	75%
	100%	91%	56%	61%
Accessibility				
Car/PT journey ratio	100%	88%	65%	77%
Access to basic services	100%	99%	84%	96%
	100%	86%	80%	91%
Transit adaption to disabled	75%	97%	100%	94%
	70%	98%	100%	100%
Affordability	93%	98%	100%	89%
Traffic safety				
Traffic accidents resulting in injury	66%	69%	73%	100%
Environmental impact				
Air emission	100%	99%	95%	77%
	100%	79%	46%	42%
Exposure to noise	18%	100%	29%	26%

Point scoring, given per subcategory:

Table 10.25

Subcategory	Subcategory score	Göteborg	Lund	Umeå	Västerås
Traffic System					
Length of infrastructure	30	6	9	6	10
Parking charge	10	10	5	7	6
Traffic volume					
Modal comparison	15	15	15	14	13
Journey length	15	15	13	15	8
Occupancy	10	10	9	10	10

Vehicle fleet	20	20	16	14	13
Accessibility					
Car/PT journey ratio	10	10	9	6	8
Access to basic services	20	20	19	16	19
Transit adaption to disabled	10	8	10	10	10
Affordability	10	9	10	10	9
Traffic safety					
Traffic accidents resulting in injury	10	7	7	7	10
Environmental impact					
Air emission	20	20	18	14	12
Exposure to noise	10	2	10	3	3

Point scoring, given per TRAST aspect:

Table 10.26

TRAST aspect	Potential max score	Göteborg	Lund	Umeå	Västerås
Traffic System	40	16,0	14,0	13,0	16,0
Traffic volume	60	60,0	53,0	53,0	44,0
Accessibility	50	47,0	48,0	42,0	46,0
Traffic safety	10	7,0	7,0	7,0	10,0
Environmental impact	30	22,0	28,0	17,0	15,0
Total score	**190**	**152,0**	**150,0**	**132,0**	**131,0**

APPENDIX VI

- SHIFT WEIGHING METHOD

The values inserted in the table are only fictional and does not represent data gathered from any municipality.

Table 10.27

Indicators	Attained level	Score		
		Achieved score		Max score
Enablers		**74**	**82%**	**90**
Knowledge of society and user needs	**2**	4	**40%**	10
Vision, strategy and leadership	**4**	24	**80%**	30
Personnel and resources	**5**	10	**100%**	10
Finance for Ecomobility	**5**	20	**100%**	20
Public participation	**3**	6	**60%**	10
Monitoring, evaluation & review	**5**	10	**100%**	10
Transport system and services		**129**	**76%**	**170**
Accessibility to services	**4**	16	**80%**	20
Planning of new city areas	**4**	12	**80%**	15
Car free and low speed zones	**4**	8	**80%**	10
Information systems and mobility management	**2**	4	**40%**	10
MM services supporting Ecomobility	**4**	8	**80%**	10
Parking Policy and other traffic restraint measures	**5**	15	**100%**	15
Accessibility for people with reduced mobility (PRM)	**4**	8	**80%**	10
Walking infrastructure	**4**	8	**80%**	10
Cycling infrastructure	**5**	10	**100%**	10
Other cycling conditions	**5**	10	**100%**	10
Coverage of PT network	**2**	4	**40%**	10
PT Speed	**2**	4	**40%**	10
PT Affordability	**2**	4	**40%**	10
PT Simplicity - ease of use	**4**	8	**80%**	10
Green vehicles	**5**	10	**100%**	10
Results and impacts		**80**	**89%**	**90**
Modal Split	**5**	30	**100%**	30
PT trips per capita	**4**	8	**80%**	10
Safety overall	**5**	10	**100%**	10
Safety - vulnerable road users	**2**	4	**40%**	10
Energy efficiency	**5**	10	**100%**	10
Greenhouse gases	**4**	8	**80%**	10
Local air quality	**5**	10	**100%**	10
Total		**283**	**81%**	**350**