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Keywords:
Sustainability, transport, city, indicators

Abstract:
The HASTA indicator framework, covering the three dimensions of sustainability, i.e. Economic, Environmental and Social, to monitor sustainability of transport in Swedish cities was elaborated. Under the three sustainability dimensions, there are 6 sustainability aspects (indicator groups), 2-3 per dimension; these are Efficiency, Accessibility (Economic dimension), Accessibility, Safety, Liveability (Social dimension); Emissions, Resource use (Environmental dimension). The accessibility indicator group is related with both economic and social sustainability. The individual indicators are structured in three levels of a hierarchical structure. The highest level is represented by the Outcome indicators which reflect the sustainability target in the subject area of the indicator. These Outcome indicators are of both objectively measurable variables and subjective variables, reflecting how the inhabitants experience sustainability of transport in their city. On the lowest level, the Input indicators provide information on possible measures to make improvements in transport sustainability. On the intermediate level, the Output indicators show the effect of the adopted measures (Input indicators). There are 19 Outcome indicators, 22 Output indicators and 42 Input indicators.

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This report is the 5th scientific report, written in the framework of the research program HASTA (Sustainable Attractive City). It presents an international overview of definitions of sustainable transportation, the selection process and the final list of sustainability indicators.

The framework Program HASTA is carried out by Traffic & Roads, Department of Technology and Society, Lund University. Research within this framework focuses on the city and its qualities. One basic quality is safety, but other important qualities are perceived safety and security, accessibility, efficiency, liveability and the environment. HASTA's vision for the sustainable and attractive city is a city that provides, within the frames of the society, its inhabitants' different and changing needs, without compromising future residents' needs. The societal frames are defined by ecological, social, and economic sustainability.

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Lund, March 2011

HASTA
HÅLLBAR ATTRAKTIV STAD

Content

Summary

The aim of this report was to elaborate a framework of indicators to monitor sustainability of transport in Swedish cities. Indicators, related with sustainable transport were collected through a review of the international literature, municipalities' websites in both Sweden and abroad, and via in-depth interviews with municipality officers in Sweden. The result of this phase was a long list – more than 200 indicators – with a wide range of scales, content and fields of use. Based on a number of criteria and conditions, a short list and a framework of sustainable transport indicators for Swedish municipalities were compiled to build a base for a monitoring tool.

The HASTA indicator framework covers the three dimensions of sustainability, i.e. Economic, Environmental and Social. The framework includes all the relevant aspects of sustainability of the transport system. Under the three sustainability dimensions, there are 6 sustainability aspects (indicator groups), 2-3 per dimension; these are Efficiency, Accessibility (Economic dimension), Accessibility, Safety, Liveability (Social dimension); Emissions, Resource use (Environmental dimension). The accessibility indicator group is related with both economic and social sustainability.

The individual indicators are structured in three levels of a hierarchical structure. The highest level is represented by the Outcome indicators which reflect the sustainability target in the subject area of the indicator. These Outcome indicators are of both objectively measurable variables and subjective variables, reflecting how the inhabitants experience sustainability of transport in their city. On the lowest level, the Input indicators provide information on possible measures or tools to make improvements in transport sustainability. On the intermediate level, the Output indicators show the effect of the adopted measures (Input indicators). There are 19 Outcome indicators, 22 Output indicators and 42 Input indicators.

The list of indictors is not to be seen as a final or ultimate list. As new knowledge emerges, the list can be updated and - especially to the input indicator list - new indicators can be added. This kind of work is continuous and the framework and indicators should be updated or altered when new knowledge is available.

The new thing with this framework and indicator list compared to earlier works is that, besides objective, measurable indicators, the HASTA framework puts weight on subjective indicators, i.e. how the population experiences the sustainability of transport in their city, their satisfaction with the transport and its effects on the environment and social issues.

Further, a new group of a different kind of indicator set, i.e. Institutional indicators are proposed to be included in the HASTA framework. The Institutional indicators reflect the capacity and readiness of the municipality administration to handle sustainability issues and they consist of Strategic, Organisational and Actions indicators.

The elaborated HASTA framework constitutes a base for developing a tool, visualising in a simple way the current situation, to monitor sustainability of transport in Swedish cities. The next step in operationalising the HASTA indicator framework is the weighting of the outcome indicators to aggregate them so that decision makers can get a simple picture of the current sustainability situation of their city.

Sammanfattning

Målet med denna rapport var att utveckla ett indikatorramverk för att följa upp transporthållbarhet i svenska städer. Indikatorer som berör hållbara transporter samlades genom en genomgång av den internationellt publicerade litteraturen inom området, från svenska och utländska kommuners hemsidor, samt genom djupintervjuer med svenska kommuntjänstemän. Resultatet från denna fas i arbetet var en lång lista med mer än 200 indikatorer på många olika skalor, med olika innehåll och tillämpningsområden. Baserat på ett antal kriterier och förutsättningar sammanställdes därefter en lista med de mest relevanta indikatorerna och ett ramverk med indikatorer för hållbara transporter i svenska kommuner skapades.

HASTAs indikatorramverk täcker de tre hållbarhetsdimensionerna; ekonomisk, ekologisk och social hållbarhet. Ramverket inkluderar alla aspekter som är viktiga för att definiera ett hållbart transportsystem. De tre hållbarhetsdimensionerna består av sju hållbarhetsaspekter (indikatorgrupper), två eller tre per dimension. Dessa är effektivitet, tillgänglighet (ekonomiska dimensionen), tillgänglighet, säkerhet, ”livability” (svensk översättning saknas för begreppet) (sociala dimensionen), utsläpp, resursanvändning (ekologiska dimensionen). Indikatorgruppen för tillgänglighet är relaterad till både ekonomisk och social hållbarhet.

De individuella indikatorerna är strukturerade i en hierarki på tre nivåer. Den högsta nivån representeras av utfallsindikatorer, vilka reflekterar hållbarhetsmålet i indikatorns ämnesområde. Dessa utfallsindikatorer består både av objektivt mätbara variabler och subjektiva variabler som återspeglar hur invånarna upplever transporthållbarheten i sin stad. På den lägsta nivån ger inputindikatorerna information om möjliga åtgärder för att förbättra transporthållbarheten. På mellannivån visar outputindikatorerna effekten av de tillämpade åtgärderna (inputindikatorerna). Det finns 19 utfallsindikatorer, 22 outputindikatorer och 42 inputindikatorer.

Listan på indikatorer ska inte ses som slutgiltig eller fullkomlig. Allt eftersom ny kunskap dyker upp kommer listan att uppdateras, speciellt listan med inputindikatorer, och utökas. Denna typ av arbete är kontinuerligt varför ramverket och indikatorerna ska uppdateras eller förändras allt eftersom ny kunskap blir tillgänglig.

Nyheten med detta ramverk och denna indikatorlista jämfört med tidigare arbeten som gjorts inom området är att HASTAs ramverk inte bara lägger fokus på objektiva och mätbara indikatorer. I HASTAs ramverk läggs tyngden istället på subjektiva indikatorer såsom hur invånarna upplever transporthållbarheten i sin stad eller hur nöjda de är med transportsystemet och dess effekter på ekologiska och sociala faktorer.

Vidare föreslås ytterligare en indikatorgrupp att inkluderas i HASTAs ramverk; institutionella indikatorer. Institutionella indikatorer återspeglar hur lätt och vilken möjlighet den kommunala administrationen har att hantera hållbarhetsfrågor. De institutionella indikatorerna består av strategiska, organisatoriska och åtgärdsindikatorer.

Det vidareutvecklade HASTA-ramverket ger en grund till att utveckla ett verktyg för att enkelt kunna visualisera den aktuella situationen med syfte att följa upp transporthållbarhet i svenska städer. Det nästa steget för att operationalisera HASTAs indikatorramverk är att vikta utfallsindikatorerna för att sätta samman dem på ett sätt som ger beslutsfattarna en enkel och överskådlig bild av hur den aktuella hållbarhetssituationen i deras stad ser ut.

1. Introduction

1.1. Background

The vision of a sustainable and attractive city requires a good insight and awareness among municipal decision-makers and officials. It also requires that municipalities have an appropriate organization and established processes to work effectively towards this vision of a sustainable and attractive city. A systematic work requires that planners, managers and decision makers have access to well-established and scientifically validated methods to monitor the development of sustainability of transport in the city.

There is a large amount of knowledge at the international scientific community concerning individual factors affecting sustainability (Munier, 2005). This knowledge has to be made available in a simply understandable form for planners, transport managers, decision makers – as well as all stakeholders.

The purpose of this segment of the HASTA project is to develop a tool to measure sustainability of the transport system in Swedish municipalities. This measuring tool will be based on a list of indicators. In the first phase of the project we tried to capture the concept of sustainability through finding answer to our questions in the literature:

- Why we need to aspire after sustainable transports?
- What is a sustainable transport system?
- How to achieve it?
- Who should start the alteration of the transport system towards sustainability?

The answers to these questions constitute the base of understanding, the starting point of our work. Since sustainability becomes a largely discussed topic in the last decades, a part of the answers are known without a large literature study. By thinking through these questions about sustainable transport the context of this general term will be adapted to the target of the HASTA project and to the Swedish ambience.

Why we need to aspire after sustainable transports?

The development of the transport system points to use of too much of non-renewable resources and goods (land, energy, money) and produce too much damage on the nature and the social environment.

What is a sustainable transport system?

There is no widely accepted, specified definition and the meaning of this term seems to be changing. To find a relevant answer to this question, a review of literature is necessary.

How to achieve it?

The need to measure sustainability appeared the same time as the concept of sustainability. Nowadays – after almost two decades of research – a wide range of literature is available related with sustainability in different contexts, emphasising the importance of a measuring process. The large majority of researchers agree, the most convenient way to measure the level of sustainability is using indicators. Several sets of indicators – involving economic, environmental and social aspects of transport – were developed during the past but many of them conclude the need of further research.

Here, we have to mention, there are cities (like Aalborg in Denmark, Oslo in Norway, London, Brighton and Hove in UK) who started to monitor their development taking into account several principles of sustainability (STATUS, 2006). But their methods focus more on the city or township on the whole treating transport system as a part which means, that the number of transport-related indicators is general and limited.

Who should start the alteration of the transport system towards sustainability?

Ideally, all actors take their part in keeping the transport system sustainable. But who should take the first step? According to the actual situation, it is the municipalities who should find an optimum between the needs of numerous stakeholders like policy makers, decision makers, inhabitants etc. Here we can recognise a reason why it is not so easy to reach this balance. There are two main lacking issues related with sustainability: power and political will (Viederman, 1995). The municipalities need to measure their current situation, see clearly an effective way to reach/keep balance in the transport system. That is why there is a need for a tool, easily understandable and reflecting the political targets.

1.2. Sustainability

As a consequence of a growing interest in sustainability and its implications for a wider and wider field, 'Sustainability' has become a keyword in the last decades. "Sustainability reflects the fundamental human desire to protect and improve the world. Sustainability emphasizes the integrated nature of human activities and therefore the need to coordinate decisions among different sectors, groups and jurisdictions" (Litmann, 2009, p.4).

Sustainability is a vast and complex issue and its meaning depends on the context. Talking about sustainability itself or sustainable development, planning, design, construction, management, etc. changes the meaning essentially. It has varying meanings to different people and in many aspects it can be considered to include conflicting goals (e.g. increasing economic growth versus global equality or decreasing resource use). Therefore, definitions of sustainability are connected to the values and value systems of people making them (Koglin, 2009).

There are various definitions and interpretations of sustainable transport. One definition, closest to hand is based on the definition of sustainability by the Brundtland commission, stating that "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1978). This definition, however, is vague and can lead to various problems, like e.g. the exclusion of people or groups from decision making processes or consensus politics where nothing is changed (see Koglin 2009). Nevertheless, it could also be of interest not to focus on the definition in order to operationalize the term, but instead to focus on the characteristics of the concept and see how they could be connected to the transport sector (Holding 2007). Sustainability encompasses many different disciplines and it has many different decisions (Poor, Lindquist 2009). All the definitions have to do with: "living within the limits; understanding the interconnections among economy, society; and environment and equitable distribution of resources and opportunities" (Sustainable Measures, 2010).

Litmann (2009) points to that "...sustainability is sometimes defined narrowly, focusing on a few specific problems such as resource depletion and pollution, but is increasingly defined broadly to include other issues. Narrowly defined sustainability can overlook connections between issues and opportunities for integrated solutions". The illustration of a broader definition, covering the 3 dimensions of sustainability is shown in figure 1.

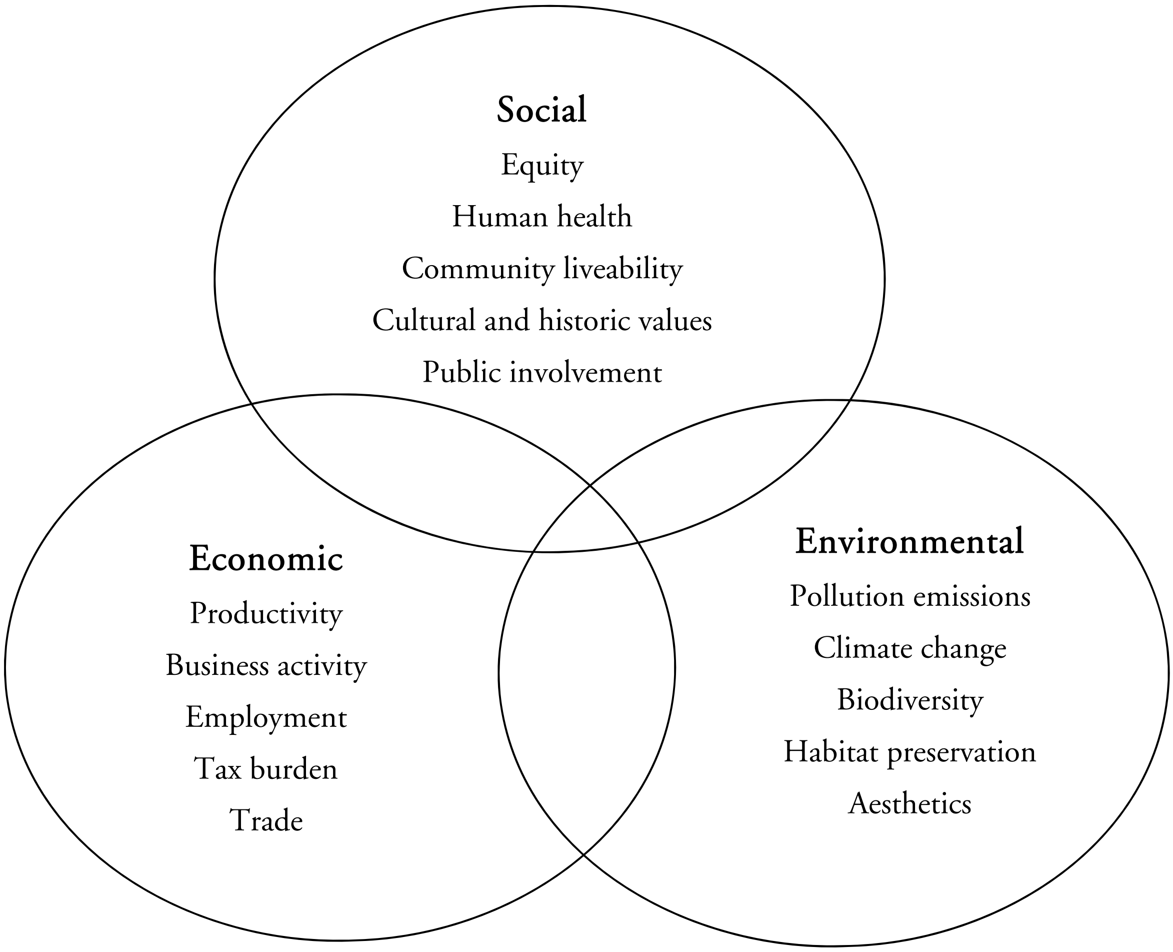


Figure 1. Sustainability dimensions and aspects (based on Litmann, 2009).

As illustrated in figure 1, the 3 dimensions of sustainability, i.e. Economic, Environmental and Social can partly overlap each other. For example, pollution is an environmental concern, which also affects human health (a social concern), and agricultural activities or tourism (economic concerns). Sustainable planning must consider that impacts and objectives often interact, hence an integrated approach is necessary. Consideration of economic, environmental and social objectives together is often called a "triple bottom line." (Litmann, 2009).

According to the "less technical" approach of sustainability, the difficulties of making a clear definition are due to the strong influence of the human factor, since sustainability includes the non-material side of life, like perception, morals, and values. These are not absolutes, and not easy to define. As Fricker (2001) points out "The challenge of sustainability is neither wholly technical nor rational. It is a matter of attitude and behaviour. Sustainability therefore must include the social discourse where the fundamental issues are explored collaboratively within the groups or community concerned". Taking into account the social issue, the context of sustainability becomes more complex. Acording to Veiderman's (1995) definition "...sustainability is a vision of the future that provides us with a road map and helps us to focus our attention on a set of values and ethical and moral principles by which to guide our actions".

1.3. Sustainable transport

Talking about sustainability and sustainable development is almost impossible without including transport. Transport is connected to mobility, which means that sustainable transport cannot be analysed without investigating mobility and mobility patterns. Human kind has always travelled. The patterns and the purposes have changed over time and space and are still changing, but the need for mobility has always been there. This makes transportation an important part of sustainability discussions (Holden 2007).

Rosén (2001) pointed out some of the major negative effects of today´s transportation system:

- An assumption of widespread car ownership by land-use planners, leads to green-field development that threatens the viability of urban centres;
- The increasing amount of land required by car-based mobility patterns;
- An increasing dependence on the car, caused in large part by suburbanization and the appropriation of city streets by traffic;
- The social exclusion that is consequently experienced by those without access to cars;
- Pollution—motorized transport makes a major contribution to the generation of airborne pollution, and hence to global warming and health problems;
- The economic impacts of traffic congestion;
- The impacts for the health and safety of road users and citizens;
- The depletion of non-renewable natural resources caused by the production of cars and the reliance on oil that their use brings about.

According to Litmann (2009, p6), "… sustainability requires limiting resource consumption to ecological constraints (such as limiting land use to protect habitat and fossil fuel use to minimize climate change), so sustainable development requires maximizing the efficiency with which wealth provides social welfare (happiness). Similarly, sustainable transportation requires that we maximize the amount of happiness produced per unit of mobility".

To achieve a sustainable transport system, it is important to define what sustainable transport is and how it can be monitored.

Much of the literature on sustainable transport focuses on the motorised traffic and its effects, like emissions, noise and congestion. It is realised that in order to create sustainable transport, the volume of motorised traffic must be reduced, short trips should be made by walking or cycling and more trips should be made by public transport. Sustainable modes of transport, such as public transport, walking and cycling have less impact on the environment than the personal motorized transport mode, the passenger car. It seems that one large aspect of the definition of sustainable transport is the environmental impact of transport. Car-use takes a lot of urban space and contributes to many environmental problems. Cycling and walking is often seen as the most sustainable way of travelling and a high rate of people walking and cycling is seen as an indicator of a sustainable transportation system. A good public transport system, which means reliable and flexible systems, is also seen as an important part of a sustainable transport system (Banister 2005, Banister and Hickman 2006, Banister 2006, Kenworthy 2006, Gudmundsson and Höjer 1996).

The focus on only environmental aspects does not make a transport system sustainable. Greene and Wegner (1997) state that the negative environmental impacts of transport, such as climate change or air pollution also have a social dimension, since climate change for example is also bad for future generations. High-income households often have more access to cars and often, through more travelling, contribute more to air pollution, than low-income households. Also, poor people tend to live in more polluted areas than richer people. Therefore sustainable transport also involves a social dimension of equalities. The combination of social, ecological and economic aspects to be considered together to create a fully sustainable transport system (Greene and Wegner 1997; Banister 2006 and 2008; Kenworthy, 2006; Gudmundsson and Höjer, 1996).

The Centre for Sustainable Transportation in Canada prepared a wide comparison of existing and applied definitions in 2005. It concludes: "Basically three threads of definition of sustainable transportation…can be identified in the literature. One might be called a literal economist's version….the second kind of definition concerns environmentally sustainable transportation. The third type of definition of sustainable transportation can be called the comprehensive type of definition" (Cormier and Gilbert, 2005).

Transport and land-use are mutually ndependent factors of development. However, transport is the dominant factor in this relationship and changes in transport policy and technology effect changes in the way land is used. Planning for a sustainable society strives to reduce the use of non-renewable fossil fuels which are the dominant energy source for today's transport systems, to promote higher density development, more compact community forms, and greater physical integration of land uses. These planning principles will incite a dramatic reduction in the number of private cars, a reduction in the number of car trips, and a reduction of the total vehicle miles travelled. (Moore et al.,1994).

Realising that financial, cost-benefit, and economic considerations are not the sole drivers of transport projects, the term "triple bottom line" was coined to encourage sustainable development by evaluating performance on the basis of social, economic, and environmental impacts in order to ensure that transport strategies and investments will result in robust economic growth; better-than-before health of the environment; and improved quality of life for all citizens. This approach gives economic, social, and environmental aspects equal consideration. (AASHTO, 2007).

According to the European arm of the Rand Corporation and several partners, the definition of sustainable transport adopted by the Ministers of Transport of the 15 European Union countries should be favoured because it is concrete, comprehensive, and "has been reviewed by political mechanisms and received general political acceptance" (Rand et al, 2003.). The ECMT (2004) defines a sustainable transport system as follows:

- It "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";
- It "is affordable, operates fairly and efficiently, offers choice of transport mode, and supports a competitive economy, as well as balanced regional development";
- It "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 minimising the impact on the use of land and the generation of noise."

1.4. Sustainable city

Sustainability is related mostly with urban development and any definition of a sustainable transport system must be part of the vision of a sustainable city.

Kenworthy (2006) identifies ten major dimensions in transport and planning for the sustainable city:

- The city has a compact, mixed-use urban form that uses land efficiently and protects the natural environment, biodiversity and food-producing areas.
- The natural environment permeates the city's spaces and embraces the city, while the city and its hinterland provide a major proportion of its food needs.
- The road infrastructure is de-emphasized in favour of public transportation, walking and cycling infrastructure, with a special emphasis on rail. Car and motorcycle use are minimized.
- There is extensive use of environmental technologies for water, energy and waste management – the city's life support systems become closed loop systems.
- The central city and sub-centres within the city are human centres that emphasize access and circulation by modes of transport other than the automobile, and absorb a high proportion of employment and residential growth.
- The city has a high-quality public realm throughout that expresses a public culture, community, and equity and good governance. The public realm includes the entire public transportation system and all the environments associated with it.
- The physical structure and urban design of the city, especially its public environments, are highly legible, permeable, robust, varied, rich, visually appropriate and personalized for human needs.
- The economic performance of the city and employment creation are maximized through innovation, creativity and the uniqueness of the local environment, culture and history, as well as the high environmental and social quality of the city's public environments.
- Planning for the future of the city is a visionary "debate and decide" process, not a "predict and provide", computer-driven process.
- All decision-making is sustainability-based, integrating social, economic, environmental and cultural considerations as well as compact, transit-oriented urban form principles. Such decision-making processes are democratic, inclusive, empowering and engendering of hope.

Kenworthy touches on a vital issue in the last dimension. When it comes to achieving sustainable transport the decisions must be formed in a democratic way in order to include all groups of people living in the city and also to create a better understanding among the cities citizens to get support from the people and create a sustainable society (Kenworthy 2006). The democratic aspect in transport planning is not only addressed by Kenworthy, but also by other authors such as Banister (2006, 2008), Baeten (2000) or Rosen (2001). The achievement in these dimensions has to be measured and monitored; hence there is a need for indicators. Without measuring the outcome of changes in the transport system it is hard to see the trends, i.e. in what direction we are heading (Gudmundsson 2007).

The framework of "TISSUE" (Trends and Indicators for Monitoring the EU Thematic Strategy on Sustainable Development of Urban Environment, 2007) defines four essential themes for sustainable urban development: Sustainable urban management, Sustainable urban transport, Sustainable urban construction and Sustainable urban design. According to their description, "A sustainable urban transport system supports the freedom of movement, health, safety and quality of life of the citizens of current and future generations. It is environmentally efficient; and supports a vibrant, inclusive economy, giving access to opportunities and services to all, including less affluent, elderly or disabled urban citizens and non-urban citizens. It achieves these objectives by:

- Promoting a more rational use of private cars, and favouring clean, quiet energy efficient vehicles powered by renewable or alternative fuels.
- Providing a regular, frequent, comfortable, modern, competitively priced, well linked network of public transport.
- Strengthening the share of non-motorised transport (walking and cycling)
- Making the most efficient use of land.
- Managing transport demand through the use of economic instruments and plans for behavioural change and mobility management.
- Being actively managed, in an integrated manner, with the participation of all stakeholders.
- Having quantified short, medium and long-term objectives, with an effective monitoring system" (Häkkinen, 2007, p.23).

1.5. Policy and democracy issues in sustainable urban transport

Policy and planning

To achieve sustainable transport there is a need for transport polices, connected to democratic processes in the urban area. Democracy and policies are interlinked, because they determine the basic principles of how an urban sustainable transport system should be designed and created and how people will participate and accept the new way of travelling.

Urban policies and urban transport planning play a key-role to achieve sustainable transport and they must work together with other important aspects of urban and city life. Both urban planners and transport planners must coordinate their work in order to create sustainable cities and a sustainable transport system. As Banister and Hickman put it: "Critically, in terms of sustainable development, it is the physical environment that is within the scope of interventions and under the control of urban planners and developers. The decisions made concerning the location of new development (including housing and employment) are a key determining factor towards future changes in travel behaviour." (Banister and Hickman 2006, p277)

That implies a shift in policy and urban planning practises to include the reduction of the need for travel. This shift includes also new urban structures and denser cities in order to achieve reduced travel needs. Urban policies and urban transport planning that promote walking and cycling will lead to, besides the reduction of travel needs and travelling, to a shift towards more sustainable modes of transport. Due to mixed land-use, distances to services, jobs and leisure activities can be reduced, which makes it much easier to walk or take the cycle instead of the car. Hence, a thoughtful urban planning practise, where the planners have a broader view also on transport must go hand in hand with urban policies promoting sustainable modes of transport. It is crucial in order to achieve an urban sustainable transport system that urban planners and urban policy makers work together. The integration of transport planning and urban planning and land-use planning is essential in order to create a sustainable transport system (Banister and Hickman 2006, Banister 2006, Banister 2008, Kenworthy 2006, Jonsson 2008).

Democratic processes

Baeten (2000) argues that the complexity of transport planning often leads to conflicts between different groups and it often lacks the democratic process. The conflicts which arise in different infrastructure projects are not acknowledged by the policy maker and transport planners, but covered by the use of the term sustainable development. The decisions are made in a non-democratic way and therefore the needs of marginalized groups are ignored. As an example of this, Baeten uses a case study of the construction of a new highway between two small towns in Belgium. In this case study, Baeten argues, conflicts between different groups are created, which, in general, include those who are for and those who are against the project. But those conflicts are invisible in the discourse of sustainable development and in discussions about sustainable transport-systems (Baeten 2000).

Through the use of the term sustainable development the construction of a highway is seen as positive by some groups, because of the economic benefits. However, the processes and decisions are made behind closed doors and in non-democratic ways excluding marginalized groups and interests of for example environmental protection activists. That leads to the conclusion that the process ignores socio-political aspects and that the marginalized groups are left out of the process (Baeten 2000). This is a problem when dealing with sustainable transport and the different groups of society must therefore be included in the decision-making processes in order to create also awareness among the citizens and in order to get input from other groups. In the case of the highway in Belgium the construction of the highway might have been prevented if environmental groups would have been included and the transport system would be more sustainable because the different aspects, such as mentioned by Kenworthy (2006), might have been considered.

Also Banister (2006 and 2008) sees the democratic aspect as an important dimension, when dealing with sustainable transport. Involving people in decision-making processes in transport and urban planning is seen by Banister as one major part of sustainable transport. He sees that political actions only appear when there is a will of the public to change the modes of transport and when the public support changes towards a more sustainable way of travelling and a more sustainable transport system. The public is one of the major actors in the transport sector and if the citizens refuse sustainable mode of transport or urban and transport policies it is hard to create a sustainable transport system. Much is known of what sustainable modes of transport are and what should be done in order to create a more sustainable transport system. But when the public is not involved in the planning and implementation processes people will rather use the mode of transport they are used to. When the processes of planning and policy and decision making is more democratic, involving people in creating a sustainable transport system, the acceptance of people to use sustainable modes of transport would increase. At the same time, the social aspects of sustainable development such as inclusion of different groups in the processes would be fulfilled (Banister 2006 and 2008).

A more democratic way of creating a sustainable transport system is shown by Evans et al. (2001) who call the strongest model of participation the "Negotiated Planning and the Reflexive City". This model presupposes "…a more contextual understanding of the social world that the planning agencies are trying to shape and create." (Evans et al. 2001, p128). Furthermore, it is not only the environmental problems or economic regeneration that is the focus of this approach, but also social networks and public participation on the planning processes. It has as a goal an equal society and fair urban transport. To get people to participate, that approach formulated by Evans et al also includes sharing the responsibility and through that getting more democratic and sustainable decisions. As they formulate it: "The responsibility for finding a solution is shared between a wide range of groups and the role of the local authority may be much more peripheral. The vision of the future is thus of the reflexive city, aware of its consequences and with users, employers and many other agencies involved in defining problems and developing solutions." (Evans et al 2001, p129)

Both transport policy and transport planning should involve not only economic aspects, but also focus on mobility, accessibility and a socially equal society. A sustainable transport policy, furthermore, should involve some restriction to car-use and a more efficient car use, as well as promoting better public transport, but the way to get there should always be democratic by consulting different groups and agencies and the public in general so that the responsibility and the view of the future transport system is shared by all and not only by few (Evans et al. 2001).

1.6. Relevance for HASTA

Looking at widely accepted definitions of a sustainable transport system, it becomes clear that:

- In many context sustainability is used as a synonym of "good",
- The definition of transport system depends on the target group (politicians, economists, planners, etc.).

To do something in a sustainable way means to take into account the future generation's needs while satisfying the present needs. Unfortunately, it is not easy to define the future needs. Another approach is more helpful saying the sustainability is a "delicate balance between the economic, environmental and social health of a community" (Fricker, 2001, p.1) But this sensitive balance is the target of a long process of development or the best way of developing? Looking at the wide range of cities, their economic, environmental and social capability – depending on their level of development and culture, we can be certain about the continuous change following various trends and targets. In this context, a **sustainable transport system attends the most possible balance between the social – environmental – economic dimensions of transport**.

It is important to state, the transport system is part of the city. **Can the transport system be sustainable but not the city?** Is it possible that the city itself is developing in a sustainable (balanced) way but the transport system is unbalanced? We did not find answer in the literature about the "relation" of city and its transport system – but we suppose if the transport system integrates successfully the principle of sustainability that means the city itself made a step as well on the way towards sustainability.

In this point we are facing the "problem of Vision". Most of the cities have short-term or/and long-term visions. These visions are taken by decision makers and define the main directions and a few steps of the next decade. **The purpose of this project is not to evaluate neither the vision nor the vision's effect on the cities transport system**. That is why it is important to separate the comprehensive vision of the city from the transport system. Even if we know more about what is unsustainable, it looks more achievable to monitor how the balance is affected by investments in the transport system than saying how sustainable the vision of the city is. If our measuring tool can inform the municipality how their transport related measures affect the transport system, showing the status of balance between the social-economic-environmental dimensions, the purpose of this project will be fulfilled.

1.7. Aim

The research work presented in this report aims to elaborate a framework of indicators to monitor sustainability of transport in Swedish cities via defining indicators that respond to the definition of sustainable transport in cities.

The outcome of the working phase, covered by the report, is a framework and a list of sustainability indicators of transport in the city (see chapter 3).

1.8. Method

The method consisted of two main steps: collection and selection of indicators.

- Collection
  Indicators, related with sustainable transport system were collected through a review of the international literature, municipalities' websites in both Sweden and abroad, and via in-depth interviews with municipality officers. The result of this phase was a long list – more than 200 indicators – with a wide range of scale, content and field of use.
- Selection of indicators
  Based on a number of criteria and conditions, a short list and a framework of sustainable transport indicators for Swedish municipalities were compiled.

2. Measuring sustainability

Defining sustainable transport and measuring sustainable transport are interlinked. As Fricker (2001) says, "The context of sustainability cannot be separated from its measurement". With other worlds, the goal of a certain project defines and describes the issues interesting to know when observing the impacts of the transportation system on society.

To monitor progress of transport, there must be not only visions, goals and targets set up for the municipalities (Munier 2005) but there is a need for a measuring tool based on sustainability indicators. To define if a transport system is processing towards sustainability or not various kinds of measures must be taken and various measurements must be carried out in order to analyse and monitor the status of the urban transport system. Sustainability indicators should be carefully selected to provide useful information. They must be clear and understandable for everyone, they must measure the present situation of the city and they must reflect a validation of goal achievement.

2.1. Frameworks of sustainability in transport

Our definition is about a sustainable "transport system". However, as Rand et al. (2004 p.9) say, "the transportation system is not an end in itself, but rather a means to other ends". The transport system benefits society, but it also causes damage to the health of humans and the ecosystem. The sustainability of the transport system should be part of the wider goal of sustainable development of the whole society.

The transport system, as its name says, is a system. It is a complex structure of interactive processes with many inputs and outputs. The individual sustainability indictors constitute a framework, a theoretical structure, systematising data and information. The framework makes the interactions between different issues explicit (Munier, 2005).

In the framework of the project "SUMMA" (SUstainable Mobility, policy Measures and Assessment) (Rand et al., 2004) a set of indicators for policy makers was developed. The approach was built around an integral system description of a policy field and it was well suited to help to understand how the transportation system might respond to policy changes and changes in external factors. In the policy assessment framework, presented in *Figure 2*, "Outcome of interest" is system outcomes related to the actors' goals and objectives. A goal is a generalised policy objective (e.g. "ensure traffic safety"). The "Transport system" consists of the description of the physical elements of the system (transportation infrastructure, vehicles, locations of residence) the actors (governments, transport companies), their behaviour (the choices they make) and their mutual relationships. "External forces" (Forces Driving System Change – FDSC) act on the "Transport system" (Rand et al,. 2004).

In the policy assessment framework, the following types of indicators were defined (Rand et al., 2004):

- Outcome indicator: Each outcome of interest is associated with a set of outcome indicators. An outcome indicator can be used to monitor changes in "Outcome of interest".
- System indicators are usually intermediate variables that are used to estimate the values of the outcome indicators. System indicators are sometimes outcomes of interest in themselves; hence a system indicator can also be used to monitor changes in the system.

- FDSC (Forces Driving System Change) indicators: The FDSC can be a technological, political, regulatory, economic, or societal development An FDSC indicator can be used to describe changes in the "External Forces".

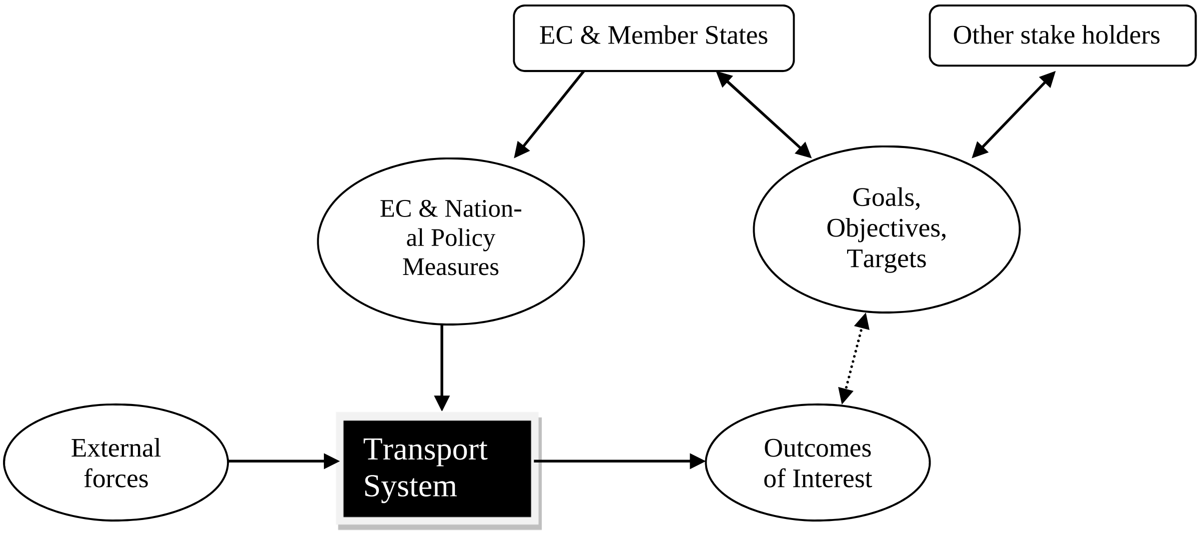


Figure 2. The policy assessment framework proposed by the SUMMA project (Rand et al., 2004).

Another example for presenting different level of the framework of sustainability in transportation is the structure of the indicator-set developed by the Victoria Transport Policy Institute. This report defines four categories as follows (Litmann, 2009):

- Process – the types of policies and planning activities, i.e. whether the organization has a process for collecting and publishing performance data, and public involvement.
- Outcomes – ultimate results, such as annual passenger kilometres travelled, modal split, number of accidents and casualties, cost of emissions for society and user satisfaction.
- Outputs – direct results from measures (Inputs), e.g. average travel speed, percentage of motor vehicle complying with the speed limit.
- Inputs – the resources that are invested in particular activities, e.g. the level of funding spent on various activities or modes, percentage of crossing points adopted to disabled, etc.

As we seen in the definitions of sustainable city and sustainable transport (chapter 1,4., 1.3.), the existence of a vision is vital. The framework of sustainability indicators has to be in line with the vision. In the field of transport, a wide range of objectives can be defined. The OECD (2003) listed a number of objectives that appear regularly in cities' policy statements.

- Economic efficiency (short travel time, operating costs and direct payments).
- Safety (reducing the loss of life, injuries and damage to property resulting from transport accidents).

- Sustainable use of resources (the consumption of non-renewable fossil fuels, materials and land).
- Accessibility (number of destinations that are accessible against reasonable costs in terms of time and money).
- Environmental protection (low noise, atmospheric pollution of differing kinds, vibration, visual intrusion, severance, fear and intimidation, and the loss of intrinsically valuable objects, such as flora and fauna, ancient monuments and historic buildings).
- Economic regeneration (reinforcing the land use plans of the area).
- Equity (equal distribution of transport benefits).

To measure the development, five sets of current and widely cited frameworks to monitor sustainability, put forward by various researchers, were found in the literature:

1. SUMMA (2004) Sustainable Mobility, Policy Measures and Assessments.
2. Litmann (2009) "Well Measured".
3. TERM (2001) Indicators Tracking Transport and Environment Integration in the European Union, European Environment Agency (2001)
4. STPI (2002) Sustainable Transportation Performance Indicators, Centre for Sustainable Transportation.
5. WBDSC (2001) Mobility 2030, World Business Council for Sustainable Development.

Most of the frameworks found in the literature reflect the widely accepted “triple bottom line” of sustainable transport, i.e. economic - social – environmental aspects. The summary of these frameworks and lists of indicators is presented in *Annex I.*

As the authors of the SUMMA project say (Rand et al., 2004. p.9.): “...to define the ‘outcomes of interest’ we need to identify the necessary components, which all together influence the sustainability performance of the transport system and which have to be monitored in order to assess its status.” The components of the definition of sustainable transport are presented in *Table 1*.

Table 1. Selected outcomes of interest for the SUMMA framework (Rand et al. 2004)*

Economic	Environmental	Social
Accessibility Transport operation cost Productivity / Efficiency Costs to economy Benefits to economy	Resource use Direct ecological intrusion Emissions to air Emissions to soil and water Noise Waste	Accessibility and affordability Safety and security Fitness and health Liveability and amenity Equity Social cohesion Working conditions in the transport sector

* system outcomes related to the actors’ goals and objectives

Litmann (2009) concluded that a single indicator is not adequate but a set of indicators, which should reflect various goals, objectives and impacts should be used see *Table 2*.

Table 2. Sustainable Transportation Impacts (Litmann, 2009).

Economic	Environmental	Social
Traffic congestion	Air pollution	Equity / Fairness
Infrastructure costs	Climate change	Impacts on mobility disadvantaged
Consumer costs	Noise and water pollution	
Mobility barriers	Habitat loss	Human health impacts
Accident damages	Hydrologic impacts	Community cohesion
Depletion of Non-Renewable Resources	Depletion of Non-Renewable Resources	Community liveability
		Aesthetics

The relevant impacts concerning sustainable transport can be discussed in terms of goals, objectives, targets and thresholds. Monitoring sustainability of transport, concerning the impact of e.g. traffic congestion involves defining indicators for congestion (units to measure congestion), goals (the amount of congestion reduction desired), objectives (shifts in mode to reduce congestion), targets (specific, feasible changes in travel behaviour that should be achieved) and thresholds (levels beyond which additional actions will be taken to reduce congestion) (Litmann, 2009).

Two other frameworks of interest – not showing strictly the "triple bottom line" in the structure – are The European Union's Transport and Environment Reporting Mechanism (TERM) (EEA, 2002) and The Sustainable Transportation Performance Indicators (STPI) (Gilbert, et al., 2002), see *Table 3*. These two frameworks reflect the most important aspects (economic, social and environmental) of sustainable transport.

Table 3. TERM and STPI frameworks of sustainable transport.

TERM (EEA, 2002)	**STPI** (Gilbert, et al. 2002)
Environmental consequences of transport	Environmental and health consequences of transport
Transport demand and intensity	Transport activity
Spatial planning and accessibility	Land use, urban form and accessibility
Supply of transport infrastructure and Services	Supply of transport infrastructure and Services
Transport costs and prices	Transportation expenditures and pricing
Technology and utilization efficiency	Technology adoption
Management integration	Implementation and monitoring

There is one indicator list among the compared ones which has another approach to sustainable transportation. The indicator list developed by World Business Council (WBDSC, 2010) is based on the principle of service. The transportation system is considered as a service, that is why the applied indicators have to reflect users' concerns, societal concerns and business concerns. This framework is basically different from the classical "sustainable" approach, but the developed indicator list (see chapter 2.3.) is surprisingly similar to the other ones.

2.2. Indicators

Measuring sustainability with help of indicators must be done on the basis of a definition of sustainability and a vision of how future urban regions and areas should look like. Some cities today have already set up their own goals and indicators but those goals and indicators are not based on scientifically validated variables. The city quite often wants to promote itself as sustainable and green, which often leads to the fact that indicators and goals are set up for certain aspects, which are very easy to achieve and which are not objectively analysed. Much of what is done has not a specific connection to traffic and transport planning, which is why we need validated indicators for sustainability in the transport area. It is important that the indicators really are measurable and necessary data is available. Some cities might be tempted to use the available governmental statistics or create indicators based on available data.

2.2.1. Definition, functions and characteristics

Before going into details of the indicators, an overview of definitions and characteristics is needed. The OECD (2003) made the following definitions:

- Parameter: a property that is measured or observed.
- Indicator: a parameter, or a value derived from parameters, which points to, provides information about, describes the state of a phenomenon/environment/area, with a significance extending beyond that directly associated with a parameter value.
- Index: a set of aggregated or weighted parameters or indicators.

The difference between an indicator and an index is made clear by an example from Litmann (2009): A sustainability index can include indicators that reflect various dimensions of analysis but it is important to take the relationships between the different indicators into account to avoid double-counting. For example, reductions in vehicle-mileage can reduce pollutants as well as damages to human health. For a good understanding of the processes, it is useful to track each of these factors, but it would be wrong to add them up as if they indicate different types of impacts (Litmann, 2009).

Indicators are variables constructed to describe a situation or a time trend about a particular concern. They have three main functions: simplification, quantification, and communication Indicators can be quantitative or qualitative, they can measure reality in absolute or relative terms. Indicators are usually part of a framework that conveys a broader purpose and significance to the individual indicator. Integrated systems of indicators can provide a comprehensive description of an entity (Gudmundsson, 2003).

The OECD pointed to two major functions of indicators (OECD 2003):

- "...they reduce the number of measurements and parameters that normally would be required to give an exact presentation of a situation. The size of an indicator set and the level of detail contained in the set need to be limited. A set with a large number of indicators will tend to clutter the overview it is meant to provide."
- "...they simplify the communication process by which the results of measurement are provided to the user. Due to this simplification and adaptation to user needs, indicators may not always meet strict scientific demands to demonstrate causal chains. Indicators should therefore be regarded as an expression of 'the best knowledge available'".

An indicator is something that points to a condition with the purpose to show the state of the system. An indicator can help to determine what direction to take to change the state of the system by addressing the relevant issue. Individual indicators are useful as proxies or substitutes for measuring conditions that are too complex to measure them directly. There are certain characteristics that effective indicators have in common (Sustainable Measures, 2010):

- Relevance - they show you something about the system that you need to know.
- Easy to understand, even by people who are not experts.
- Reliability: the information that the indicator is providing can be trusted.
- Are based on accessible data; the information is available or can be gathered while there is still time to act.

Leitmann (1999) gives some additional characteristics for objective indicators:

- Quantifiable,
- Based on existing data – when possible, indicators should be derived from reliable existing information to speed up their use and minimise costs,
- Affordable – the financial cost and time required to assemble and analyse indicators should be prescribed by a predetermined budget,
- Based on a time series – the same indicator should be collected over a regular interval so that change can be evaluated,
- Quickly observable – indicators should change as conditions change so that they can accurately reflect reality,
- Widely accepted – indicators should be understood and accepted by their users,
- Easy to understand – indicators should be reported in a simple fashion so that a wide range of people can understand them,
- Balanced – indicators should be politically neutral and allow for measurement of both positive and negative impacts.

Most of these characteristics are also important when considering indicators based on qualitative data. This list of requirements is somewhat idealistic, but it provides a standard to strive for (Steg et al., 2006).

The OECD (2003) mentioned three key aspects when it comes to sustainability indicators: policy relevance, measurability and analytical validity. In practical work the focus is often on the first two aspects, which leads to some problems. The main problem is that many cities focus on measurability and policy relevance and neglect indicator alidity. Further, the focus on the first two aspects lead to that many important aspects are not measured, hampering the progress towards sustainability (Keirstead and Leach 2008).

The characteristic and function of an indicator also, are influenced by the use of itself. Information behind an indicator can be translated differently according to the purpose. In case of using indicators for helping decision-making or to define policies the indicators are basically different than indicators that are used to determine weakness in a system or help in inputs balancing. To apply well selected indicators can lead to discovery of hidden effects or unexpected correlations (Munier, 2005).

2.2.2. Types of indicators

There is a wide variety of potential indicators to describe the framework of sustainable transportation. An important selection criterion for these indicators is that they should give the most information about the respective group of systems' outcomes. The indicators can be of various types:

Quantitative and qualitative data

Quantitative data consist of numerically measureable information. Qualitative data can consist of words, picture, observational data, etc. Quantitative data is often considered more objective and easier to analyse, which can create a problem: easier to measure impacts tend to receive more consideration than impacts that are more difficult to measure. For example, travel time or vehicle speeds are easy to measure, but liveability and walkability are more difficult to quantify, and so they often receive less consideration than justified by their value to affected people (Litmann, 2009).

"Soft" Indicators (also called individual indicators)

The individual indicators aim to measure the users' satisfaction, which is "a state related to the fulfilment of one's wishes, expectations, or needs and it reflects the pleasure derived from this" (Steg et al., 2006. p.9.) Individual indicators can be assessed subjectively by asking people about them which is usually done by surveys studies. Responses are given on a rating scale, e.g. on a Likert type scale (1=Very satisfied, 2=Satisfied, 3=Not satisfied, not dissatisfied, 4=Dissatisfied, 5=Very dissatisfied) (Steg et al., 2006).

Ratio indicators

Reference units (also called ratio indicators) are measurement units normalized to facilitate comparisons, such as per-year, per-capita, per-mile, per-trip, per-vehicle-year and per unit of money (Litman 2003; GRI 2006). "The selection of reference units can affect how problems are defined and solutions prioritised. For example, measuring impacts such as emissions, crashes and costs per vehicle-mile ignores the effects of changes in vehicle mileage; for example, it does not consider increases in per capita vehicle travel as a contributor to these problems, and ignores mobility management strategies as solutions. Measuring these impacts per capita does account for changes in vehicle travel. Comparisons can be structured in various ways to reflect different perspectives, such as comparisons between different areas and groups, or trends over time." (Litmann, 2009).

Relative indicators

Many impacts are best evaluated using relative indicators, showing trends over time or comparisons between different groups. A municipality can compare its current level of sustainability by comparing its indicators with other cities, considered similar. Equity can be evaluated based on the transport options and impacts of disadvantaged groups (people with low incomes, disabilities or other disadvantages) compared with advantaged groups (Litmann, 2009).

A part of this type of indicator also called "state" indicators, the idea of the same, "how close or how far" the result of an action is in reaching a goal. The "warning" indicator is based on the same principle as well, but considered as a lower threshold value (Munier, 2005).

"Conventional" transport indicators

Indicators of traffic like average traffic speed, average daily traffic, density, delay, travel time, level-of-service mostly describe motor vehicle traffic conditions and focus generally on the quality of motor vehicle travel. These indicators tend to justify policies and projects that increase motorised travel (capacity expansion, car-oriented land use system, etc.). An approach, evaluating impacts per vehicle-km rather than per capita contradicts sustainability objectives as it does not consider increased vehicle mileage to be a negative factor and it ignores vehicle traffic reductions as possible solution to transport problems (Litmann, 2009). On the other hand, motor vehicle travel - measured as Vehicle Kilometres and personal travel – measures as Passenger Kilometres are sometimes used as a sustainability indicator, assuming that motorised travel is unsustainable because it is resource intensive and environmentally harmful. But this is controversial because motorised travel also provides economic and consumer benefits (Dudson, 1998). Viewed from an economic efficiency perspective, "current transport markets are distorted in ways that result in economically excessive motor vehicle travel, including various forms of road and parking under pricing, uncompensated environmental impacts, biased transport planning practices, and land use planning practices that favour lower-density, automobile-oriented development" (Market Principles, VTPI 2008) There is some indication that more than a third of all motor vehicle travel results from these distortions. "To the degree that market distortions increase vehicle travel beyond what is economically optimal, the additional vehicle travel can be considered unsustainable and policies that correct these distortions increase sustainability. In this context, vehicle mileage and shifts to non-automobile modes can be considered sustainability indicators. Specific planning decisions can be evaluated according to whether they increase or reduce market efficiency." (Litmann 2009 p.14.).

"Conventional" Economic indicators

Sustainable development is highly connected to economic development and therefore solutions for a better environment are often taken from economic theories and models, which fail to address the problems (see Foster 2002). The economic and more general measures for measuring sustainability often focus on a national level and include for example green GDP, the ecological footprint or the Human Development Index. Those are very general indicators taking implicitly many aspects into account and often used to measure a nation's sustainability or the performance of a nation in sustainable development. However, those indicators take not specifically urban, transportation and social aspects into account (Nourry 2008, Haberl, Wackernagel and Wrbka 2004, Munier 2005).

"Conventional" Environmental/Ecological indicators

Although the ecological footprint can also be calculated for regions and cities, it still seems a more general indictor for sustainability. The ecological footprint method focuses more on ecological aspects, such as pollution and use of resources. With this method one can calculate how much space a city consumes. But it has no local dimension and does not measure for example the local social problems (Rees and Wackernagel 1996, Munier 2005).

2.3 Indicator sets

2.3.1. Economic indicators

Several papers discuss the relation of transport and economy. Most of them agree that the transport sector does not have an own natural purpose. This sector has an important service function, supports the mobility needs of people and goods, and serves a wide range of economic activities. Thus, the transport sector consumes a large amount of natural capital and produces costs for the society, firms, and individuals instead of building up capital. The sector itself could, therefore only be justified in its relation to other sectors (Rand et al. 2004).

Economic indicators help us to describe the efficiency of the transport system and the benefits and costs for the society and individuals. The purpose of an economic framework and indicators is to monitor these parameters and to evaluate the economic impacts of transport policies – or in general – changing of the system.

The role of indicators is not only to reflect the cost and benefit of vehicle use, but to reflect the efficiency of the transport sector. According to Litmann (2009) "Increased mobility that provides little or negative net benefits to society can be considered to reduce sustainability, while policies that increase the net benefits from each unit of mobility can be considered to increase sustainability".

The proposed economic indicators by different indicator projects vary according to the purpose of the respective project. A comparison table (*Table 4*) shows the main fields of indicators of the selected 5 projects (find complete list of indicators in the *Annex I*).

Table 4. Comparison of economic indicators for five sustainability frameworks (Canete-Medina , 2007).

Indicators	SUMMA	Litmann	TERM	STPI	WBCSD	Data Avail.*	Direction
Commute travel time		X	X		X	C	Less is better
Vehicle km/mile traveled		X	X	X		N	Less is better
Land use	X	X	X	X		C	Less is better
Accessibility	X	X	X	X		C	More is better
Modal Split		X	X	X			
% car use						C	Less is better
% public transport						C	More is better
% walking, cycling						C	More is better
Traffic congestion delay	X	X	X	X		n.a.	Less is better
Household travel costs	X	X	X	X	X	N	Less is better
Facility costs	X	X	X	X	X	n.a.	Less is better
Transport cost efficiency	X	X	X		X	n.a.	More is better
Economic Equity / User price	X	X	X	X		n.a.	More is better

(*) N=national data; C=City data; n.a.=not available

All indicators in *Table 4* are related with two general aspects (two framework-indicators), i.e. accessibility, costs and benefits.

Accessibility is one of the most common objectives of transport. It has an economic and a social dimension. The economic dimension of accessibility is access for goods and people to industrial activities, working places, shopping centres, etc. This aspect is represented by indicators like traffic jams or the reliability of time tables of trains, public services, etc. The social dimension of accessibility can be described as the possibility of individuals to reach sites and locations of socially beneficial activities (Rand et al. 2004).

Transport related **costs** are costs for building, maintenance and renewal of transport infrastructure, financed from the public budget. Other costs for the society are subsidies, costs for delay, accident costs, environmental costs and these have to be monitored as part of a sustainable transport policy (Rand et al. 2004.). Transport operation costs comprise market prices for transport services, costs for the transport equipment and personal and costs for users of the transport system. Market prices of the transport system generally do not reflect all external cost components (damages, injuries, etc.).Vehicle-, equipment- and personal costs, are objective, but do not reflect the situation on the transport market. In case of any problems with efficiency, e.g. congestion, user costs will rise (Rand et al. 2004).

The benefits of the transport sector to national economy consist of gross value added generated by the sector as the difference between input and output as result of the national accounting, the direct public revenues from taxes and traffic charging and the indirect growth effects stimulated by the transport sector (Rand et al. 2004).

2.3.2. Environmental indicators

An environmental indicator may best be characterized as a parameter that presents, in an understandable and summary fashion, the state of a particular environmental phenomenon that has significance beyond the property originally measured, and which requires little further explanation (OECD, 1998). Generally, environmental indicators are expressed in a form that relates one reference variable to another equally important variable, such as pollutant emissions per capita. Two defining characteristics of such indicators are that they are first able to quantify information in such a way that their significance is well understood and, second, that the information can be simplified for easy communication (Hammond et al. 1995).

Environmental dimension of sustainability is the most studied and developed in comparison with the economic and social aspects. Various methods can be used to measure impacts and estimate their costs; however, uncertainty about costing methodologies and resulting values is considerable, even if there are various ways of dealing with this uncertainty (Litmann, 2009).

Environmental indicators can serve as powerful and relatively cost-effective tools for decision makers in helping with the following:

- Reporting on the state of the environment per national law or other agreements.
- Raising environmental issues onto the political agenda to promote further debate.
- Supporting policy development to address priority environmental concerns.
- Supporting efforts to address environmental problems during budget formulation

- Measuring environmental performance and the success of policy responses.
- Identifying trends by major sectors, e.g., transport, energy, agriculture and industry.
- Establishing environmental targets at the sectoral and sub national levels.
- Providing early warning to prevent environmental damage.
- Measuring progress towards sustainable development.
- Facilitating national, regional, and international environmental planning.
- Prioritizing regional intervention and engagement activities.
- Communicating progress to the public and national and international institutions.

The authors of SUMMA project (Rand et al. 2004) proposed an input-output framework for the classification of the environmental outcomes of interest, see *Figure 3.* The framework differentiates between the inputs needed from the environment to the transport system, and the outputs from the transport system into the environment. Both the inputs and outputs have mainly harmful impacts. The framework differentiates between two different types of outputs: The direct or immediate ones and the indirect or secondary outputs (Rand et al. 2004).

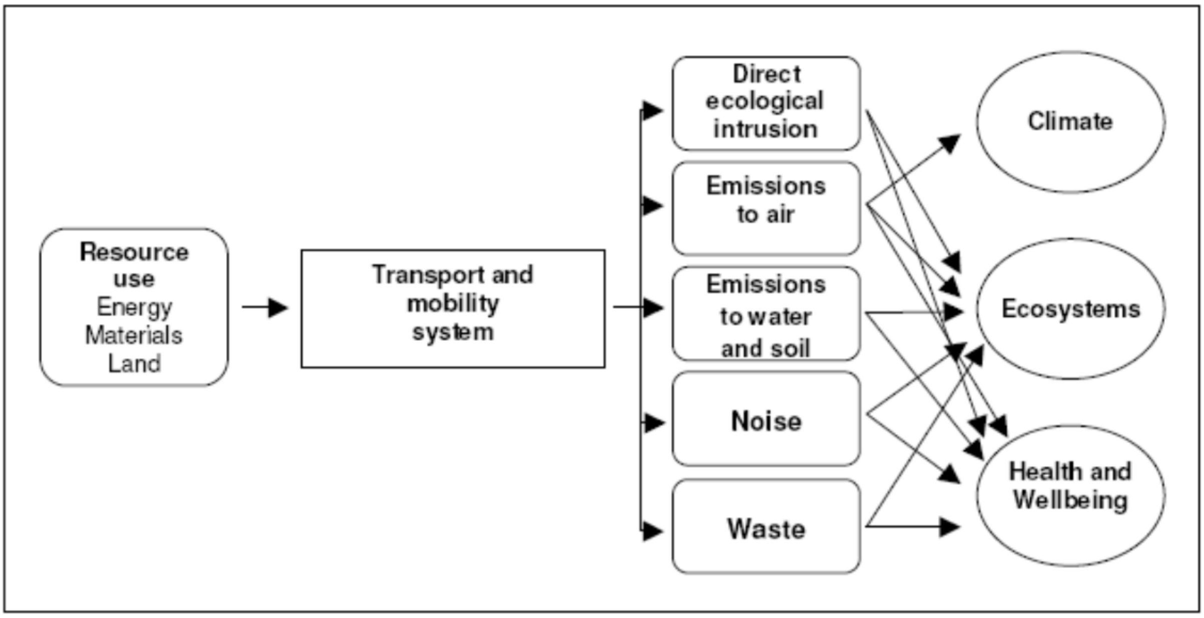


Figure 3. Input–output framework of the environmental outcomes of interest (adapted from Gudmundsson (2002)).

Comparing the indicator sets of the five studied frameworks, no significant differences between the indicators can be found, see *Table 5*.

Table 5. Comparison of environmental indicators from five sustainability frameworks (Canete-Medina , 2007).

Indicators	SUMMA	Litmann	TERM	STPI	WBCSD	Data Avail.*	Direction
Fuel Consumption	X	X	X	X	X	N	Less is better
CO2 Emissions	X	X	X	X	X	N	Less is better
Conventional Pollutants Emissions	X	X	X	X	X	N	Less is better
Air Quality		X	X	X	X	C	More is better
Noise Pollution	X	X	X	X	X	n.a.	Less is better
Water Pollution	X	X	X	X	X	n.a.	Less is better
Land Take	X	X	X	X	X	N,C	Less is better
Preservation of Habitat	X	X	X	X	X	n.a.	More is better
Resource Consumption	X	X			X	N	Less is better

(*) N=national data; C=City data; n.a.=not available

Thus the environmental aspect of the sustainability is the "oldest", the indicators are well defined and some of them has a standardized measuring method. All named indicators are referring to two big groups, resource use and emissions.

Resource use

The transport sector uses huge amounts of natural resources in form of energy, material and land resources. It stands for about a half of world's oil consumption. Building the transport infrastructure; roads, rail, stations and terminals, as well as vehicle manufacturing consume material and land resources and maintenance of the transport services require chemicals. The resources used by the transport sector have environmental impacts. Resource use is an important issue for sustainability, if we want to develop our society in a way that the future generations also can enjoy the limited resources (Rand et al. 2004).

Emission from the transport sector pollutes air, soil and water and creates disturbances to both humans and wildlife (Rand et al. 2004).

- Emissions into air are often considered as the most important environmental impacts of transport. They are divided into two types: those having mainly global impacts, i.e. greenhouse gases, and those having mainly local impacts, i.e. air pollutants.
- Emissions to soil and water come from released chemicals in road accidents, or from road maintenance or wearing off of vehicle materials.
- Noise pollution is a source of annoyance to both humans as well as wildlife. It is difficult to measure the overall amount of annoyance from noise. The best way to measure the sustainability problem of noise is to look at the amount of people exposed to it.
- Waste products from transport vehicles and infrastructure end up in landfills and incinerators. The questions of material consumption, often described by waste indicators, is usually considered under resource use.

2.3.3. Social indicators

The social aspect of transport system is a part of research related with "quality of life". This largely developed area is focusing on the social aspect of urban life. There is no universally accepted definition of "life quality" in the transport context yet, but most definitions refer to "well-being", "satisfaction" and "happiness" – related with the urban area, the public spaces. "Life quality" is highly relevant when considering the social dimension of sustainable development. This does not imply that "life quality" is affected by social conditions only. It may be affected by economic, social and environmental conditions. Since sustainability implies a balance between environmental, social and economic qualities, policies that seriously decrease individual's "life quality" can hardly be called sustainable (Steg and Gifford, 2005).

Risser (2004) proposed a model to analyse the social aspects of the public space. According to the model, the public space involves at least five areas: (1) individual characteristics; (2) communication with other people or road users; (3) socialisation agents, culture, social establishment and media (summarised as social aspects); (4) the infrastructure of the public space; and (5) vehicle or mode characteristics. These areas interact, as reflected in the diamond-shaped figure, see *Figure 5*. The model underlines the necessity that several disciplines are involved in both planning and assessing implementations in the public space. The most relevant area of this diamond is related to infrastructure aspects, i.e., most implementations are infrastructure-related (Risser, 2004).

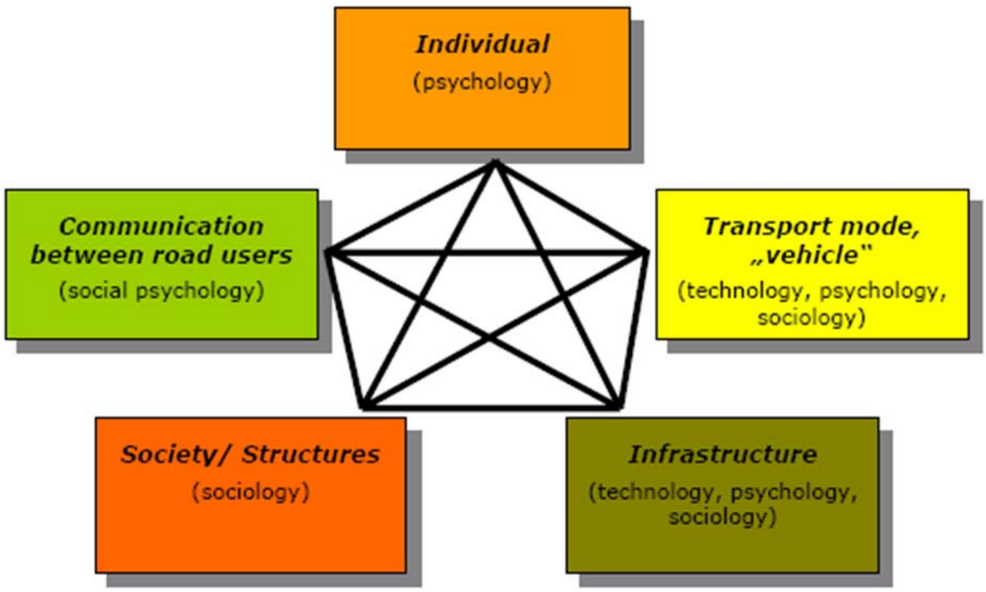


Figure 5. Traffic as a social system – the diamond model (Risser, 2004).

According the diamond model, the social aspect of transport system can be the objective and subjective evaluation of the transport related public space.

In most of the recent papers dealing with sustainable development or sustainable transport, the social aspect is the most underdeveloped. This "poor status" is reflected in the comparison of the five frameworks as well (see *Table 6.*).

Table 6. Comparison of social indicators in five sustainability frameworks (Canete-Medina , 2007).

Indicator	SUMMA	Litmann	TERM	STPI	WBCSD	Data Avail.*	Direction
Safety	X	X	X	X	X	N	Less harm is better
Liveability	X	X			X	n.a.	More is better
Accessibility / Affordability/ Social Equity	X	X			X	n.a.	More is better

All the five analysed framework sets applied safety as part of their framework. The other groups (liveability and affordability/social equity) are key-topics of research related with the quality of life and proved (e.g. Risser, 2004) that the transport system has a large influence on the perceived level. In general, the intensity and way of travelling may have important consequences for the quality of life, thus travel is an important element in the integration of society. An overview of key set of Quality of Life indicators and way to assess these indicators objectively are shown in *Annex I*. (Steg et al., 2006).

Accessibility is the possibility of individuals to reach sites and locations of beneficial activities (medical services, work, school, shopping). Part of accessibility is affordability, i.e. the ability to pay for the mobility and necessary transport services. Financial costs of transport users should not be excessive. As a general rule, transportation costs should not exceed 20% of household's income (Rand et al., 2004).

Safety in transport refers to the absence of accidents and their consequences and is measured by the number of fatalities, injuries property damages related to exposure (inhabitants, time or person-km). This objective measurement of safety is not always in line with the citizens' subjective experienced safety when in traffic. Subjective safety only can be measured by asking the citizens about their experienced safety. **Security** implies freedom from risk to be exposed to unauthorised and unexpected actions (e.g. crimes) of any kind.

The term **liveability** refers to "qualities and attributes people value about a place that contributes to the experience of 'good life' and/or high 'life quality'. They are related to those natural or physical qualities and characteristics of an area that contribute to people's appreciation of its pleasantness, aesthetic coherence, and cultural and recreational attributes. Such qualities can be tangible and measurable like noise but also less tangible like people's perceptions and attitudes" (Rand et al., 2004., p.87).

3. The HASTA framework and indicators

3.1. Structure of indicator set

The structure of the indicator-list should reflect the diversity of sustainability-related areas (horizontal diversity) and the various levels of hierarchy (vertical diversity).

Horizontal diversity:

To monitor a working system, we need to define the relevant fields covered by the "three dimensions" of sustainability. The framework consists of all the relevant aspects of the transport system which should be involved in the monitoring process (see chapter 2.1.). Taking into account the principles of sustainable transport system (see chapter 1.) and the purpose of the HASTA project, the framework shown in *Table 7* is adopted for further work.

Table 7. Adopted framework for monitoring sustainability of the transport system in HASTA (based on chapter 2.1., 2.3.).

Economic			**Social**		**Environmental**	
Efficiency	Accessibility Business	Personal	Safety	Liveability	Emission	Resource use

The accessibility indicators have both economic and social related sides. In the HASTA framework these two aspects are not separated explicitly but on the indicator level this separation is more articulated (see chapter 3.2.).

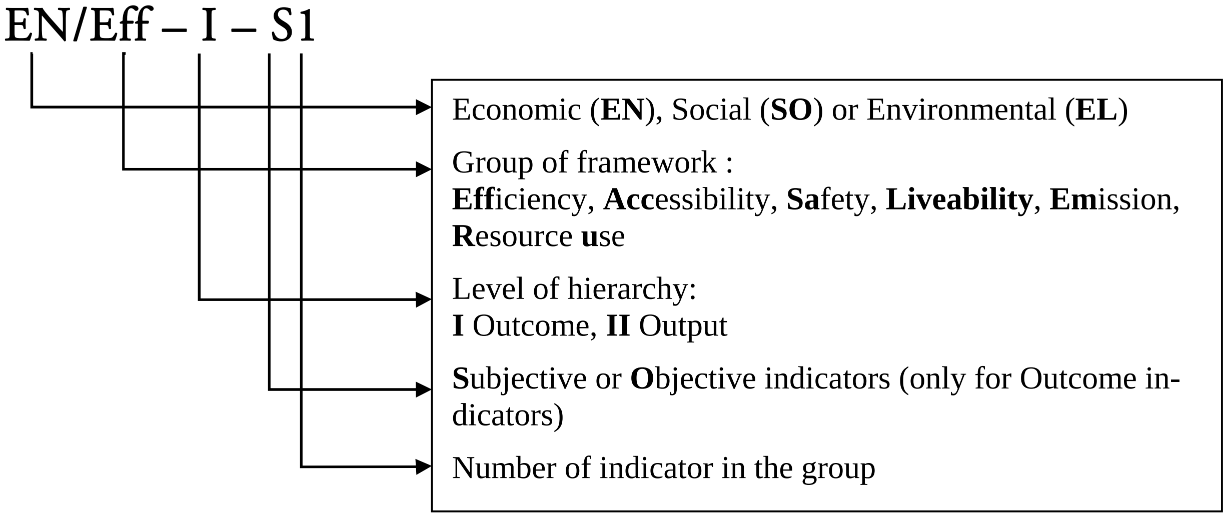
Vertical diversity:

To develop an appropriate set of indicators, we adopted three levels of hierarchy of indicators:

- Outcome indicators, describing generally the overall aim for transport sustainability. These indicators intend to capture both the objectively measurable side of sustainability and how the citizens experience it:
  - objective indicators of the "real" situation based on quantitative information
  - subjective indicators reflecting the inhabitants' satisfaction with sustainability related issues.
- Output indicators, which are indirect or intermediate indicators, showing the effectiveness of the applied measures (Input indicators) towards the fulfilment of the aim (Outcome).
- Input indicators, which are possible measures to improve Output or Outcome.

Coding:

The outcome and output indicators are involved in the evaluation process; the identification is helped by a coding system. The code of an indicator defines the precise position of the indicator in the framework:



The structure of HASTA indicators is shown in *Table 8*.

Table 8. The vertical, horizontal and coding structure of the HASTA indicator set.

Dimensions	Aspects	Outcome	Output	Input
Economic	Efficiency	EN/Eff-I-S.. EN/Eff-I-O..	EN/Eff-II-..	...
	Accessibility (business)	EN/Acc-I-S.. EN/Acc-I-O..	EN-SO/Acc-II-..	...
Social	Accessibility (personal)	SO/Acc-I-S.. SO/Acc-I-O..		...
	Safety	SO/Sa-I-S.. SO/Sa-I-O..	SO/Sa-II-..	...
	Liveability	SO/Li-I-S.. SO/Li-I-O..	SO/Li-II-..	...
Environmental	Emission	EL/Em-I-S.. EL/Em-I-O..	EL/Em-II-..	...
	Resource use	EL/Ru-I-S.. EL/Ru-I-O..	EL/Ru-II-..	...

There is one group of indicators describing and characterizing the institutional background of a municipality. The group is called “institutional indicators”. Institutional indicators reflect the capacity and readiness of the municipality administration to handle sustainability issues.

3.2. Indicator set

During the selection process, a large number of indicators were collected from international literature, national documents and local practice. The indicators not fulfilling the following criteria were omitted:

- Reflect our definition of sustainable transport system (see chapter 1.6.),
- Reflect the actual Swedish political targets of transport,
- Reflect the actual Swedish society (no indicator on deep poverty),
- Characterize well (= be relevant for) the Swedish transport system on municipal level (e.g. not national or regional values),
- Are of non-private interest (the city can not affect the private companies)

During the selection process, four more phenomena were considered.

- Overlapping: Because the elements of transport interplay with each other, the various indicators will unavoidably overlap and cohere. We tried to keep repeated information behind indicators on the "minimal" level. When indicators describe the objective (measurable) and subjective (inhabitants' perception) side of the same phenomena this does not count as overlapping (e.g.: objective side: injury risk, subjective side: % of population feeling unsafe from traffic accident).
- Coherency: The coherence between the indicators is moving on a wide scale. From the independence to the "dummy" indicators (this means for example some of the main issues of the ecological or social aspect of the sustainable transport policy like safety, pollution etc. has an accentuated role in the economic side as well). In this phase we prepared a table between indicators and marked if they cohere (see *Annex* III). To take into account the level of coherency will be one of the challenges of the model building which is next phase of the project.
- Availability: a large amount of the information described by the indicators (especially social indicators) is not available today. Hence the indicator-list might be seen as a "wish-list" showing what kind of new measurements are needed to monitor sustainability.
- Conflict between indicators' targets: there are several elements of transport system which are influencing indicators with opposing target (e.g.: mobility is in the first place something that satisfies preferences of people and is therefore perceived as desirable. While the vehicle-kilometres perceived are much less favourable due to the direct relationships with side effects of mobility (TISSUE, p. 64). A coherence-analysis is needed before the model building which is next phase of the project.

The HASTA indicator-set is shown in *Annex* II.

3.2.1. Efficiency

The term "efficiency" means producing results with little wasted effort. An efficient transport system with modern infrastructure favours many economic changes, most of them positive. When transport systems are efficient, they provide economic and social opportunities and benefits that lead to positive multiplying effects such as better accessibility to markets, employment and additional investments. When transport systems are deficient in terms of capacity or reliability, they can have an economic cost such as reduced or missed opportunities.

Outcome

EN/Eff-I-S1	Percentage of business companies and public organizations satisfied with the transport system
Unit:	percentage (%)
Description:	The transport sector is an important component of the economy affecting the development and the welfare of the population. A well-functioning transport system which is a key factor for economic development. Important transport quality variables are shipping time, punctuality and reliability. The correlation between this indicator and sustainability is positive: higher percentage is better.
Target:	100% business companies and public organizations satisfied with the transport system.

EN/Eff-I-O1	Annual ton-km / transport investment costs
Unit:	ton km/SEK
Description:	An efficient use of the transport system imply that the construction, improvement and maintenance cost by mode should be minimized and the use of the infrastructure (benefits) maximized resulting in an efficient use of existing and new infrastructure. Maintenance cost for streets are determined by average values depending on street classification. Maintenance cost for tracks are determined by average values based on national statistics. The correlation between this indicator and sustainability is positive: higher value is better.
Target:	An effective use of resources both invested in costs related to maintenance

EN/Eff-I-O2	Annual passenger km / transport investment costs
Unit:	passenger km/SEK
Description:	An efficient use of the transport system implies that the construction, improvement and maintenance costs by mode should be minimized and the use of the infrastructure (benefits) maximized resulting in an efficient use of existing and new infrastructure. Maintenance cost for streets are determined by average values depending in street classification. Maintenance cost for tracks are determined by average values based on national statistics. Investments in transport infrastructure/capita will have a general positive effect on the satisfaction of business companies and public organizations. There should be a focus on sustainable transport modes. The correlation between this indicator and sustainability is positive: higher value is better.
Target:	Not identified.

Output

EN/Eff-II-1	Average freight transport speed in the city
Unit:	km/h
Description:	An efficient transport system with modern infrastructure favours many economic changes, most of them positive. It provides market accessibility by linking producers and consumers. The correlation between this indicator and sustainability is positive: higher value is better. The main target is that companies should be satisfied with the transport system regarding the speed of freight transport in the city, since a well functioning transport system is a key factor for economic development. In relation to sustainability, there should, of course, be focus on the transport system based on rail transport and effective use of road transport.
Target:	Not identified.

Input

In case of the values of outcome and output indicators are found inadequate, the municipality can achieve an improvement via increased focus on measures affecting input indicators.

Input indicators for efficiency improvement are:

- Investments in transport infrastructure / capita
- Percentage of free parking spaces / capita
- Percentage of arterial streets of the total street network

3.2.2. Accessibility

The clear allocation of outcomes of interest to the three dimensions of sustainability (economic, environmental and social) is not always possible. E.g. accessibility as a common objective of sustainable mobility can be regarded as an outcome of interest in social, as well as in the economic dimension.

Evaluating performance from an accessibility perspective provides a balanced, more holistic approach to transport analysis and planning. Notably, it gives attention to alternative strategies for reducing traffic congestion and mitigating environmental problems, such as promoting efficient, resource-conserving land-use arrangements. Compact, mixed-use development, can substitute for physical movement by both shortening travel time distances and prompting travellers to walk instead of driving. Good level of accessibility is one of a key objective of the Swedish political targets.

Outcome

EN/Acc-I-S1	Percentage of population satisfied with the transport system regarding commuting trips
Unit:	percentage (%)
Description:	The transport sector is an important component of the economy affecting the development and the welfare of the population. When transport systems are efficient, they provide economic and social opportunities and benefits that lead to positive multipliers effects such as better accessibility to markets, employment and additional investments. Transport infrastructure improvements may open up markets and stimulate agglomeration economies. Reduction in travel time distances increase the spatial size of labour markets, even if the propensity to commute over time distances larger than 45 minutes is limited (Graham, 2007; Johansson, 2007). The correlation between this indicator and sustainability is positive: higher percentage is better.
Target:	100% of population satisfied with the transport system.

EN/Acc-I-O1	Percentage of job opportunities and services within 45 minutes travel distance of residence
Unit:	percentage (%)
Description:	Transport infrastructure improvements may open up markets and stimulate agglomeration economies. Diminishing time distances increase the spatial size of labor markets, but the propensity to commute over time distances larger than 45 minutes is limited (Graham, 2007; Johansson, 2007). The majority of the population should be able to easily reach job opportunities within 45 minutes. This increases the possibility for employees to find relevant jobs but also increases the possibility for companies to find relevant employees. The correlation between this indicator and sustainability is positive: higher percentage is better.
Target:	Not identified.

SO/Acc-I-S1	Percentage of population satisfied with the transport system regarding non-work related trips
Unit:	percentage (%)
Description:	This indicator describes how population perceives the efficiency and quality of the transport system when they use it in their "free time". The satisfaction influenced by travel time, as well as the level of service. From social point of view the non-work related trips are enforcing participation in the society and increase the personal feeling of freedom (Rand et al., 2004). This indicator also allows that many of facilities (shops, offices, recreation area) can be reached with a short travel time of residents. The correlation between this indicator and sustainability is positive: higher percentage is better.
Target:	100% of population satisfied with the transport system.

SO/Acc-I-O1	Travel ratio between sustainable transport modes (walking-cycling-public transport) and passenger cars
Unit:	ratio
Description:	Modal split is a transport term that describes the number of trips or percentage of travellers using a particular type of transport (non-motorized, passenger cars and public transport). The term is often used when analyzing the sustainability of transport within a city or region. Modal split refers to the varying proportions of different transport modes which may be used at any one time. Modes of transport may be seen as competing services, particularly between the private car and public transport systems. In many cases the travelling time and comfort of a car journey outweigh costs so that non-cost factors play an important part in determining modal choice. Year by year changes in modal split are significant: in general, trips by bicycle or on foot are decreasing, while trips using motorised modes of transport have increased, especially individual motorised modes. The relationship between this indicator and sustainability is positive: more is better.
Target:	Not identified.

Output

EN-SO/Acc-II-1	Average travel speed along arterial streets in peak hours
Unit:	km/h
Description:	The main function of the arterial network is to facilitate good accessibility and fast transports between different areas. The average travel speed (another way of expressing travel time) on these streets indicates the effectiveness of transport. It is affected by traffic density and congestion. The correlation between this indicator and economic sustainability is positive: higher travel speed (giving shorter travel time) is better. A high average travel speed indicates effectiveness, but should not be mixed up with high spot speed which affects the road safety outcome.
Target:	Not identified.

EN-SO/Acc-II-2 Average travel speed along entry roads in peak hours

Unit: km/h

Description: The capacity of entry roads to the city during peak hours is of fundamental importance for transport effectiveness. The average travel speed (another way of expressing travel time) on these entry roads is the indicator of transport effectiveness. It is affected by traffic density and congestion.
The correlation between this indicator and economic sustainability is positive: higher travel speed is better. A high average travel speed indicates effectiveness, but should not be mixed up with high spot speed which affects the road safety outcome.

Target: Not identified.

EN-SO/Acc-II-3 Percentage of population with access to public transport (300 m – as the crown flies)

Unit: percentage (%)

Description: Transport infrastructure improvements stimulate agglomerations' life through diminished time distances. Availability of public transport is a key to increased commuting trips by other means than car. The European Environment Agency use the concept "within 15 minutes' walk" to define accessibility. It may reasonably be assumed that this corresponds to around 500 m on foot for an elderly person, which in turn may be equivalent to 300m "as the crown flies" (Tarzia, 2003).
The correlation between this indicator and sustainability is positive: higher percentage is better.

Target: 100% of of population with access to public transport.

EN-SO/Acc-II-4 Average speed of public transport

Unit: km/h

Description: Travel time, besides reliability, punctuality and frequency, is a main quality indicator of public transport. Travel time is expressed in a normalised way as travel speed. The correlation between this indicator and sustainability is positive: higher travel speed is better. A high average transport speed indicates efficiency, but should not be mixed up with high spot speed which affects the road safety outcome.

Target: Not identified.

EN-SO/Acc-II-5 Percentage of public transport means keeping time table	
Unit:	percentage (%)
Description:	Public transport punctuality increase reliability of public transport, and thereby strengthens its competitiveness against car. It gives a clear indication of the quality of public transport. Public transport means arriving at the stop / station within ± 3 minutes according to the time table are considered keeping the time table. The correlation between this indicator and sustainability is positive: higher percentage is better.
Target:	100% of public transport means keeping time table.

EN-SO/Acc-II-6 Vehicle km / day / capita of public transport means	
Unit:	Vehicle km / day / capita
Description:	The frequency of public transport means is one of the main quality indicators of public transport. The unit “Vehicle km / day” reflects frequency and was found to be the most important explanatory variable influencing the number of trips with public transportation (Persson, 2008). The correlation between this indicator and sustainability is positive: higher value is better.
Target:	Not identified.

Input

In case of the values of outcome and output indicators are found inadequate the municipality can achieve an improvement via increased focus on measures affecting input indicators.

Input indicators for accessibility improvement are:

- Percentage of population living and working in the city
- Percentage of crossing points adopted to disabled
- Percentage of bus stops adopted to disabled
- Signal priority for public transport
- Percentage of low floor vehicles in public transport fleet.
- Number of bicycle parking / capita
- Percentage of continuous bicycle paths of total bicycle path length
- Priority to bicycles at crossings with motorized traffic
- Percentage of separate walking paths of total length of the transport network
- Percentage of free parking places / capita
- Parking price / hours in the central area
- Existence of congestion charging in city centres
- Existence of pricing and tax policies for freight vehicles.

3.2.3. Safety

Traffic safety is a key priority and, being a public health problem influencing people's well being, is an important social indicator. Policymakers and managers targeting a higher level of safety need to have a clear view about what and how they can affect the current situation and they need feedback about achievements (ETSC, 2001). A number of research programs focused on developing indicators measuring performance in road safety. A number of safety indicators, proposed and proven by several best practices, are selected for the HASTA framework.

Outcome

SO/Sa-I-S1	Percentage of population feeling safe (free from accident)
Unit:	percentage (%)
Description:	This indicator reflects the concept of quality of life (Steg et al. 2006), saying travel is a vital element of urban life, not only a service but almost a "basic bill of right" and the users' satisfaction is fundamental when considering sustainability. A traffic system – judged unsafe by users – can be a constant source of displeasure, stress in daily use and can influence human health deeply. This indicator focuses on the users' feeling of safety – on the whole length of the staying on traffic related public area. The perceived safety along the journey as a pedestrian, cyclist or driver based on the difference between the expected and real behavior of other participants. Higher reliability on the rules (and the willingness of a rules-following behavior) gives higher feeling of safety. This indicator is not dealing with possible crime alongside the road or on other traffic related public places (parking houses, pedestrian areas, etc). The correlation between this indicator and sustainability is positive: higher percentage is better. However, one must always foresee the problem of people feeling safe may behave less safe, i.e. this effect may at least partly jeopardize safety effects.
Target:	100% of the population feeling safe from traffic accident.

SO/Sa-I-O1	Injury risk / person-km
Unit:	rate
Description:	This indicator provides a measure of the effect of road traffic on health through non-occupational injury. It can be presented either in absolute terms (e.g. total number of deaths or injuries) as a population rate (e.g. number of deaths or injuries per hundred thousand people), in terms of the total traffic volume (e.g. vehicle kilometres travelled) or in terms of the number of trips. Due to the technical development of car design and road design, the chance to survive a crash is increasing. New technology, however, may have a negative effect on drivers' behaviour in form of reduced alertness and more risk taking. The importance of this indicator is to have information about the real effect of applied measures. The correlation between this indicator and sustainability is negative: lower rate of injury risk is better.
Target:	Zero fatalities and injuries.

Output

SO/Sa-II-1	Percentage of motor vehicles above speed limit
Unit:	percentage (%)
Description:	Speeding is one of the strongest contributory factors to traffic accidents. There is a well established relationship between the speed level and the number and severity of accidents (Finch et al., 1994; Nilsson, 2004; Elvik and Vaa, 2004. Non-compliance with the traffic rules indicates missing respect for other persons and social norms and has a negative effect on society. The correlation between this indicator and sustainability is negative: lower percentage is better.
Target:	No drivers violating speed limits (0%).

SO/Sa-II-2	Percentage of drivers above permitted blood alcohol limit
Unit:	percentage (%)
Description:	Drunk driving is a significant contributory factor to traffic accidents. The relationship between drunk driving and the number of accidents is well documented (WHO, 2007). Non-compliance with the traffic rules indicates missing respect for other persons and social norms and has a negative effect on society. The correlation between this indicator and sustainability is negative: lower percentage is better.
Target:	No drivers driving drunk (0%).

SO/Sa-II-3	Percentage of motor vehicle occupants wearing safety belt
Unit:	percentage (%)
Description:	A relatively high part of killed vehicle occupants in traffic crashes would survive if they used the safety belt (WHO, 2009). Even if the percentage of vehicle occupants wearing safety belt is relatively high in Sweden, the majority of motorist killed did not wear safety belt (Trafikverket, 2010). Non-compliance with the traffic rules indicates missing respect for social norms and has a negative effect on society. The correlation between this indicator and sustainability is positive: higher percentage is better.
Target:	100% of car occupants using safety belt.

Input

In case of the values of outcome and output indicators are found not satisfactory, the municipality can apply a number of countermeasures to affect input indicators.

Input indicators for safety improvement are:

- Percentage of crossing points for vulnerable road users meeting safety standards,
- Percentage of local streets with traffic calming measures,
- Percentage of "safe" arterial street intersection (RAP),
- Percentage of motor vehicles equipped with ISA,
- Percentage of motor vehicles equipped with Alcolock,
- Percentage of motor vehicles equipped with safety belt reminder.

3.2.4. Liveability

Well-being of citizens is an important component of sustainability. Liveability generally means having conditions of safe and affordable housing, availability of basic services, good environment, opportunities to participate in activities and decision making. Transport related liveability indicators comprise qualities and characteristics of an area that contribute to people's appreciation of its pleasantness, aesthetic coherence, comfort, cleanness, liveliness and security.

Outcome

SO/Li-I-S1	Percentage of population feeling safe from security violation in the transport system (e.g. in tunnels)
Unit:	percentage (%)
Description:	Security is a feeling of attended to and cared for by others (Steg et al., 2006). The feeling of safety and security in the transport system – including the whole infrastructure – is an important social value and vital element of sustainability. It has effect on the environmental and social aspect too. In a city where the factual and perceived security is low, the users favor to travel with passenger car (Rand et al., 2003, 2004). This indicator shows the users' feeling about security using transport system. The correlation between this indicator and sustainability is positive: higher percentage is better.
Target:	100% of population feels safe from security violation in the transport system.

SO/Li-I-S2	Percentage of population satisfied with the transport related public space (comfortable, clean, aesthetic)
Unit:	percentage (%)
Description:	This indicator focuses not only on the roads and their environment, but the walking and cycling facilities' environment as well. The liveability of a place is influenced by the inhabitants' perception of attractiveness of public space (comfort, cleanness, aesthetic, liveliness). In a city, the population prefer clean, lively and appealing places (Steg et al., 2006). An attractive public space is good not only for the social aspect of sustainability but has a strong effect on the mobility as well. An attractive space influences significantly the means of transport for short trips. The road users will choose more often to walk or to cycle in case of short trips (Rand et al. 2004). The correlation between this indicator and sustainability is positive: higher percentage is better.
Target:	100% of population satisfied with the transport related public spaces.

SO/Li-I-O1	Annual number of reported incidents of personal security violation in the transport system / person-km
Unit:	rate
Description:	This indicator has two main components (Rand et al. 2004): * Vehicle related crimes, thefts of vehicles, theft from vehicles, attempted thefts from vehicles and car damaging and vandalism. “Vehicles” here are all devices that are used to transport people or cargo. * Non-vehicle related crimes: Incidents on public transport means, incidents on public places related with transport (bus stops, bus and train stations, bicycle/pedestrian routes, including tunnels, etc.) The importance of this indicator is that it will give an objective, quantitative view of the personal security level in the transport system. The correlation between this indicator and sustainability is negative: lower rate is better.
Target:	Zero personal security incidents in the transport system.

SO/Li-I-O2	Percentage of children going to school by other means than car
Unit:	percentage (%)
Description:	Today, more and more children are transported to school by individual passenger cars (Tarzia, 2003), contributing to the negative effects from transport on sustainability. Today’s children are the travelers of the future and if they get used to the private car as the principal means for their transport they will continue with their transport habits in their adulthood, keeping the negative loop of sustainability intact. The correlation between this indicator and sustainability is positive: higher percentage is better.
Target:	Not identified.

Output

SO/Li-II-1	Percentage of population within walking distance from a grocery store
Unit:	percentage (%)
Description:	Access to basic services is vital not only for quality of life but the viability of local economy. Having basic services close to home reduces the need to travel (Tarzia, 2003). This indicator shows the rate of the inhabitants having a grocery store in walking distance. The correlation between this indicator and sustainability is positive: higher percentage is better.
Target:	100% of population within walking distance from a grocery store.

SO/Li-II-2	Percentage of population living within walking distance from recreation areas
Unit:	percentage (%)
Description:	Easy access to recreation area (open spaces, leisure activities) is essential for social and individual development, contribute to better health decreasing daily stress, reduces the need for travel (Rand et al. 2004). The indicator shows the rate of the population having access to recreation areas. The correlation between this indicator and sustainability is positive: higher percentage is better.
Target:	100% of population within walking distance from recreation areas.

SO/Li-II-3	Percentage of children living within walking distance from a school
Unit:	percentage (%)
Description:	Having school close to home increase the car-independency and give opportunity to children to learn how to use the streets as pedestrians, bikers and to acquaint public transport service. Accesses to school decrease the need to travel, and without necessity of driving children to school is a way to let them learning environmental awareness and sustainable behavior (Rand et al. 2004). Today's children are the travelers of the future and if they get used to the private car as the principal means for their transport they will continue with their transport habits in their adulthood, keeping the negative loop of sustainability intact. This indicator shows the percentage of children in living at walking distance from school. The correlation between this indicator and sustainability is positive: higher percentage is better.
Target:	100% of population children within walking distance from schools.

Input

In case of the values of outcome and output indicators are found not satisfactory, the municipality can apply a number of countermeasures to affect input indicators.

Input indicators for liveability improvement are:

- Percentage of illuminated walking and bicycle paths of the total length of the whole network
- Number of facilities (shops, bar, coffee shop, restaurants, kiosks, etc.) / meter of path (opening times: day/night)
- Number of proper seats / walking distance – 300 m (benches, stools, sitting walls, balustrades, rails, columns).
- Percentage of overfilled garbage bins (just before the garbage collection).

3.2.5. Emissions

Urban air pollution from road transport is a growing concern in a large number of cities worldwide. With rising income, the use of motorized transport is expected to continue to increase in the coming years, potentially worsening air quality (Gwiliam et al. 2004).

Road transport releases pollutants that can cause deterioration of soil quality, i.e. emissions from all transport means, driven by internal combustion engines, also deposits in form of particulate matter to the soil.

Outcome

EL/Em-I-S1	Percentage of population feeling disturbed by air pollution and/or noise from traffic at their homes
Unit:	percentage (%)
Description:	Noise and pollution can produce serious health effects, influence social and behavioral habits as well as annoyance, sleep disturbance, increased daily stress (Sommer et al. 1999). This indicator describes the amount of population having annoyance in daily routine and/or sleep disturbance due to air pollution and/or noise from traffic. The definition of annoyance is essential for the surveys' design as well as for methodology used to describe the impact. Several methods had been developed to understand how the researcher define "annoyance" (Guski et al., 1999) The correlation between this indicator and sustainability is negative: lower percentage is better.
Target:	Nobody (0%) feeling disturbed by pollution and/or noise from traffic at their homes

EL/Em-I-O1	Annual cost for society / capita due to emissions from transport
Unit:	SEK / capita
Description:	Air pollution from road transport is a major health hazard and in combination with other environmental problems an important issue. Poor air quality has been shown to have seriously adverse effects on public health, principally affecting the body's respiratory system and the cardiovascular system. Polluted air contributes to the occurrence of various health problems at population that is under the continuous influence of toxic air polluters. The World Health Organization estimated that 650,000 people died prematurely from urban air pollution in developing countries in 2000 (EU commission, 2010). The importance of this indicator is that it expresses the pollutants in monetesed values making socio-economic valuation of them possible. The correlation between this indicator and sustainability is negative: lower cost is better.
Target:	Zero SEK due to emissions from transport

Output

EL/Em-II-1	Percentage of population living in areas where pollution is higher than air quality standards
Unit:	percentage (%)
Description:	Road transport is one of the major sources of toxic air pollutants in urban areas: NO_x, CO, PM, CH, SO_2. Air pollution from road transport is a major health hazard and in combination with other environmental problems an important issue. Poor air quality has been shown to have seriously adverse effects on public health, principally affecting the body's respiratory system and the cardiovascular system. Polluted air contributes to the occurrence of various health problems at population that is under the continuous influence of toxic air polluters. The World Health Organization estimated that 650,000 people died prematurely from urban air pollution in developing countries in 2000 (EC, 2010). The importance of this indicator is that it will give a clear overview of the part of the population living in those areas with poor air quality, i.e., where these emissions are higher than the permitted limit of urban air quality. Still, individual reactions to air pollutants depend on the type of pollutant a person is exposed to, the degree of exposure, and the individual's health status and genetics. The correlation between this indicator and sustainability is negative: lower percentage is better.
Target:	Nobody (0%) of population living in areas where pollution is higher than air quality standards.

EL/Em-II-2	Percentage of population living in areas where noise emission is greater than 55dbA
Unit:	percentage (%)
Description:	Transport noise is an increasing problem in modern society and it is the dominating source of noise in the urban environment. Urban transport accounts for the largest part of noise emission (over 80%) (Wolfram et al., 2005). Noise is more than an annoying event, still it has much less attention than air pollution. Increased level of noise has negative impacts on health, affecting especially the weak (children and elderly). Research has proven that noise emission higher than 55 dbA can cause many harmful psycho-physical health effects (nuisance, anxiety, behavior changes, sleeping disorders, cardio problems and problems with high blood pressure; loss of productivity)(Wolfram et al., 2005). The correlation between this indicator and sustainability is negative: lower percentage is better.
Target:	Nobody (0%) of population living in areas where noise emission is higher than 55dbA.

EL/Em-II-3	Contribution of transport (%) to the total amount of greenhouse gases
Unit:	percentage (%)
Description:	The greenhouse effect is a process that plays a major part in the changes of global climate. Increased use of fossil fuels during the last century has created an enhanced greenhouse effect, known as global warming (IEA 2010) Transport significantly contributed to this increase. Road transport is the greatest source of greenhouse gases in the transport sector (Li, 2009) Greenhouse gas from the road sector comes mainly from carbon dioxide emitted during fuel combustion in vehicle engines. Emissions are directly related to fuel consumption. Principal fuels are petrol and diesel. Carbon dioxide (CO_2), produced by combustion of fuels, is one of the principal greenhouse gases. Higher concentrations of CO_2 and other greenhouse gases trap more infrared energy in the atmosphere than occurs naturally. The additional heat further warms the atmosphere and Earth's surface causing changes in the climate. Today, climate change is potentially one of the most serious environmental threats facing the world. Therefore reducing CO_2 emissions and fuel consumption from road transport has become an important strategy for the European Union against climate change (Li, 2009) The correlation between this indicator and sustainability is negative: lower percentage is better.
Target:	Not identified.

EL/Em-II-4	Contribution of transport (%) to the soil contamination
Unit:	percentage (%)
Description:	Road storm water run-off can increase the risk of soil erosion, and can contain pollutants such as fuel oils, heavy metals and other toxic pollutants that may cause pollution of the receiving watercourses. Water that runs off a road surface can convey some of the pollutants in a dissolved or suspended form to the roadside (Bohemen and Janssen, 2003). The level of the soil pollution is mainly in correlation with the degree of the transport density. Urban zones with heavy traffic and with vehicles travelling short distances have high emission of toxic pollutants. Emission is also increased by engine troubles and worn out motors. Contamination of soil also comes from the road salt used for the maintenance of streets and residential areas. The large amounts of salt used especially during long winters accumulate in the ground and raise the amount of chloride within the soil. Therefore, soil contaminants can have significant harmful consequences for ecosystems. These road salt and harmful heavy metal contaminants can execute a significant impact on soil quality and plant growth, depending on its form, as well as its transport and accumulation in soil. The concern over soil contamination rises primarily from health risks, from direct contact with the contaminated soil, vapors from the contaminants, and from secondary contamination of water supplies within and underlying the soil. The correlation between this indicator and sustainability is negative: lower percentage is better.
Target:	Not identified.

Input

In case of the values of outcome and output indicators are found not satisfactory, the municipality can apply a number of countermeasures to affect input indicators.

Input indicators for affecting emission volumes are:

- Number of wastewater treatment plants / transport land use
- Annual used road salt / capita / snowy days
- Percentage of storm water run-off treated in wastewater treatment plants
- Travel time ratio between sustainable transport modes (walking-cycling-public transport) and passenger cars
- Travel cost ratio between sustainable transport modes (walking-cycling-public transport) and passenger cars
- Car ownership in the city / capita
- Number of commuting trips to and from the city / day / capita
- Percentage of freight vehicles in transport
- Veh-km driven by passenger cars in the city / capita
- Veh-km driven by freight vehicles in the city / capita
- Existence of programs for vehicle operator training for eco-driving
- Percentage of main streets in the total transport network with heavy vehicles (including buses and motorcycles) not allowed
- Percentage of heavy vehicles (including buses and motorcycles) in traffic flow in streets with housing.
- Number of intermodal transfer facilities (road freight transport – railway transport) in the city / transportation land use
- Percentage of annual ton-km transported on railway of total freight transport / year
- Percentage of public transport means using renewable fuels
- Percentage of cars using renewable fuels
- Percentage of heavy vehicles using renewable fuels

3.2.6. Resource use

Land is a finite resource. The amount of land used for different purposes is a key indicator of the impact of public policies, but most importantly, it is a key indicator of progress towards sustainability.

Outcome

EL/Ru-I-S1	Percentage of population thinking that the land areas occupied of transport related activities related to the total area of the municipality are appropriate
Unit:	percentage (%)
Description:	Cities often lacks significant outdoor recreation areas, pedestrian and cyclist areas rending more difficult for the inhabitants to find easily outdoor activities. This indicator describes the rate of inhabitants who feel annoyance by the size of motorized transport related area (roads, parking places, impediment) related to the total area of the city, or with other words missing the accessibility of outdoor recreation areas (open spaces as small parks, preservation areas, wild areas, free spaces) (Joumard, 2010). The correlation between this indicator and sustainability is positive: higher percentage is better.
Target:	100% of population thinking that the mark areas occupied of transport related activities related to the total area of the municipality are appropriate.

EL/Ru-I-S2	Percentage of population thinking that using renewable fuels is affordable
Unit:	percentage (%)
Description:	"Affordability" means the willingness and ability to pay for a service or a product (Rand et al. 2004). The Swedish government and other national governments have policies on green procurement, promoting and buying eco-labeled goods and services. Municipalities and cities are working on policies to prioritize "green" procurements (Tarzia, 2003). A part of this process is to inform inhabitants about the actual market price for a change to a more sustainable means of transport. This indicator gives an overview about the population who know the price and judging affordable of using renewable fuels. The correlation between this indicator and sustainability is positive: higher percentage is better.
Target:	100% of population thinking that that using renewable fuels is affordable.

EL/Ru-I-O1	Percentage of land use for transport of total area of the municipality
Unit:	percentage (%)
Description:	Land intrusion and fragmentation due to the expansion of transport infrastructure networks contributes to loss of habitat and green space and the reduction of available living space. Transport land use is a significant threat to biodiversity because of the direct impacts from proximity and disturbance of transport means. Another threat to biodiversity comes from fragmentation and isolation of habitats and creating barriers. Important factors for land intrusion are the transport infrastructure characteristics, which determine the visual impact on the landscape and the extent to which the infrastructure constitutes a barrier for the movement of animals or people (EEA, 2003). The land occupied by roads, railways, parking lots, fuel stations, bicycle and walking surfaces depends entirely of current level of development of urban transport, but also of effectiveness of urban planning. The relationship between this indicator and sustainability is negative: lower value is better, accomplished with increased participation of other small-land-use modes in urban transport (public transport, cycling, walking).
Target:	Not identified.

EL/Ru-I-O2	Percentage of renewable fuels of total fuel consumption in transport
Unit:	percentage (%)
Description:	This indicator shows the materialized rate of "preparedness" to decrease the negative environmental effect of transport. The relationship between this indicator and sustainability is positive: higher percentage is better.
Target:	Not identified.

Output

EL/Ru-II-1	Density of transport links (km/km^2)
Unit:	rate (km/km^2)
Description:	Density of transport links due to the expansion of transport infrastructure networks is an important threat to loss of land and to biodiversity because of the direct impacts from proximity and disturbance of transport means. Density of transport links also contributes for loss of habitat and green space and the reduction of available living space. The extent of the density of roads, railways, bicycle and walking surfaces depends entirely of current level of development of urban transport, but also of effectiveness of urban planning. The relationship between this indicator and sustainability is negative: less is better, but sustainability can only be accomplished with optimally chosen and build transport links, which have positive influence on accessibility, total travel time and transport land use.
Target:	Not identified.

EL/Ru-II-2	Transport land use / annual person-km
Unit:	rate (km^2/person-km)
Description:	Person-kilometres are a measure of activity for the transport sector, meaning transport of 1 person over 1 kilometer. The land occupied by roads, railways, parking lots, bicycle and walking surfaces depends entirely of the current level of development of urban transport and the efficiency of measures for transport management, but it also depends of effectiveness of urban planning. Referring sustainability and environmental protection, it is clear that orientation from passenger cars towards more sustainable transport modes is better. But, to achieve this change, it is important that citizens have a choice between their car and more convenient, accessible and punctual public transport. At the same time, a safe and coherent transport infrastructure for bicycling and walking has to be offered. Increasing the number of person kilometres at annual level using environmentally less harmful modes of transport doesn't mean that a sustainability goal is achieved, if its realization demands the building of an extended, new transport infrastructure. Lower degree of land take can be achieved with effective measures of transport management on the current transport network, avoiding the expansion of land surfaces. The relationship between this indicator and sustainability is negative: less is better, accomplished by increased participation of sustainable transport modes (public transport, cycling, and walking), without expanding the transport infrastructure.
Target:	Not identified.

EL/Ru-II-3	Transport land use / annual ton-km
Unit:	rate (km^2/ton-km)
Description:	Tonne kilometres are a measure of activity for the transport sector, meaning transport of 1 tonne over 1 kilometre. The land occupied by the transport infrastructure depends entirely of the current level of development of urban transport and efficiency of measures for transport management, but it also depends of the effectiveness of urban planning. Referring sustainability and environmental protection, it is clear that orientation from heavy goods vehicles in road transport to other mode of goods transport that is environmentally less harmful (railway transport) is better. To achieve this change, it is important to offer a safe, fast, cheap and effective railway transport. At the same time, there is a need for nodes where an effective intermodal change of the transported goods can be performed. Increasing the number of ton kilometers at annual level using environmentally less harmful mode of transport doesn't mean that a sustainable goal is achieved, if its realization demands the building of an extended, new transport infrastructure. Lower degree of land take can be achieved by using the transport network more efficiently and avoiding the expansion of land use. The relationship between this indicator and sustainability is negative: less is better, accomplished by sustainable mode (by railway instead by heavy goods vehicles), without expanding the transport infrastructure.
Target:	Not identified.

Input

In case of the values of outcome and output indicators are found not satisfactory, the municipality can apply a number of countermeasures to affect input indicators.

Input indicators for resource use improvement are:

- Number of intermodal transfer facilities (road freight transport - railway transport) in the city / transportation land use
- Percentage of annual ton-km transported on railway of total freight transport / year
- Travel time ratio between sustainable transport modes (walking-cycling-public transport) and passenger cars
- Travel cost ratio between sustainable transport modes (walking-cycling-public transport) and passenger cars
- Car ownership / capita
- Number of commuting trips to and from the city / day / capita
- Percentage of freight vehicles in transport
- Veh-km driven by passenger cars / capita
- Veh-km driven by freight vehicles / capita
- Existence of programs for vehicle operator training for eco-driving
- Percentage of main streets in the total transport network with heavy vehicles (including buses and motorcycles) not allowed
- Percentage of heavy vehicles (including buses and motorcycles) in traffic flow in streets with housing

- Number of intermodal transfer facilities (road freight transport – railway transport) in the city / transportation land use
- Percentage of annual ton-km transported on railway of total freight transport / year
- Percentage of public transport means using renewable fuels
- Percentage of cars using renewable fuels
- Percentage of heavy vehicles using renewable fuels

3.2.7. Institutional indicators

Institutional indicators reflect the capacity and readiness of the municipality administration to handle sustainability issues. These indicators show the existence of a capable organisation, visions, strategies, processes and actions.

Strategic

- Existence of a sustainable transport policy, adopted by decision makers
- Existence of formalized cooperation between departments

Organizational

- Clearly defined responsibilities at the municipality for implementing and monitoring sustainability
- Public participation in the transport planning process – other than regulated by law

Actions

- Initiatives to achieve sustainable transport (mobility management, enlightenment programs, campaigns car pooling, etc.)
- Expenditures/investments in transport on accessibility/mobility related information and research

4. Discussion

The aim of this report was to elaborate a framework of indicators to monitor sustainability of transport in Swedish cities. The resulting HASTA framework has benefited a lot from input from earlier research findings on sustainability, their proposed frameworks and lists of indicators. The HASTA indicators are adapted to Swedish conditions, for monitoring sustainability of transport in the city.

The HASTA indicator framework covers the three dimensions of sustainability, i.e. Economic, Environmental and Social. The framework includes all the relevant aspects of importance of the transport system. Under the three sustainability dimensions, there are 6 sustainability aspects (indicator groups), 2-3 per dimension; these are Efficiency, Accessibility (Economic dimension), Accessibility, Safety, Liveability (Social dimension); Emissions, Resource use (Environmental dimension). The accessibility indicator group is related with both economic and social sustainability.

The individual indicators are structured in three levels of a hierarchical structure. The highest level is represented by the Outcome indicators which reflect the sustainability target in the subject area of the indicator. These Outcome indicators are of both objectively measurable variables and subjective variables, reflecting how the inhabitants experience sustainability of transport in their city. On the lowest level, the Input indicators provide information on possible measures or tools to make improvements in transport sustainability. On the intermediate level, the Output indicators show the effect of the adopted measures (Input indicators). There are 19 Outcome indicators, 22 Output indicators and 42 Input indicators.

The list of indictors is not to be seen as a final or ultimate list. As new knowledge emerges, the list can be updated and - especially to the input indicator list - new indicators can be added. This kind of work is continuous and the framework and indicators should be updated or altered when new knowledge is available.

The new thing with this framework and indicator list compared to earlier works is that, besides objective, measurable indicators, the HASTA framework puts weight on subjective indicators, i.e. how the population experiences the sustainability of transport in their city, their satisfaction with the transport and its effects on the environment and social issues. This is a new territory in sustainability research, hence there is a need for testing and operationalising of these subjective aspects.

Further, a new group of a different kind of indicator set, i.e. Institutional indicators are proposed to be included in the HASTA framework. The Institutional indicators reflect the capacity and readiness of the municipality administration to handle sustainability issues and they consist of Strategic, Organisational and Actions indicators.

The main criteria used to identify the HASTA indictors were their ability to reflect the HASTA definition of sustainable transport system, reflect the Swedish national targets for transport, characterize well the Swedish society and transport system on municipal level, and being of non-private interest. During the selection process, four more issues were considered:

- To avoid overlapping between indicators,
- To keep track of coherence between the indicators in the sense whether some of the main issues of one of the three dimensions of sustainability influence any other dimension,

- Availability: a large amount of the information described by the indicators (especially social indicators) is not available today, hence the indicator list might be seen as a "wish-list" showing what kind of new measurements are needed to monitor sustainability,
- To keep track of conflicts between indicators with opposing targets.

The elaborated HASTA framework constitutes a base for developing a tool, visualising in a simple way the current situation, to monitor sustainability of transport in Swedish cities. The next step in operationalising the HASTA indicator framework is the weighting of the outcome indicators to aggregate them so that decision makers can get a simple picture of the current sustainability situation of their city. Trade-offs between the indicators must be made based on scientific knowledge. This is a complicated task as it is not always possible to express all indicators in the same unit and even more difficult to monetise them. For many of the indicators there is no scientifically or politically defined target, which also makes the weighting procedure difficult.

The directions towards a sustainable situation in the three dimensions are defined, but in some cases it is a challenge to find measures where the indicators of the different dimensions all will show development in the positive direction. Further research is needed to find out where the positive and negative developments are in minimal conflict and which trade-offs give the best value. Making these choices also implies political considerations. A municipality giving high priority to economic development, or employment issues will have different trade-off considerations than a municipality giving highest priority to environmental considerations.

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Annexes

1. Annex I – Indicator lists from earlier literature

I.1. Indicators of Sustainable Mobility, policy Measures and Assessment - SUMMA (Rand et al. 2004);

I.2. Indicators for Comprehensive and Sustainable Transport Planning (Litmann 2009);

I.3. Indicators tracking transport and environment integration in the European Union - TERM 2001 (EEA 2001);

I.4. Sustainable Transportation Performance Indicators – STPI (Gilbert et al., 2002);

I.5. Sustainable Mobility of World Business Council for Sustainable Development - WBCSD (WBCSD 2001);

I.6. Indicators of life quality in transport planning and urban design (Plum book) (Steg et al., 2006)

I.1. Indicators developed in the frame of SUMMA project (Rand et al, 2004)

Economic Outcome of Interest	Indicator name
EC1 ACCESSIBILITY	EC11 Intermodal Terminal facilities EC12 Accessibility of origins/ destinations EC13 Access to basic services (SO11) EC14 Access to public transport (SO12)
EC2 TRANSPORT OPERATION COSTS	EC21 Supplier operating costs EC22 Transport- related expenditures of households (soc 21) EC23 Transport prices
EC3 PRODUCTIVITY /EFFICIENCY	EC31 Freight haulage-related costs on product costs EC32 Utilisation rates EC33 Energy consumption efficiency of transport sector EC34 Energy efficiency
EC4 COSTS TO ECONOMY	EC41 Infrastructure costs EC42 Public subsidies EC43 External transport costs EC44 Final energy consumption (EN11)
EC5 BENEFITS TO ECONOMY	EC51 Gross value added EC52 Public revenues from taxes and traffic system charging EC53 Benefits of transport

Environmental Outcome of Interest	Indicator name
EN1 RESOURCE USE	EN11 Energy consumption EN12 Consumption of solid raw materials EN13 Land take
EN2 DIRECT ECOLOGICAL INTRUSION	EN21 Fragmentation of land EN22 Damage of underwater habitats EN23 Losses of nature areas EN24 Proximity of transport infrastructure to designated nature areas EN25 Light emissions EN26 Collisions with wildlife EN27 Introduction of non-native species
EN3 EMISSIONS TO AIR	EN31 Transport emissions of greenhouse gases EN32 Greenhouse gas emissions from manufacture and maintenance EN33 Transport emissions of air pollutants EN34 Air pollutant emissions from manufacture and maintenance
EN4 EMISSION TO SOILAND WATER	EN41 Hardening of surfaces EN42 Polluting transport accidents EN43 Runoff pollution from transport infrastructure EN44 Wastewater from manufacture and maintenance of transport infrastructure EN45 Discharges of oil at sea EN46 Discharges of wastewater and waste at sea
EN5 NOISE	EN51 Exposure to transport noise
EN6 WASTE	EN61 Generation of non-recycled waste

Indicators developed in the frame of SUMMA project (cont.) (Rand et al, 2004)

Social Outcome of Interest	Indicator name
SO1 ACCESSIBILITY AND AFFORDABILITY (users)	SO11 Access to basic services SO12 Access to public transport SO13 Car independence SO14 Affordability SO15 Trip length
SO2 SAFETY AND SECURITY (users, drivers, the affected)	SO21 Accident related fatalities and serious injuries SO22 Vehicle thefts & other crimes SO23 Security on public transport
SO3 FITNESS AND HEALTH (users)	SO31 Walking and cycling as transport means for short distance trips
SO4 LIVEABILITY AND AMENITY (inhabitants, society, the affect-ed)	SO41 Walkability, pedestrian friendliness SO42 Traffic calming SO43 Children's journey to school SO44 Open space availability and accessibility
SO5 EQUITY (users and the affected)	SO51 Horizontal equity (fairness) SO52 Vertical equity (income) SO53 Vertical equity (mobility needs and ability)
SO6 SOCIAL COHESION (inhabitants, society and the affected)	SO61 Public opinion profile on transport and transport policy issues SO62 Violation of traffic rules SO63 Long distance commuting
SO7 WORKING CONDITIONS IN TRANSPORT SECTOR (employees, drivers, operatives)	SO71 Occupational accidents SO72 Precarious employment conditions SO73 Work absence due to accidents and illness

I.2. Indicators proposed by Comprehensive and Sustainable Transport Planning (Litmann 2009)

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

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

I.3. Indicators tracking transport and environment integration in the European Union (TERM 2001) (EEA 2001);

Transport and environment performance	
Group	Indicators
Environmental consequences of transport	Transport final energy consumption and primary energy consumption, and share in total by mode and by fuel
	Transport emissions of greenhouse gases (CO2 and N2O) by mode
	Transport emissions of air pollutants (NOx, NMVOCs, PM10, SOx, total ozone precursors) by mode
	Exceedances of EU air quality standards for PM10, NO2, benzene, ozone, lead and CO Population exposed to exceedances of EU urban air quality standards
	% of population exposed to and annoyed by traffic noise, by noise category and by mode
	Fragmentation of ecosystems and habitats Proximity of transport infrastructure to designated areas
	Land take by transport infrastructure by mode
	Waste from road transport: number of end-of-life vehicles, number of used tyres
	Accidental and illegal discharges of oil by ships at sea
	Number of transport accidents, fatalities, injured, and polluting accidents (land, air and maritime)
Transport demand and intensity	Passenger transport (by mode and purpose): • vehicle kilometre • total passengers • total passenger-km • passenger-km per capita • passenger-km per GDP
	Freight transport (by mode and group of goods) • vehicle kilometre • total passengers • total passenger-km • passenger-km per capita • passenger-km per GDP

Indicators tracking transport and environment integration in the European Union (TERM 2001) (EEA 2001) (cont)

Determinants of the transport/environment system	
Group	Indicators
Spatial planning and accessibility	Regional access to markets: the ease (time and money) of reaching economically important assets (e.g. consumers, jobs), by various modes (road, rail, aviation)
	Access to basic services: average passenger journey time and length per mode, purpose (commuting, shopping, leisure) and location (urban/rural)
	Access to transport services, e.g.: • vehicle ownership and number of motor vehicles per household • % of persons in a location having access to a public transport node within 500 metres
Supply of transport infrastructure and services	Capacity of transport infrastructure networks, by mode and by type of infrastructure (motorway, national road, municipal road, etc.)
	Investments in transport infrastructure/capita and by mode
Transport costs and prices	Real change in passenger transport price by mode
	Total amount of external costs by transport mode (freight and passenger); average external cost per p-km and t-km by transport mode
	Implementation of internalisation instruments i.e. economic policy tools with a direct link with the marginal external costs of the use of different transport modes
	Fuel prices and taxes
	Subsidies
	Expenditure on personal mobility per person by income group
Technology and utilization efficiency	Overall energy efficiency for passenger and freight transport (per passenger-km and per tonne-km and by mode)
	Emissions per passenger-km and emissions per tonne-km for CO_2, NO_x, NMVOCs, PM_{10}, SO_x by mode
	Occupancy rates of passenger vehicles
	Load factors for road freight transport (LDV, HDV)
	Uptake of cleaner fuels (unleaded petrol, electric, alternative fuels) and numbers of alternative-fuelled vehicles
	Average age of the vehicle fleet
	Proportion of vehicle fleet meeting certain air and noise emission standards (by mode)
Management integ-ration	Number of Member States that implement an integrated transport strategy
	Number of Member States with national transport and environment monitoring system
	Uptake of strategic environmental assessment in the transport sector
	Uptake of environmental management systems by transport companies
	Public awareness and behaviour
	Number of Member States with a formalised cooperation between the transport, environment and spatial planning ministries

I.4. Sustainable Transportation Performance Indicators – STPI
(Gilbert et al., 2002)

Framework topics	Indicator set
Environmental and health consequences of transport	1. Use of fossil fuel energy for all transport 2. Greenhouse gas emissions from all transport 3. Index of emissions of air pollutants from road transport 4. Index of incidence of injuries and fatalities from road transport
Transport activity	5. Total motorized movement of people 6. Total motorized movement of freight 7. Share of passenger travel not held by land-based public transport 8. Movement of light-duty passenger vehicles
Land use, urban form and accessibility	9. Rate of use of urban land
Supply of transport infrastructure and Services	10. Length of paved roads
Transportation expenditures and pricing	11. Index of relative household transport costs 12. Index of the relative cost of urban transit
Technology adoption	13. Index of energy intensity of the road vehicle-fleet 14. Index of emissions intensity of the road-vehicle fleet
Implementation and monitoring	

I.5. Sustainable Mobility of World Business Council for Sustainable Development - WBCSD (WBCSD 2001);

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

I.7. Indicators of life quality in transport planning and urban design (Plum book) (Steg et al., 2006)

Mobility for all (availability and accessibility)	% of residents with an access to the public transport network nearer than 500m
	% of access points to public transport with total accessibility
	% of public transport means with total accessibility
	% of sidewalks with total accessibility
	% of pedestrian crossings with total accessibility
	Travel time/distance ratio
A safe environment (safety)	Number of accidents (considering all the possible combinations cars / motorbikes / bicycles / pedestrians)
	% of users which witnessed, directly or indirectly, a traffic accident in the area during the last 5 year
	% of street-km in the network with 30 km/h (or lower) speed limit
	% of street-km in the network with 30 km/h (or lower) V85 (actual speed measured)
A comfortable environment (comfort)	% of pedestrians using legal crossings (in comparison with the total crossing flow)
	% of pedestrians using sidewalks (in comparison with total longitudinal flow)
	% of traffic light with pedestrians red phase longer than x sec
	Yellow traffic-light phase
	% of streets with sidewalks wider than 3m
	% of streets with open-air noise > than 55 dBA
	% of streets with in-house noise > than 45 dBA
	Traffic flow volume and composition
A secure environment (security)	% of users which witnessed, directly or indirectly, a petty crime episode in the area during the last 5 year
	Number of lights/square meter
	Amount of light lumen/square meter
	Number of open activities/m along the street (day/night)
	Number of "eyes and ears" along the street (day/night)
A clean environment (cleanliness)	% of overfilled garbage bins (just before the garbage collection)
	Number of wastes left on the ground/m
An appealing environment (aesthetics)	Number of interesting views present on the path
	Number of green elements per meter or % of green area per square meter
	Number of landmarks and/or point of reference per meter
	% of the rectilinear length of the path
A busy environment (availability facilities)	Number of services per meter of path (opening times : day/night)
	Number of shops per type: daily, weekly, per meter, and opening times (day/night)
	Number of facilities (bar, coffee shop, restaurants, kiosks, etc.) per meter of path (opening times: day/night)
A lively environment (social aspects)	Number of proper and improper seats (benches, stools, sitting walls, balustrades, rails)
	Number of squares, widening
	Number of elements of urban furniture per square meter

2. Annex II – HASTA indicator-set

II.1. HASTA Outcome and output indicators (coded indicators)

		Outcome – Subjective	Outcome – Objective	Output
Economic	*Efficiency*	**EN/Eff-I-S1** Percentage of business companies and public organizations satisfied with the transport system	**EN/Eff-I-O1** Annual ton-km / transport investment costs **EN/Eff-I-O2** Annual passenger-km / transport investment costs	**EN/Eff-II-1** Average freight transport speed in the city
Economic	*Accessibility*	**EN/Acc-I-S1** Percentage of population satisfied with the transport system regarding commuting trips	**EN/Acc-I-O1** Percentage of job opportunities and services within 45 minutes travel distance of residents	**EN-SO/Acc-II-1** Average travel speed along arterial streets in peak hours **EN-SO/Acc-II-2** Average travel speed along entry roads in peak hours **EN-SO/Acc-II-3** Percentage of population with access to public transportation (300 m - as the crown flies) **EN-SO/Acc-II-4** Average speed of public transport **EN-SO/Acc-II-5** Percentage of public transport means keeping time table **EN-SO/Acc-II-6** Vehicle km / day / capita of public transport means.
Social	*Accessibility*	**SO/Acc-I-S1** Percentage of population satisfied with the transport system regarding non-work related trips	**SO/Acc-I-O1**Travel ratio between sustainable transport modes (walking-cycling-public transport) and passenger cars	
Social	*Safety*	**SO/Sa-I-S1** Percentage of population feeling safe (free from accident)	**SO/Sa-I-O1** Injury risk / person-km	**SO/Sa-II-1** Percentage of motor vehicles above speed limit. **SO/Sa-II-2** Percentage of drivers above permitted blood alcohol limit. **SO/Sa-II-3** Percentage of motor vehicle occupants wearing safety belt.
Social	*Livability*	**SO/Li-I-S1** Percentage of population feeling safe from security violation in the transport system (e.g. in tunnels) **SO/Li-I-S2** Percentage of population satisfied with the transport related public space (comfortable, clean, aesthetic)	**SO/Li-I-O1** Annual number of reported incidents of personal security violation in the transport system / person-km **SO/Li-I-O2** Percentage of children going to school by other means that car	**SO/Li-II-1** Percentage of population within walking distance from grocery store **SO/Li-II-2** Percentage of population within walking distance from recreation areas **SO/Li-II-3** Percentage of children within walking distance from schools
Environmental	*Emission*	**EL/Em-I-S1** Percentage of population feeling disturbed by pollution and/or noise from traffic at their homes	**EL/Em-I-O1** Annual costs for society / capita due to emissions from transport	**EL/Em-II-1** Percentage of population living in areas where pollution is higher than air quality standards **EL/Em-II-2** Percentage of population living in areas where the noise emission is greater than 55 dbA **EL/Em-II-3** Contribution of transport (%) to the total amount of greenhouse gases **EL/Em-II-4** Contribution of transport (%) to soil contamination
Environmental	*Resource use*	**EL/Ru-I-S1** Percentage of population thinking that the mark areas occupied of transport, related activities related to the total area of the municipality are appropriate	**EL/Ru-I-O1** Percentage of transport land use of total area of the municipality	**EL/Ru-II-1** Density of transport links (km/ km^2) **EL/Ru-II-2** Transport land use / annual person-km **EL/Ru-II-3** Transport land use / annual ton-km
Environmental	*Resource use*	**EL/Ru-I-S2** Percentage of population thinking that using renewable fuels is affordable	**EL/Ru-I-O2** Percentage of renewable fuels of total fuel consumption in transport	**EL/Ru-II-4** Percentage of annual passenger-km using renewable fuels **EL/Ru-II-5** Percentage of annual ton-km using renewable fuels

II.2. HASTA Outcome, output and input indicators

		Outcome	Output	Input
Economic	Efficiency	EN/Eff-I-S1 Percentage of business companies and public organizations satisfied with the transport system EN/Eff-I-O1 Annual ton-km / transport investment costs EN/Eff-I-O2 Annual passenger-km / transport investment costs	EN/Eff-II-1 Average freight transport speed in the city	• Investments in transport infrastructure / capita • Percentage of free parking spaces / capita • Percentage of arterial streets of the total street network
Economic	Accessibility	EN/Acc-I-S1 Percentage of population satisfied with the transport system regarding commuting trips EN/Acc-I-O1 Percentage of job opportunities and services within 45 minutes travel distance of residents	EN-SO/Acc-II-1 Average travel speed along arterial streets in peak hours EN-SO/Acc-II-2 Average travel speed along entry roads in peak hours EN-SO/Acc-II-3 Percentage of population with access to public transportation (300 m - as the crown flies) EN-SO/Acc-II-4 Average speed of public transport EN-SO/Acc-II-5 Percentage of public transport means keeping time table EN-SO/Acc-II-6 Vehicle km / day / capita of public transport means	• Percentage of population living and working in the city • Percentage of crossing points adopted to disabled • Percentage of bus stops adopted to disabled • Percentage of low floor vehicles in public transport fleet. • Number of bicycle parking / capita • Percentage of continuous bicycle paths of total bicycle path length • Percentage of separate walking paths of total length of the transport network • Percentage of free parking places / capita • Parking price / hours in the central area • Existence of congestion charging in city centers • Existence of pricing and tax policies for freight vehicles
Social	Accessibility	SO/Acc-I-S1 Percentage of population satisfied with the transport system regarding non-work related trips SO/Acc-I-O1Travel ratio between sustainable transport modes (walking-cycling-public transport) and passenger cars		
Social	Safety	SO/Sa-I-S1 Percentage of population feeling safe (free from accident) SO/Sa-I-O1 Injury risk / person-km	SO/Sa-II-1 Percentage of motor vehicles above speed limit. SO/Sa-II-2 Percentage of drivers above permitted blood alcohol limit. SO/Sa-II-3 Percentage of motor vehicle occupants wearing safety belt.	• Percentage of crossing points for vulnerable road users meeting safety standards. • Percentage of local streets with traffic calming measures • Percentage of "safe" arterial street intersection (RAP) • Percentage of motor vehicles equipped with ISA • Percentage of motor vehicles equipped with Alcolock • Percentage of motor vehicles equipped with safety belt reminder
Social	Livability	SO/Li-I-S1 Percentage of population feeling safe from security violation in the transport system (e.g. in tunnels) SO/Li-I-S2 Percentage of population satisfied with the transport related public space (comfortable, clean, aesthetic) SO/Li-I-O1 Annual number of reported incidents of personal security violation in the transport system / person-km SO/Li-I-O2 Percentage of children going to school by other means that car	SO/Li-II-1 Percentage of population within walking distance from grocery store SO/Li-II-2 Percentage of population within walking distance from recreation areas SO/Li-II-3 Percentage of children within walking distance from schools	• Percentage of illuminated walking and bicycle paths of the total length of the whole network • Number of facilities (shops, bar, coffee shop, restaurants, kiosks, etc.) / meter of path (opening times: day/night) • Number of proper seats / walking distance – 300 m (benches, stools, sitting walls, balustrades, rails, columns) • Percentage of overfilled garbage bins (just before the garbage collection).

HASTA Outcome, output and input indicators (cont.)

		Outcome	Output	Input
Environmental	*Emission*	**EL/Em-I-S1** Percentage of population feeling disturbed by pollution and/or noise from traffic at their homes **EL/Em-I-O1** Annual costs for society / capita due to emissions from transport	**EL/Em-II-1** Percentage of population living in areas where pollution is higher than air quality standards **EL/Em-II-2** Percentage of population living in areas where the noise emission is greater than 55 dbA **EL/Em-II-3** Contribution of transport (%) to the total amount of greenhouse gases **EL/Em-II-4** Contribution of transport (%) to soil contamination	• Number of wastewater treatment plants / transport land use • Annual used road salt / capita / snowy days • Percentage of storm water run-off treated in wastewater treatment plants
				• Travel time ratio between sustainable transport modes (walking-cycling-public transport) and passenger cars • Travel cost ratio between sustainable transport modes (walking-cycling-public transport) and passenger cars • Car ownership in the city / capita • Number of commuting trips to and from the city / day/capita • Percentage of freight vehicles in transport • Veh-km driven by passenger cars in the city / capita • Veh-km driven by freight vehicles in the city / capita • Existence of programs for vehicle operator training for eco- driving • Percentage of main streets in the total transport network with heavy vehicles (including buses and motorcycles) not allowed • Percentage of heavy vehicles (including buses and motorcycles) in traffic flow in streets with housing
	Resource use	**EL/Ru-I-S1** Percentage of population thinking that the mark areas occupied of transport, related activities related to the total area of the municipality are appropriate **EL/Ru-I-O1** Percentage of transport land use of total area of the municipality	**EL/Ru-II-1** Density of transport links (km/ km^2) **EL/Ru-II-2** Transport land use / annual person-km **EL/Ru-II-3** Transport land use / annual ton-km	• Number of intermodal transfer facilities (road freight transport – railway transport) in the city / transportation land use • Percentage of annual ton-km transported on railway of total freight transport / year
		EL/Ru-I-S2 Percentage of population thinking that using renewable fuels is affordable **EL/Ru-I-O2** Percentage of renewable fuels of total fuel consumption in transport	**EL/Ru-II-4** Percentage of annual passenger-km using renewable fuels **EL/Ru-II-5** Percentage of annual ton-km using renewable fuels	• Percentage of public transport means using renewable fuels • Percentage of cars using renewable fuels • Percentage of heavy vehicles using renewable fuels

II.3.Institutional indicators

Institutional	**Strategic:** • Existence of a sustainable transport policy, adopted by decision makers • Existence of formalized cooperation between departments **Organizational:** • Clearly defined responsibilities at the municipality for implementing and monitoring sustainability • Public participation in the transport planning process – other than regulated by law **Actions:** • Initiatives to achieve sustainable transport (mobility management, enlightenment programs, campaigns car pooling, etc.) • Expenditures/investments in transport on accessibility/mobility related information and research

3. Annex III – Coherence tables of HASTA indicators

III.1. Coherence between Outcome indicators

III.2. Coherence between Outcome and Output indicators

III.3. Coherence between Output indicators

III.4. Coherence between Outcome and Input indicators

III.5. Coherence between Output and Input indicators

III.1. Coherence between Outcome indicators

OUTCOME	EN/Eff-I-S1	EN/Eff-I-O1	EN/Eff-I-O2	EN/Acc-I-S1	EN/Acc-I-O1	SO/Acc-I-S1	SO/Acc-I-O1	SO/Sa-I-S1	SO/Sa-I-O1	SO/Li-I-S1	SO/Li-I-S2	SO/Li-I-O1	SO/Li-I-O2	EL/Em-I-S1	EL/Em-I-O1	EL/Ru-I-S1	EL/Ru-I-O1	EL/Ru-I-S2	EL/Ru-I-O2		OUTCOME
Efficiency		x	x																	EN/Eff-I-S1	% of business companies and public organizations satisfied with the transport system
								x	x	x	x	x						x		EN/Eff-I-O1	Annual passenger-km / transport investment costs
																				EN/Eff-I-O2	Annual ton-km / transport investment costs
Accessibility							x	x	x	x	x	x								EN/Acc-I-S1	% of population satisfied with the transport system regarding commuting trips
							x								x					EN/Acc-I-O1	% of job opportunities and services within 45 minutes travel distance of residents
								x	x	x	x	x								SO/Acc-I-S1	% of population satisfied with the transport system regarding non-work related trips
															x					SO/Acc-I-O1	Travel ratio between sustainable transport modes and passenger cars
Safety									x				x							SO/Sa-I-S1	% of population feeling safe (free from accident)
													x							SO/Sa-I-O1	Injury risk / person km
Livability											x		x							SO/Li-I-S1	% of population feeling safe from security violation in the transport system
												x	x			x	x			SO/Li-I-S2	% of population satisfied with the transport related public space
													x							SO/Li-I-O1	Annual number of reported incidents of personal security violation in the transport system /person-km
																				SO/Li-I-O2	% of children going to school by other means that car
Emission															x					EL/Em-I-S1	% of population feeling disturbed by pollution and/or noise from traffic at their home
																			x	EL/Em-I-O1	Annual costs for society per capita due to emissions from transport
Resource use																	x			EL/Ru-I-S1	% of population thinking that transport related areas are too big
																				EL/Ru-I-O1	Transport land use / total city area
																			x	EL/Ru-I-S2	% of population thinking that using renewable fuels is affordable
																				EL/Ru-I-O2	% of renewable fuels of total fuel consumption in transport

III.2. Coherence between Outcome and Output indicators

OUTCOME	EN/Eff-I-S1	EN/Eff-I-O1	EN/Eff-I-O2	EN/Acc-I-S1	EN/Acc-I-O1	SO/Acc-I-S1	SO/Acc-I-O1	SO/Sa-I-S1	SO/Sa-I-O1	SO/Li-I-S1	SO/Li-I-S2	SO/Li-I-O1	SO/Li-I-O2	EL/Em-I-S1	EL/Em-I-O1	EL/Ru-I-S1	EL/Ru-I-O1	EL/Ru-I-S2	EL/Ru-I-O2		OUTPUT
Efficiency	x		x											x						EN/Eff-II-3	Average freight transport speed in the city
Accessibility	x			x	x	x	x	x			x		x	x	x					EN-SO/Acc-II-1	Average travel speed along arterial streets in peak hours
	x			x	x	x	x	x						x	x					EN-SO/Acc-II-2	Average travel speed along entry roads in peak hours
		x		x	x	x	x						x							EN-SO/Acc-II-3	% of population with access to public transport
		x		x	x	x	x						x							EN-SO/Acc-II-4	Average speed of public transport
		x		x	x	x	x						x							EN-SO/Acc-II-5	% of public transport' means keeping time table
		x		x	x	x	x						x	x						EN-SO/Acc-II-6	Vehicle km / day / capita of public transport means
Safety								x	x		x		x	x						SO/Sa-II-1	% of motor vehicles above speed limit
								x	x				x							SO/Sa-II-2	% of drivers above permitted blood alcohol limit
									x											SO/Sa-II-3	% of motor vehicles occupants wearing safety belt
Livability							x													SO/Li-II-1	% of population within walking distance from grocery store
							x													SO/Li-II-2	% of population living within walking distance from recreation areas
							x						x							SO/Li-II-3	% of children within walking distance from school
Emission													x	x	x					EL/Em-II-1	% of population living in areas where pollution is higher than air quality standards
													x	x	x					EL/Em-II-2	% of population living in areas where the noise emission is greater than 55 dbA
													x		x					EL/Em-II-3	Contribution of transport (%) to the total amount of greenhouse gases
													x		x					EL/Em-II-4	Contribution of transport (%) to the soil contamination
Resource use	x	x	x	x	x	x	x			x	x	x		x		x	x			EL/Ru-II-1	Density of transport links (km/km2)
		x									x					x	x			EL/Ru-II-2	Transport land use / annual person km
			x								x					x	x			EL/Ru-II-3	Transport land use / annual ton-km
															x			x	x	EL/Ru-II-4	% of annual passenger-km using renewable fuels
															x			x	x	EL/Ru-II-5	% of annual ton-km using renewable fuels

III.3. Coherence between Output indicators

		OUTPUT	EN/Eff-II-3	1	2	3	4	5	6	SO/Sa-II-1	SO/Sa-II-2	SO/Sa-II-3	SO/Li-II-1	SO/Li-II-2	SO/Li-II-3	EL/Em-II-1	EL/Em-II-2	EL/Em-II-3	EL/Em-II-4	EL/Ru-II-1	EL/Ru-II-2	EL/Ru-II-3	EL/Ru-II-4	EL/Ru-II-5
Efficiency	EN/Eff-II-3	Average freight transport speed in the city		x	x		x		x	x										x		x		
Accessibility	EN-SO/Acc-II-1	Average travel speed along arterial streets in peak hours			x		x	x	x	x						x	x	x		x	x	x		
	EN-SO/Acc-II-2	Average travel speed along entry roads in peak hours					x	x	x	x						x		x		x	x	x		
	EN-SO/Acc-II-3	% of population with access to public transport																x		x			x	
	EN-SO/Acc-II-4	Average speed of public transport						x	x											x			x	
	EN-SO/Acc-II-5	% of public transport' means keeping time table																		x			x	
	EN-SO/Acc-II-6	Vehicle-km / day / capita of public transport means																					x	
Safety	SO/Sa-II-1	% of motor vehicles above speed limit																x						
	SO/Sa-II-2	% of drivers above permitted blood alcohol limit																						
	SO/Sa-II-3	% of motor vehicles occupants wearing safety belt																						
Livability	SO/Li-II-1	% of population within walking distance from grocery store																						
	SO/Li-II-2	% of population living within walking distance from recreation areas																						
	SO/Li-II-3	% of children within walking distance from school																						
Emission	EL/Em-II-1	% of population living in areas where pollution is higher than air quality standards																		x			x	x
	EL/Em-II-2	% of population living in areas where the noise emission is greater than 55 dbA																		x				
	EL/Em-II-3	Contribution of transport (%) to the total amount of greenhouse gases																					x	x
	EL/Em-II-4	Contribution of transport (%) to the soil contamination																					x	x
Resource use	EL/Ru-II-1	Density of transport links (km/km2)																			x	x		
	EL/Ru-II-2	Transport land use / annual person-km																						
	EL/Ru-II-3	Transport land use / annual ton-km																						
	EL/Ru-II-4	% of annual passenger-km using renewable fuels																						x
	EL/Ru-II-5	% of annual ton-km using renewable fuels																						

III.4. Coherence between Outcome and Input indicators

	Efficiency			Accessibilty				Safety		Livability				Emission		Resource use				
OUTCOME	EN/Eff-I-S1	EN/Eff-I-O1	EN/Eff-I-O2	EN/Acc-I-S1	EN/Acc-I-O1	SO/Acc-I-S1	SO/Acc-I-O1	SO/Sa-I-O1	SO/Sa-I-S1	SO/Li-I-S1	SO/Li-I-O1	SO/Li-I-S2	SO/Li-I-O2	EL/Em-I-S1	EL/Em-I-O1	EL/Ru-I-S1	EL/Ru-I-O1	EL/Ru-I-S2	EL/Ru-I-O2	INPUT
City							X								X		X			% of population living and working in the city
							X	X	X			X	X	X	X	X	X		X	car ownership / capita
Road network	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X			investments in transport infrastructure / capita
	X			X		X	X	X	X			X	X	X	X					% arterial roads of the total road network
								X	X			X	X							% of main streets in the total transport network with heavy vehicles not allowed
							X	X	X			X	X							% of "safe" arterial street intersection (Road Assessment Program)
							X	X	X			X	X							% of local streets with traffic calming measures
							X	X	X			X	X							% of crossing points adopted to disabled
							X	X	X				X							% of crossing points for vulnerable road users meeting safety standards.
		X		X		X	X					X	X							% of bus stops adopted to disabled
Traffic flow		X					X						X	X	X		X			travel time ratio between sustainable transport modes and passenger cars
		X					X						X	X	X		X			travel cost ratio between sustainable transport modes and passenger cars
		X	X				X	X	X			X	X	X	X		X			veh-km driven by passenger cars in the city / capita
			X					X	X			X	X	X	X		X			veh-km driven by freight vehicles in the city / capita
		X						X	X			X	X	X	X		X			number of commuting trips to and from the city per day / capita
			X					X	X			X	X	X	X		X			% of heavy vehicles (including buses and motorcycles) in traffic flow in streets with housing
			X					X	X			X	X	X	X		X			% of annual ton-km transported on railway of total freight transport/year
Parking		X					X					X	X	X	X		X			% of free parking spaces / capita
		X					X					X	X	X	X		X			number of public parking places / capita
		X					X						X	X	X		X			parking price / hour in the central area
Mainte-nance															X					number of wastewater treatment plants / transport land use
							X													annual used road salt/capita/snowy days
															X					% of storm water run-off treated in wastewater treatment plants

Coherence between Outcome and Input indicators (cont)

	Efficiency			Accessibilty				Safety		Livability				Emission		Resource use				
OUTCOME	EN/Eff-I-S1	EN/Eff-I-O1	EN/Eff-I-O2	EN/Acc-I-S1	EN/Acc-I-O1	SO/Acc-I-S1	SO/Acc-I-O1	SO/Sa-I-O1	SO/Sa-I-S1	SO/Li-I-S1	SO/Li-I-O1	SO/Li-I-S2	SO/Li-I-O2	EL/Em-I-S1	EL/Em-I-O1	EL/Ru-I-S1	EL/Ru-I-O1	EL/Ru-I-S2	EL/Ru-I-O2	INPUT
Vehicle/fleet		X					X	X	X											% of low floor vehicles in public transport fleet
									X											% of motor vehicles equipped with ISA
									X											% of motor vehicles equipped with Alcolock
									X											% of motor vehicles equipped with safety belt reminder
															X				X	% of means of public transport with renewable fuels
															X				X	% of cars with renewable fuels
															X				X	% of heavy vehicles with renewable fuels
Walking & Cycling							X	X	X			X	X							% of separate walking paths of total length of whole transport network
							X	X	X	X	X	X	X							% of illuminated walking and bicycle path of the total length of whole network
				X		X	X	X	X			X	X		X					% of continuous bicycle paths of total bicycle path length
				X		X	X					X	X		X					number of bicycle parking / capita
Economic measurements		X	X				X						X		X		X		X	existence of congestion charging in city centers
			X										X		X		X		X	existence of pricing and tax policies for freight vehicles
			X												X		X		X	number of intermodal transfer facilities (road – railway) in the city/transport land use
															X				X	% of renewable fuels from total fuel consumption in transport
			X						X											existence of programs for vehicle operator training for ecodriving
City							X				X	X	X							number of facilities (shops, restaurants, kiosks, etc.) / meter of path
							X					X	X							number of proper seats (benches, stools, sitting walls, balustrades, rails, columns)
												X								% of overfilled garbage bins (just before the garbage collection)

III.5. Coherence between Output and Input indicators

	Eff	Accessibilty						Safety			Livability			Emission				Resource use					
OUTCOME	EN/Eff-II-1	1	2	3	4	5	6	SO/Sa-II-1	SO/Sa-II-2	SO/Sa-II-3	SO/Li-II-1	SO/Li-II-2	SO/Li-II-3	EL/Em-II-1	EL/Em-II-2	EL/Em-II-3	EL/Em-II-4	EL/Ru-II-1	EL/Ru-II-2	EL/Ru-II-3	EL/Ru-II-4	EL/Ru-II-5	INPUT
City				X												X	X	X	X				% of population living and working in the city
		X	X		X									X	X	X	X	X	X				car ownership / capita
Road network	X	X	X	X	X	X	X							X	X	X	X	X	X	X	X	X	investments in transport infrastructure / capita
	X	X	X		X									X	X	X	X	X	X	X			% arterial roads of the total road network
	X				X	X								X	X	X	X						% of main streets in the total transport network with heavy vehicles not allowed
	X	X			X			X															% of "safe" arterial street intersection (Road Assessment Program)
								X															% of local streets with traffic calming measures
		X		X	X			X															% of crossing points adopted to disabled
	X	X			X			X															% of crossing points for vulnerable road users meeting safety standards.
				X	X																		% of bus stops adopted to disabled
Traffic flow							X							X	X	X	X		X				travel time ratio between sustainable transport modes and passenger cars
														X	X	X	X		X				travel cost ratio between sustainable transport modes and passenger cars
	X	X	X		X	X								X	X	X	X	X	X				veh-km driven by passenger cars in the city / capita
	X	X	X		X	X								X	X	X	X	X		X			veh-km driven by freight vehicles in the city / capita
	X		X		X	X								X	X	X	X	X	X				number of commuting trips to and from the city per day / capita
	X	X	X		X	X								X	X	X	X						% of heavy vehicles (including buses and motorcycles) in traffic flow in streets with housing
	X	X	X		X	X								X	X	X	X	X		X		X	% of annual ton-km transported on railway of total freight transport/year
Parking														X	X	X	X		X				% of free parking spaces / capita
														X	X	X	X		X				number of public parking places / capita
														X	X	X	X		X				parking price / hour in the central area
Mainte-nance																	X						number of wastewater treatment plants / transport land use
	X	X	X		X	X		X									X						annual used road salt/capita/snowy days
																	X						% of storm water run-off treated in wastewater treatment plants

Coherence between Output and Input indicators (cont)

	Eff	Accessibilty						Safety			Livability			Emission				Resource use					
OUTCOME	EN/Eff-II-1	1	2	3	4	5	6	SO/Sa-II-1	SO/Sa-II-2	SO/Sa-II-3	SO/Li-II-1	SO/Li-II-2	SO/Li-II-3	EL/Em-II-1	EL/Em-II-2	EL/Em-II-3	EL/Em-II-4	EL/Ru-II-1	EL/Ru-II-2	EL/Ru-II-3	EL/Ru-II-4	EL/Ru-II-5	INPUT
Vehicle/fleet				X															X				% of low floor vehicles in public transport fleet
		X	X					X															% of motor vehicles equipped with ISA
									X														% of motor vehicles equipped with Alcolock
										X													% of motor vehicles equipped with safety belt reminder
																X					X		% of means of public transport with renewable fuels
																X	X				X		% of cars with renewable fuels
																X	X					X	% of heavy vehicles with renewable fuels
Walking & Cycling				X																			% of separate walking paths of total length of whole transport network
																							% of illuminated walking and bicycle path of the total length of whole network
				X															X				% of continuous bicycle paths of total bicycle path length
																			X				number of bicycle parking / capita
Economic measurements														X	X	X	X	X	X	X	X	X	existence of congestion charging in city centers
														X	X	X	X			X		X	existence of pricing and tax policies for freight vehicles
														X	X	X	X	X		X		X	number of intermodal transfer facilities (road – railway) in the city/transport land use
																X					X	X	% of renewable fuels from total fuel consumption in transport
		X	X					X						X		X	X						existence of programs for vehicle operator training for ecodriving
City											X												number of facilities (shops, restaurants, kiosks, etc.) / meter of path
																							number of proper seats (benches, stools, sitting walls, balustrades, rails, columns)
																							% of overfilled garbage bins (just before the garbage collection)

The framework project HASTA (Sustainable Attractive City) is carried out by Traffic & Roads, Department for Technology and Society at Lund University. Research within this framework focuses on the city and its qualities and problems. One basic quality is safety, but other important qualities are perceived safety and security, accessibility, comfort and environment. HASTA´s vision for the sustainable and attractive city is a city that provides, within the frames of the society, its inhabitants´ different and changing needs, without compromising future residents´ needs. The societal frames are defined by ecological, social, and economic sustainability.

This report is written for the project "Development of sustainability indicators, which aims at producing indicators for measuring sustainable urban development, with a focus on transportation. This report is the 5th scientific report, written in the framework of the research program HASTA (Sustainable Attractive City). It presents an international overview of definitions of sustainable transportation, the selection process and the final list of sustainability indicators.

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