

## Combined Mobility (MaaS) – A framework for evaluating ecological, economic and social impacts

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## 1. Introduction

In 2017, the Swedish Government's 'Cooperative Group for Next Generation Travel and Transport' (*Samverkansgrupp för Nästa generations resor och transporter*) initiated a programme called 'The Roadmap for Combined Mobility as a Service in Sweden – KOMPIS'. The programme aims to promote the emergence of combined mobility<sup>1</sup> (i.e. mobility services that offer the possibility of travelling by car, bicycle, public transport and other transport modes as integrated services accessed via single interfaces). KOMPIS aims to create favourable conditions and reduce barriers to the development and implementation of combined mobility services (hereafter MaaS) that contribute to fulfilment of the Swedish transport policy objectives. The overarching objective of Swedish transport policy is: "To ensure a socially economically-efficient and long-term sustainable transport system for citizens and businesses across the entire country".

This overarching objective is supported by two sub-objectives: the 'functional' goal and the 'consideration' goal. The functional goal is formulated as follows: "The design, function and use of the transport system will contribute to providing everyone with a basic level of accessibility, of high quality and usability, whilst supporting Swedish economic development. The transport system must also function equitably by responding to individuals' transportation needs in a gender-neutral fashion". The consideration goal is formulated as follows: "The design, function and use of the transport system will be adapted such that no-one is killed or seriously injured due to travel, and such that it contributes to the fulfilment of generational targets for environment and environmental-quality objectives, whilst contributing to improved health".

An important milestone for the KOMPIS programme is to evaluate whether and to what extent MaaS can improve the environmental, economic and social sustainability of the transport system. To enable such a valuation, a framework is being developed and relevant key performance indicators (KPIs) are being formulated. Within KOMPIS, funds have been allocated for calls for proposals that aim to, among other things, facilitate pilots and trials of different types of mobility services with real users. Projects that receive funding via KOMPIS calls are obligated to allow for data collection that will in turn facilitate evaluations and assessments using the KOMPIS framework and associated KPIs. As such, KOMPIS pilots will facilitate comparative assessments of the sustainability impacts of MaaS.

KOMPIS pilots include various types of combined mobility services, such as those which directly target individuals/households, and those which target organisational customers, such that employees are users of the service. The initial version of the framework has focused on MaaS services that directly address private individuals / households. Updates to include different segments will follow.

In order to harmonise data collection and enable comparisons between and across different pilots, four questionnaires have been designed. These should be used as the basis of data collection for each MaaS pilot, and include:

- Two questionnaires targeting travellers/pilot participants

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<sup>1</sup> Also known as Mobility-as-service or MaaS.

- One questionnaire targeting service providers.
- A fourth questionnaire targets the municipalities and/or regions involved in and affected by the pilot.

There is also a *travel diary* which targets travellers/participants in the pilot in order to collect detailed data on travel routes, travel times and modal choices. Ideally, this data should be collected through some form of smartphone application with a built in GPS tracker, but given the scarce availability of such apps, the travel diary is a viable alternative.

All personal data that is collected via KOMPIS will be anonymised in compliance with GDPR legislation. Data collected via questionnaires, travel apps and/or travel diaries will be stored in an open *national database* (see figure 1) to enable research on traveller behaviour, sustainability impacts, service development, and so on.

Efforts to develop the framework constitute a process in which the formulation of KPIs, the design of instruments for data collection, and the database are developed iteratively via dialogues with organisations involved in MaaS pilots. The final version of the KOMPIS framework, the database, and techniques for data collection, are forecast to be completed in the second half of 2020 (figure 2).

	2017	2018	2019	2020
Inventory needs		■		
Inventory KPIs		■		
Criteria for KPI selection		■		
KPI definitions and specification of data collection techniques		■		
Formulation of data collection tools and manual (version 1)		■	■	
Formulation of descriptors for MaaS services		■	■	
Data collection trial with one pilot			■	■
Database development			■	■
Data analysis, evaluation of techniques and manual in collaboration with one pilot			■	■
Formulation of data collection tools and manual (version 2)			■	■
Data collection trial with several pilots plus inputs to database				■
Data analysis, evaluation of techniques and manual in collaboration with several pilots				■
Formulation of data collection tools and manual (final version)				■
Final specification of framework and KPIs				■

Figure 2. Timetable for developments of the KOMPIS framework, KPIs and database.

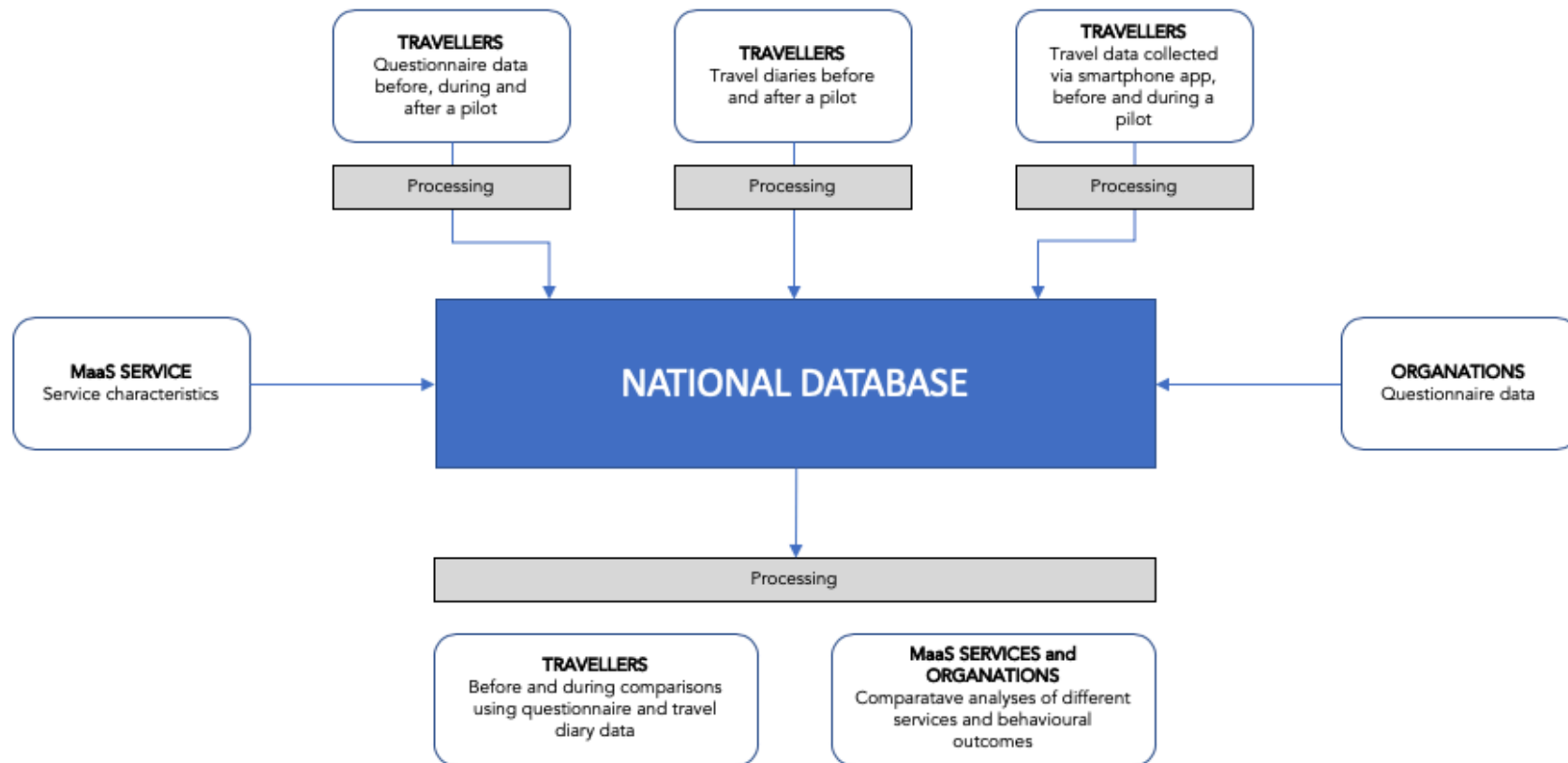


Figure 1. KOMPIS data will be collected in a national database and made available for research on the sustainability impacts of MaaS.

## 2. The framework

The KOMPIS framework aims to evaluate the sustainability impacts of MaaS with regard to the ecological, economic and social effects of changes to everyday travel patterns<sup>2</sup>.

- **Everyday** travel refers to trips to/from work or school, shopping trips, trips to/from leisure activities and trips to work etc. Future versions of the framework, will include business-related travel.
- **Ecological effects** include environmental impacts in the form of reductions in energy use and air pollutants/emissions (CO, CO<sub>2</sub>, etc.), and altered land use patterns (e.g. a reduction the space required for car parking).
- **Economic effects** include changes in individuals' and/or households' travel costs (in time and money); the viability of MaaS business models; and the potential effects of MaaS in terms of job creation, innovation etc.
- **Social effects** include changes in citizens' access to the transport services; access to places, activities and functions (such as work, school, healthcare, etc.); and impacts on human health.

The framework is based on a systemic perspective with three analytical levels: a micro level which focuses on individual travellers; a meso level that encompasses organisations who create and deliver MaaS services; and a macro level that can be modified to refer to communities, cities, regions or nations (figure 3). Within the framework, **the sustainability impacts of MaaS are seen to emerge from activities performed at the traveller and organisational levels that intertwine within MaaS pilots**. That is, the provision of MaaS services and aspects of individual travellers combine to result in sustainability impacts.

For analysis via the KOMPIS framework, data is collected and allows for the evaluation of sustainability impacts at the scale of individual **MaaS pilots**. The sustainability impacts of an individual MaaS pilot level are a consequence of how the MaaS service is designed and delivered, and of how travellers perceive, use and value the service.

The pilot level therefore includes:

- Public and/or private organisations that design, mediate and/or deliver the mobility services that are part of a MaaS service. Within the KOMPIS framework, these constitute the meso level of **organisations/service providers**.
- Individuals and/or households (and in future versions of the framework, employees) that trial a MaaS service within a pilot. Within the KOMPIS framework, these constitute the micro level of **travellers**.

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<sup>2</sup> Key points of departure for the KOMPIS framework include two previous projects: IRIMS (see e.g. Mukhtar-Landgren et al. 2016); and MaaSIFiE (see e.g. Karlsson et al. 2017)

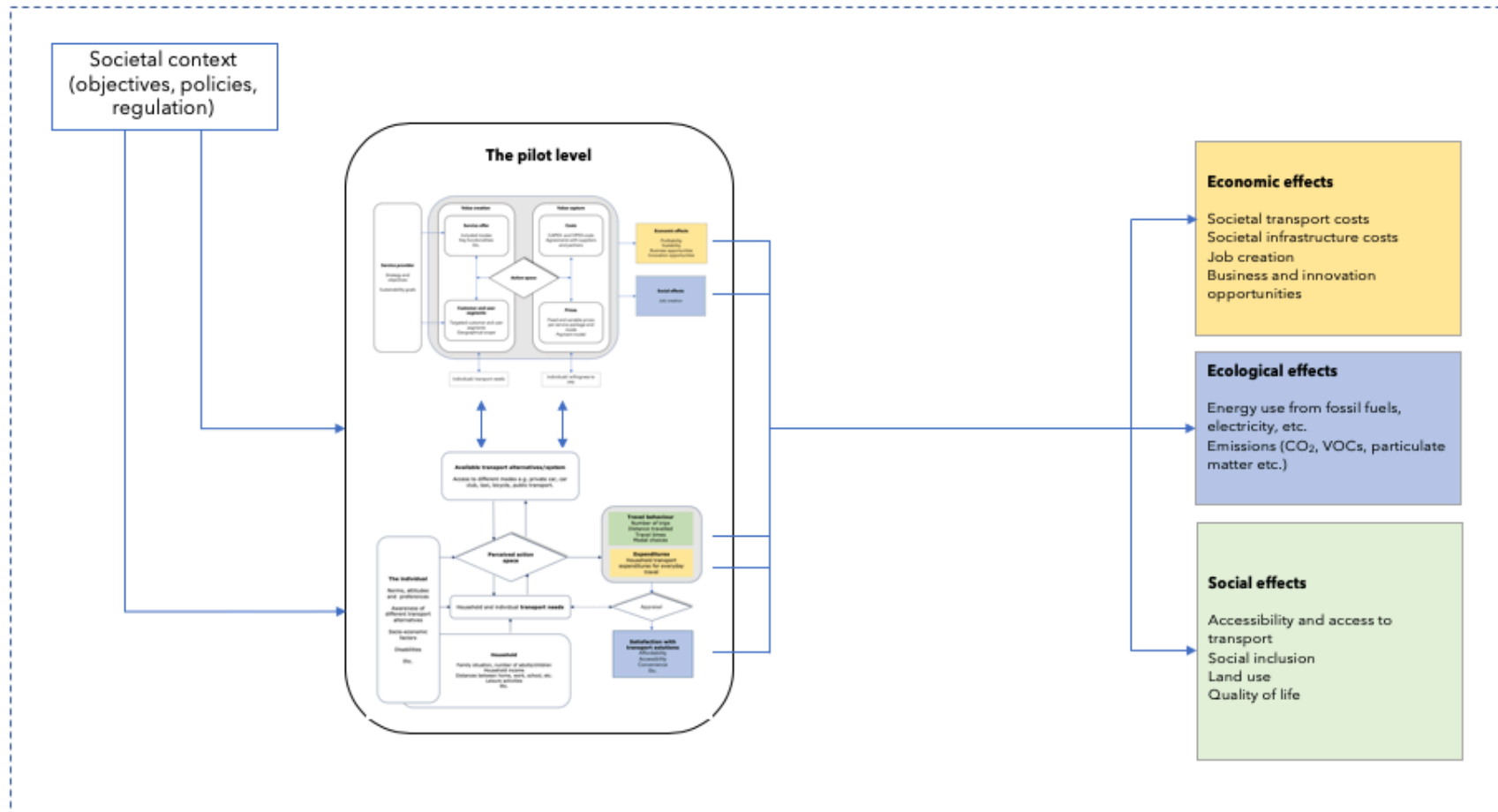


Figure 3. The framework is based on a systemic perspective where the interaction between the design of MaaS services and travellers' use of those services is central to emergent sustainability impacts.

Data collected from individual MaaS pilots also enables the assessment of sustainability impacts at a societal (macro) level, especially when data has been collected from several pilots and comparisons between them can be made.

The societal (macro) level includes:

- Modelled assessments of the cumulative sustainability impacts of MaaS at the level of communities, cities, regions and nations, based on data from the pilot level. Impacts include ecological effects (e.g. emissions), economic effects (e.g. innovation, job creation, tax revenues, infrastructure costs, etc.) and social effects (e.g. accumulated health impacts, accessibility, etc).



### 3. MaaS pilots

As noted above, the impacts of MaaS at the level of individual pilots are a consequence of how MaaS are services designed, communicated and delivered to customers and users, and how individual travellers – the users of the service – perceive, use and value the service.

#### 3.1. The micro level of individual travellers

##### 3.1.1. Basic assumptions

The starting point for evaluation at the micro level of individual travellers is a model (see figure 4) that describes the relationship between different factors that influence travel behaviour.

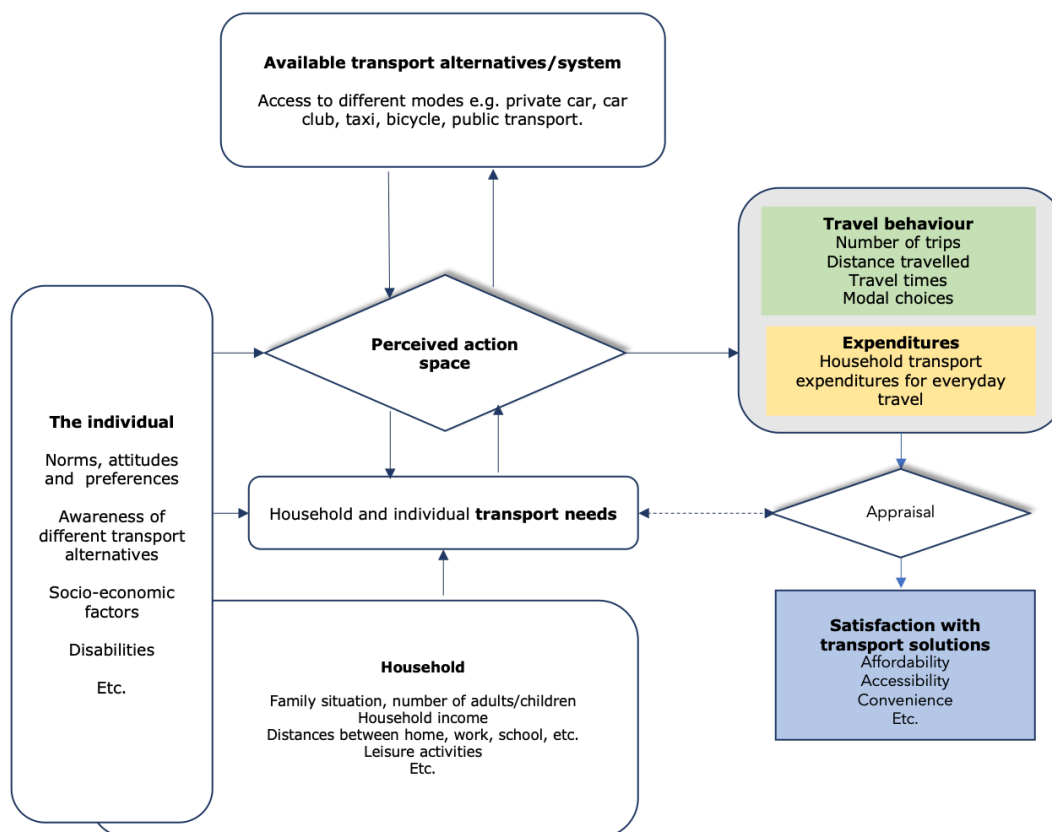


Figure 4. The micro level of individual travellers within the KOMPIS framework (NB: yellow = economic effects, blue = social effects, green = ecological effects).

The micro level is based on certain circumstantial *conditions* that broadly influence individual travellers. These are described at the far left and top of the figure and include demographic factors (e.g. household size, education, and income), other factors that influence the transportation-related needs (e.g. distance between home and workplace), and the presence of transportation alternatives available to particular individuals and households (e.g. private vehicles, taxi services, car pools, public transport, etc.). The model assumes that individuals compare (more or less actively) and evaluate the alternatives available to them relative to their transport needs. The interplay between

these factors results in a traveller's *action space*, which refers to the range of choices an individual perceives as plausible in relation to means of transport, travel times, etc<sup>3</sup>. This is a result of the relationship between individuals' transportation needs and requirements and the alternatives that the transport system offers (and are perceived to offer) in a specific context. The action space may thus be perceived differently by individuals and households due to their varying perceptions of some key factors. Individuals' evaluations lead to actions in the form of actual travel behaviour (number of trips, travel times, modal choices, etc.) that entail costs for the individual/household. Individuals also evaluate outcomes with regard to factors such as safety, convenience, value for money, access to transport and accessibility. The model assumes that choices made by individuals with regard to these factors result in emergent ecological, economic and social impacts.

### 3.1.2. Indicators at the micro level

In order to evaluate the sustainability impacts of MaaS following individuals' choices, a number of key performance indicators (KPIs) have been formulated to elucidate micro-level effects. The assessment of the *ecological effects* (table 1) is based on issues related to how individuals change their travel behaviour and modal choices given the availability and use of a MaaS service. *Economic effects* refer to whether the use of a MaaS service results in increased or decreased travel costs for individuals and households (table 2). *Social effects* are evaluated by examining perceptions of satisfaction in relation to existing transport alternatives and accessibility in terms of 1) access to transport alternatives, and 2) access to different places and activities (table 3).

Ecological KPIs			
KPI	Description	Unit	Data Source
KPI_IM1: Number of trips per individual and month.	<u>Total</u> number of trips per individual and month including work trips, but excluding holiday trips.	# trips	User travel diaries or a smartphone app with a GPS tracker. If this is not possible, through user surveys.
KPI_IM2: Number of trips with each type of transport mode per individual and month.	<u>Total</u> number of trips per individual and month including work trips, but excluding holiday trips with each of the following transport modes: - Public transport (bus, tram, subway, local train, regional train) - Taxi	# trips per vehicle	User travel diaries or a smartphone app with a GPS tracker. If this is not possible, through user surveys.

<sup>3</sup> For examples, see Strömberg (2015) and Strömberg et al. (2016)

	<ul style="list-style-type: none"> <li>- Passenger car (petrol, hybrid, electric)</li> <li>- Motorcycle / moped</li> <li>- Bicycle / e-bike</li> <li>- Walking</li> </ul>		
<p>KPI_IM3: The proportion of trips with each transport mode per individual and month.</p>	<p>The percentage of the <u>total</u> number of trips per subject per month (as above) that occurred with each of the following modes:</p> <ul style="list-style-type: none"> <li>- Public transport (bus, tram, subway, local train, regional train)</li> <li>- Taxi</li> <li>- Passenger car (petrol, hybrid, electric)</li> <li>- Motorcycle / moped</li> <li>- Bicycle / e-bike</li> <li>- Walking</li> </ul>	% trips per vehicle	Primary: users' travel diaries/travel app. If this is not possible, through user surveys.
<p>KPI_IM4: The proportion of total journeys that are multimodal per individual and month.</p>	<p>The proportion of the total number of trips per individual and month (as above) where the individual combined different modes of transport during a single trip (e.g. bus and bicycle).</p>	% trips	Primary: user's travel diaries/travel app. If this is not possible, through user surveys.

Table 1. KPIs for evaluating micro-level ecological effects

Economic KPIs			
KPI	Description	Unit	Data Collection
KPI_IE1: Monthly travel costs for a household	The (estimated) total monthly cost of everyday travel for a household, including: <ul style="list-style-type: none"> <li>- Public transport (bus, tram, subway, local train, regional train)</li> <li>- Taxis</li> <li>- Passenger car (petrol, hybrid, electric)</li> <li>- Motorcycle / scooter</li> <li>- Bicycle / electric bike</li> <li>- Walking</li> </ul>	SEK	User survey (possibly supplemented by expert assessment of cost per car per km)
KPI_IE2: Travel expenses as a proportion of a household's total monthly income	The proportion of the household's total monthly income that devoted to everyday travel.	%	User survey

Table 2. KPIs for evaluating micro-level economic effects

Social KPIs			
KPI	Description	Unit	Data Collection
KPI_IS1: Perceived access to the transport system	The extent to which the user feels that the transport system is designed in a way that makes it easy to use the system as a whole, including different modes of transport.	LIKERT scale estimation	User survey
KPI_IS 2: Perceived accessibility to destinations such as work, school, etc.	The extent to which the user feels that the transport system is designed in a way that makes it easy to travel to various destinations such	LIKERT scale estimation	User survey

	as work, school, grocery store, leisure activities, etc.		
KPI_IS4: Perceived accessibility to activities and organisations.	The extent to which the user feels that the transport system is designed in a way that makes it easy to participate in various social activities and organisations.	LIKERT scale estimation	User survey

Table 3. KPIs for evaluating micro-level social impacts

### 3.1.3. Data collection at the micro level

At the micro level data collection commences **before** users begin to trial a MaaS service in order to establish **baseline** measurements of their travel behaviour. A second round of data collection occurs when users have experience of the service for a **longer** period of time, e.g. one month before the pilot ends, in order to provide data that can be used to examine changes in travel behaviour.

It is important to aim to collect data during commensurate periods that correspond to each other in terms of travel patterns, seasonal variations in weather, and so on. This means, for example, that if the baseline data is collected in the month of May, the second round of data collection should ideally commence during May the year after, with the pilot up and running. Further, it is not advisable to collect data during periods that (normally) differ in terms of travel patterns and modes of transport (e.g. summer compared to winter); during long weekends (e.g. Christmas and New Year holidays); or during school holidays (e.g. February or November holidays).

**NB:** It is the responsibility of every pilot to comply with the EU Data Protection Regulation entitled GDPR (General Data Protection Regulation). This implies that participants must be informed about what information is collected, why it is collected and how it is used. User must also be informed of their rights with respect to access to their data<sup>4</sup>.

### 3.1.4. Questionnaires

At the micro level, questionnaires are used to gather information on users' demographics, such as age, gender and income, as well as on existing travel patterns and transport behaviour, travel expenditures, and satisfaction existing solutions, and so on. KOMPIS has designed two questionnaires for the micro level:

<sup>4</sup> More information can be found at: <https://www.datainspektionen.se/lagar--regler/dataskyddsförordning/>

- **User questionnaire A** – to be distributed and answered by users / customers **before** a MaaS pilot starts.
- **User questionnaire B** – to be distributed and answered by the users / customers when they have used the service for an **extended** period of time.

To distribute the questionnaires, a **web-based survey tool** should be used. It is important to choose a tool that 1) provides the required question and answer formats; 2) can export data in SPSS format (or equivalent); and 2) meets the requirements of the Data Protection Regulation (GDPR). Some individuals may not want for be able to answer digital questionnaires. Hence opportunities to answer a paper-based questionnaire should also be offered. For paper-based versions, GDPR rules must be complied with.

A summary of the content of the questionnaires is given in table 4. The questionnaires are designed from the perspective of evaluating ecological, economic and social effects, **not** to evaluate how users/customers view particulars of MaaS service design. We recommend that MaaS service providers add these types of questions where necessary.

### 3.1.3.2 Travel diaries and travel apps

Data on the users' travel should also be collected through travel diaries (from a smaller group of users) and/or a travel app. This data must be collected for **at least** one 7-day cycle **before** users adopt the service and for **at least** one 7-day cycle **during** the pilot (after such an amount of time that new travel patterns have a possibility to be established in a form of "steady state"). If travel apps are deployed, they should be capable of documenting each trip, how long the trip is in terms of distance and time, and be capable of distinguishing between different transport modes within a single trip.

Information	Questionnaire A	Questionnaire B	Travel diary or app
Background information: age, gender, education, income, vehicle ownership, etc.  <i>Comment: The information is required to be able to describe who the users of the MaaS service are, if different groups use the service to varying degrees etc. The information is collected once but in questionnaire B a follow-up question is asked whether any radical changes have taken place.</i>	X	X	
Estimated travel costs  <i>Comment: In order to be able to assess economic effects at the individual level, an understanding of travel expenditures is needed.</i>	X	X	
Attitudes towards different modes of transport	X	X	

<p><i>Comment: Although attitudes alone cannot explain modal choices, it is important to examine whether users' attitudes change positively or negatively during MaaS pilots.</i></p>			
<p>Travel patterns, modal choices</p> <p><i>Comment: Although the travel app/travel diary should collect data on the individuals' travel patterns and modal choices the questionnaires include questions about the individuals' modal choices according to seasonal variations and different types of trips. These questions complement but do not replace the app / diary and compensate for any data loss.</i></p>	X	X	X
<p>Motives and reasons for modal choices</p> <p><i>Comment: Motives for modal choices can include convenience, economic considerations and environmental concerns. This question is intended to provide a clearer picture of the participants within each pilot.</i></p>	X		
<p>Satisfaction with the current transport options and solutions</p> <p><i>Comment: Regardless of how users fulfil their transport needs, they can be more or less satisfied with existing alternatives. One motive for participating in a pilot may be that the individual is not completely satisfied with existing solutions and are searching for alternatives.</i></p>	X	X	
<p>Expectations (A) and outcomes (B)</p> <p><i>Comment: A comparison between users' expectations regarding piloted services relative to the actual (perceived) outcomes is important, especially if users</i></p>	X	X	

<i>intend to continue using the MaaS service.</i>			
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Table 5. Overview of the information collected in micro-level questionnaires.

### Interviews and focus groups

In addition to questionnaires, travel diaries and travel apps, interviews and/or focus group studies can (and should) be conducted with users of a piloted MaaS service. At present, KOMPIS cannot provide interview guides, although questionnaires A and B can be used to derive questions.



## 3.2. The meso level of MaaS organisations and service providers

### 3.2.1. Basic assumptions

As noted previously, the KOMPIS framework treats the sustainability impacts of MaaS as emerging from the interplay between meso-level services and micro-level impacts that result from individuals' use of MaaS, such as travel patterns and modal choices. The meso level focuses on the organisational aspects of MaaS, which are inherent to the provision of MaaS as a service. Travel behaviour is significantly influenced by the way in which services are designed, the combination of transport modes, and the types of incentives embedded within each MaaS service. Further, there are sustainability impacts which emanate solely from the meso level, related to the economic sustainability of MaaS business models. Hence this section deals with the sustainability impacts that pertain to MaaS providers. The term "MaaS providers" refers to those organisations responsible for integrating and bundling different transport services and offering those to customers via a MaaS business model (i.e. organisations act as operators within MaaS pilots). Along with micro-level impacts, the meso level influences macro-level impacts in the economic and social sustainability dimensions.

The starting point for the evaluation at the meso level is a model (figure 5) that describes the relationship between contextual factors and the structure and content of MaaS business models.

The meso level is defined using a business model perspective. A business model can be defined in many different ways but is considered here based on three well-established processes – how an organisation creates, captures and distributes value. Of these, the model focuses on two processes – value creation and value capture – as they are considered important in a pilot phase. How an organisation creates value depends on interactions between the organisation in question and different customer segments or user groups at the micro level. As such, the micro level is considered a prerequisite for the design of the service at the organisational level. For example, the transportation needs and preferences of different customer and user segments are decisive for how an organisation creates value through a combined mobility service and how it should be delivered through a service offering. How an organisation captures value also depends on a relationship between this and the micro level. By understanding the willingness to pay among different customer segments and how individuals wish to pay for a combined mobility service, conditions are created for how MaaS services are priced and for the selection of suitable payment models. Value capture also depends on how an organisation packages a combined mobility service through agreements with actors in the value chain and, specifically, what costs an organisation incurs to run a service.

All factors related to value creation and value capture are considered in the model as variables according to an input-output logic. Another factor that comes into play is the organisation itself in terms of its culture, strategy and goals – *the nature of the service provider*. Together, all variables and factors constitute a *context* that creates a scope for *business model innovation*. Different pilots are likely to test different business hypotheses by developing a provisional business model to be evaluated, in part using this model.

The *economic effects* of the service are evaluated on the basis of an analysis of the aforementioned variables included in the business model. The service's *profitability* and *scalability* are assessed on the basis of its value-adding processes – the scope for the business model to generate profits both in the present and in the future, and whether an increased number of customers and users results in reduced operational expenditures. This assessment is related to whether a MaaS service provider has a business model that has the potential to scale and grow. The meso level model also evaluates whether service providers perceive that the pilot has led to or will lead to new business and innovation opportunities, and whether the service being tested during the pilot will lead to the creation of new jobs. The ecological effects of the service are evaluated on via syntheses between meso level data and data collected at the micro level.

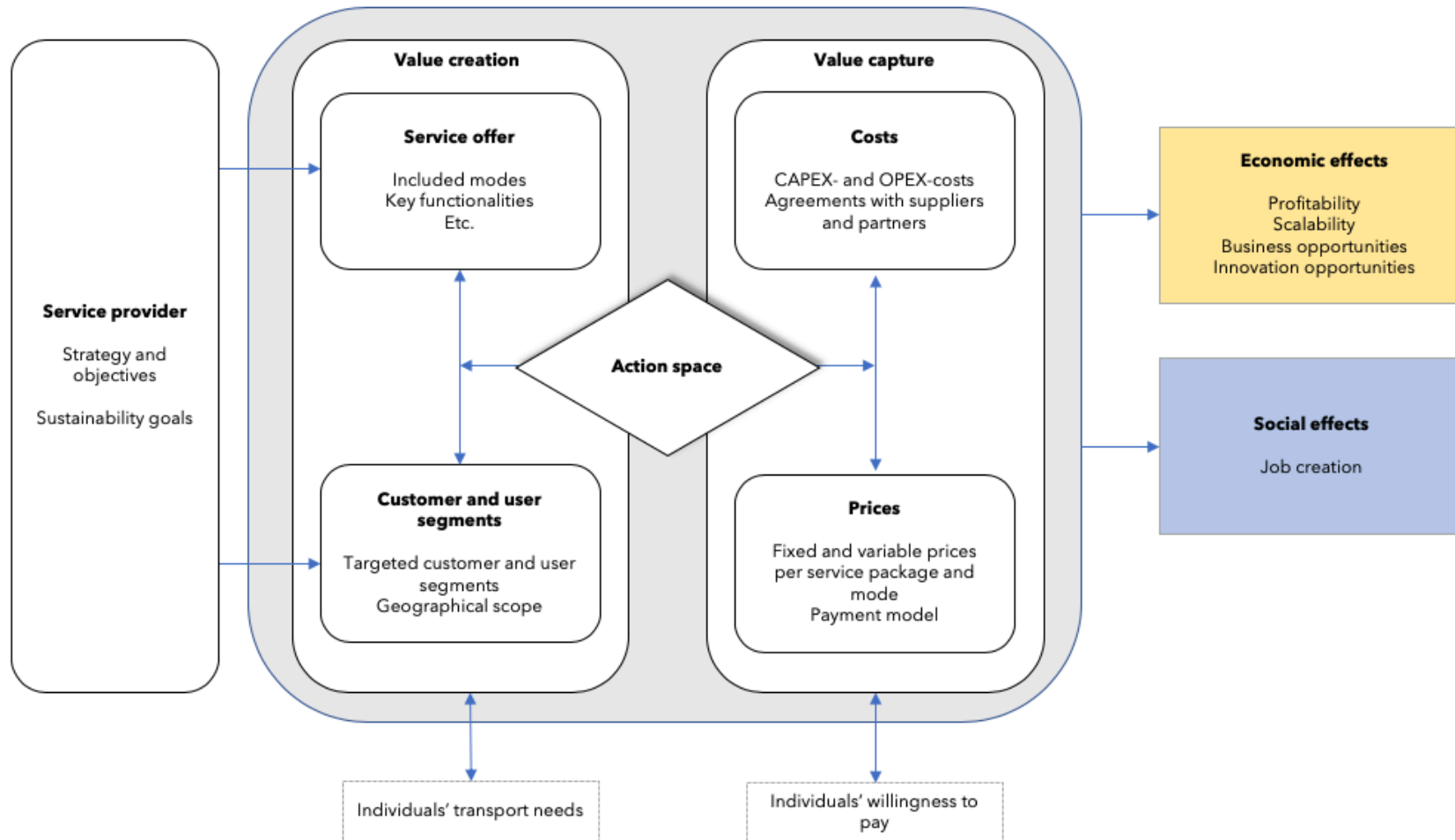


Figure 5. The meso level of the KOMPIS framework. Yellow = economic effects, blue = social effects.

### 3.3. Indicators at the meso level

In order to assess the sustainability impacts of a piloted MaaS service, a number of key performance indicators (KPIs) have been formulated. The assessment of the economic effects will primarily analyse the service's captivating processes, i.e. the profitability and scalability of the service and whether the service provider feels that the service leads to new business and innovation opportunities (table 7). For the evaluation of the social effects, it is analysed whether the service provider feels that the service leads to new jobs (table 8). The ecological effects of the service are evaluated on the basis of the data collected at the passenger level.

Economic KPIs			
KPI	Description	Unit	Data Collection
KPI_OE1a: Profitability	A MaaS service provider's net profit margin, i.e. the ratio of total revenue minus costs divided by total revenue	%	Expert assessment (service provider questionnaire)
KPI_OE1b: The perceived (future) profitability of the service	The service provider's estimate of future profitability after the pilot is terminated	LIKERT scale estimation	Service provider questionnaire
KPI_OE2a: Scalability of the service	Assessment of the potential for the service provider's business model to scale cost-effectively	SEK / new customer	Expert assessment (based on service provider questionnaire)
KPI_OE2b: The scalability of the service	The service provider's perceptions of whether the business model can grow cost-effectively	LIKERT scale estimation	Service provider questionnaire
KPI_OE3: Business opportunities	The extent to which the service is perceived to lead to new business opportunities.	LIKERT scale estimation	Service provider questionnaire

KPI_OE4: Innovation potential	The extent to which the service is perceived to lead to: (a) new business models (b) new forms of cooperation (c) new partnerships (d) new mobility services (e) new ancillary services	LIKERT scale estimation	Service provider questionnaire
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Table 7. KPIs for evaluating economic effects at the meso level.

Social KPIs			
KPI	Description	Unit	Data Collection
KPI_OS1a: Job creation	Total number of new jobs created	#	Service provider questionnaire
KPI_OS1b: Future job creation	The service provider's assessment of the extent to which the service can lead to new jobs	LIKERT scale estimation	Service provider questionnaire

Table 8. KPIs for evaluating social impacts at the meso level

### 3.4. Data collection at the meso level

#### 3.4.1. Questionnaire

At the meso level, data is collected using a **questionnaire** sent to each organisation that is responsible for creating a MaaS service and offering it to customers/users as part of a KOMPIS pilot. The questionnaire must be sent out *one month* before each pilot ends.

To distribute the questionnaires, a **web-based survey tool** should be used. It is important to choose a tool that 1) provides the required question and answer formats; 2) can export data in SPSS format (or equivalent); and 2) meets the requirements of the Data Protection Regulation (GDPR). Some individuals may not want for be able to answer digital questionnaires. Hence opportunities to answer a paper-based questionnaire should also be offered. For paper-based versions, GDPR rules must be complied with.

The questionnaire collects information on background factors such as the nature of the pilot organisation, why the organisation in question is interested in developing MaaS services, the nature of the MaaS service, etc. The survey also collects information about

service providers' business models and their environmental credentials. The basic content of the questionnaire is summarised in table 9.

Description of the service provider	<ul style="list-style-type: none"> <li>Organisation type and size</li> <li>Driving forces and motivations</li> <li>Integrated transport modes and services</li> <li>Service features and functionalities</li> <li>User interfaces</li> <li>Customer segments and user groups</li> <li>The size and geographical scope of the pilot</li> </ul>
Prices and costs	<ul style="list-style-type: none"> <li>Payment models</li> <li>Monthly rates for different packages</li> <li>Revenue per month per customer segment</li> <li>CAPEX and OPEX costs</li> <li>Profitability and scalability of the business model</li> </ul>
Innovation	<ul style="list-style-type: none"> <li>Collaboration opportunities with different ecosystem actors</li> <li>New business opportunities</li> <li>New job opportunities</li> <li>Innovation opportunities</li> </ul>

Table 9. Overview of the data collected service provider questionnaire.

#### 3.4.2. Interviews

In addition to the survey, interviews are recommended with service providers and additional actors within the MaaS ecosystem for each pilot. At present, KOMPIS cannot provide interview guides, although the service provider questionnaire can be used to derive interview questions.

### 3.5. The macro level (societal impacts)

#### 3.5.1. Basic assumptions

The macro level of the KOMPIS framework can be used to evaluate sustainability impacts at the level of individual communities, towns and cities, for regions, counties or provinces, or for an entire nation. The geographical boundaries are not stringently distinguished, in order to allow for macro level assessments that can inform and assist public-sector decision making related to policies, legislation and financial incentives, at different levels of government.

The macro level is based on the following model (figure 6), which can be used to assess the ecological, economic and social effects of a significant uptake of MaaS. To perform such assessments, the macro level utilises data collected at the micro and meso levels and applies relevant scenario-based modelling techniques.

The left-hand part of the model describes societal level factors related to public policy that influence transport-related decisions and actions. This “transport policy context” is very broad, and the model focuses on the contextual factors that have a direct or strong indirect influence on the development, introduction and use of MaaS services. Examples are taxation on vehicles, fuel charges, bans on certain types of vehicles in city centres, and congestion taxes. Other examples include measures that aim to promote car sharing and indirect support for MaaS via infrastructure designs and urban development planning. All of these factors can influence individuals’ modal choices, as individuals compare and evaluate available transportation alternatives. The transport policy context also influences organisations in their development of MaaS services and business models.

Certain KPIs at the macro level can be calculated using direct summations from the micro and meso levels, or by analysing a combination of KPIs from these levels. For other KPIs, more advanced models are needed to make calculations based on data at the micro and meso levels. The black box in the model describes how data from the micro and meso levels are aggregated into KPIs at the macro level.

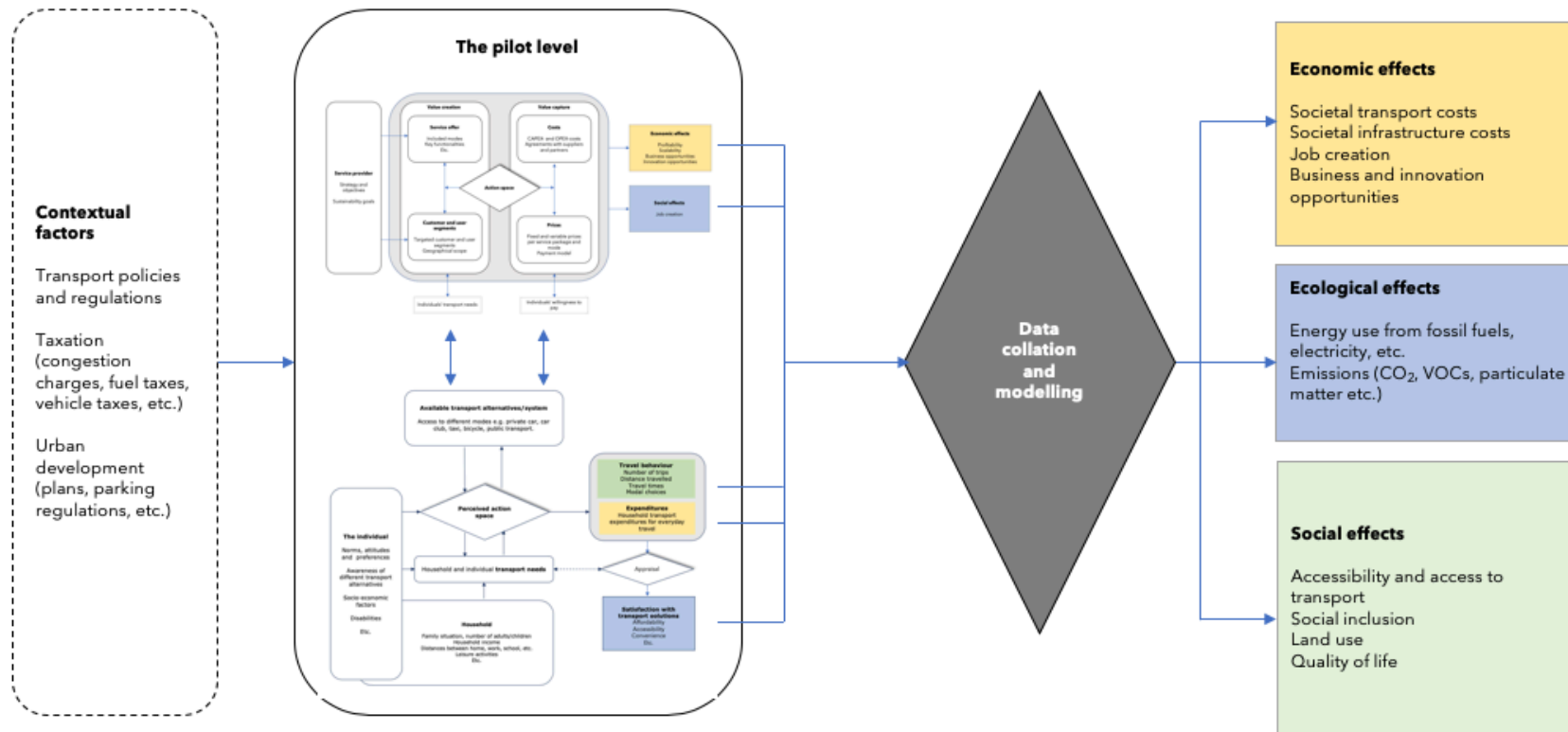


Figure 6. The macro level of the KOMPIS framework. Yellow = economic effects, blue = social effects, green = ecological effects.



### 3.5.2. Macro-level indicators

In order to evaluate the impacts MaaS at societal levels, a number of key performance indicators (KPIs) have been formulated and categorised in terms of the ecological, economic and social dimensions of sustainability. The assessment of ecological effects is based on how access to MaaS will influence total energy use and greenhouse gas emissions within the transport system (table 10). The assessment of economic effects is based on changes in the societal cost of transportation, infrastructural expenditures required to support MaaS developments, and the number of business opportunities and new job creation resulting from MaaS developments (table 11). The assessment of social effects rests on analyses of accessibility to transport at a societal level, land use changes and the way in which MaaS influences quality of life (table 12).

Ecological KPIs			
KPI	Description	Unit	Data Collection
KPI_SM1: Energy use within the passenger transportation system	Changes in the total amount of energy used for passenger transport per year	kWh total per year	Data derived from micro-level assessments
KPI_SM2: Greenhouse gas emissions from the passenger transportation system	Changes in CO <sub>2</sub> emissions from vehicles in the entire transport system	Tons of CO <sub>2</sub> per year	Data derived from micro-level assessments

Table 10. KPIs for evaluating ecological effects at the macro level

Economic KPIs			
KPI	Description	Unit	Data Collection
KPI_SE1: Societal costs of transport	The total costs of travel for individuals plus the societal costs per traveller and km plus costs of travel time (travel time * time value for travel with different modes of transport).	SEK per year	Data derived from micro-level assessments  Questionnaire or interviews with public sector representatives
KPI_SE2: Societal costs for physical infrastructure	Societal costs for physical transport infrastructure	SEK per year	Questionnaire or interviews with public sector representatives

KPI_SE3: Number of companies	Total number of (new) companies / organisations related to MaaS	# companies	Data derived from meso-level assessments
KPI_SE4: Job creation	Total number of new jobs in companies / organisations related to MaaS	# new jobs	Data derived from meso-level assessments

Table 11. KPIs for evaluating economic effects at the macro level

Social KPIs			
KPI	Description	Unit	Data Collection
KPI_SS1: Changes in perceived accessibility to transport	Change in the percentage of people who feel that the transport system is designed such that it is easy to travel to destinations for activities and organisations.	%	Data derived from micro-level assessments
KPI_SS: 2 Changes in quality of life	Percentage of people who feel that the transport system is designed in a way that leads to improved travel quality and higher travel time values.	%	Data derived from micro-level assessments
KPI_SS3: Land utilised by MaaS services	Proportion of land used / planned for use to support the implementation and operation of MaaS services, including e.g. parking and exchange hubs, infrastructure, road networks.	% of land used according to different categories	Questionnaire or interviews with public sector representatives

Table 12. KPIs for evaluating social effects at the macro level

### 3.5.3. Data collection at the macro level

Assessments at the macro level rely primarily on data collected at the micro and meso levels. In particular, data collected on travel behaviour and modal choice via travel diaries and/or travel apps is important for calculations at the macro level. Some impacts at the macro level can be calculated directly from the data collected at the micro and meso levels, but in other instances, scenario-based modelling is necessary. The development and modification of such models is beyond the scope of KOMPIS. In Sweden, model development will occur in future projects. Internationally, the open access KOMPIS database allows researchers to develop their own models for conducting macro-level assessments.

In addition to data collected at the micro and meso levels, data must be collected on relevant background factors and transport policy contexts that influence MaaS developments. In practice, data on these issues must be collected following geographical boundary setting regarding what is to be treated as the macro level (community, town, city, region, nation, etc.). After boundaries have been drawn, questionnaires or interviews with relevant public sector officials can be conducted to elucidate the transport policy context. KOMPIS does not currently provide materials for this type of data collection.

Table 13 summarises the types of data collected for macro-level assessments.

Supportive measures	<ul style="list-style-type: none"> <li>Policies for MaaS services</li> <li>Regulations and legislation that influence MaaS developments</li> <li>Attitudes toward MaaS</li> </ul>
Land use	<ul style="list-style-type: none"> <li>MaaS-related infrastructure services</li> <li>Parking infrastructure and policies</li> <li>Roads and mobility hubs</li> </ul>
Innovation	<ul style="list-style-type: none"> <li>Opportunities for and barriers to collaboration among different service providers</li> <li>New business opportunities</li> <li>New job opportunities</li> </ul>
Sustainable development in the transport system	<ul style="list-style-type: none"> <li>Attitudes towards sustainability in the transport system</li> <li>Implemented sustainability measures targeting the transport system</li> <li>Planning for sustainability in the transport system</li> </ul>

Table 13. Overview of the types of data collected from cities/municipalities/regions where MaaS services have been implemented or are planned.

## 4. References

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