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Impact Assessment Framework (D01)

EIT Urban Mobility - Mobility for more liveable urban spaces

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Executive Summary

This report describes a new impact assessment framework to identify the policy measures (or 'solutions') that enable cities to meet their vision and objectives, taking into account the local context. The framework was developed as a part of the EIT Innovation Pathway activity (KAVA 20061). The framework consists of three groups of indicators, describing:

- the city-level context in which the policy measures are applied
- the characteristics of the process through which the policy measures are applied
- the likely outcomes and impacts of the policy measure

The framework intends to cover gaps in existing sets of indicators. The main aim of these current indicator sets is to assist city benchmarking, i.e. the evaluation of how each city progresses, or performs against others, in terms of the effects of policy measures. As such, the indicators cannot be linked to the introduction of specific measures, or to the comparison between possible alternative measures. Existing indicator sets also exclude aspects of the process of implementing the measures, such as governance and feasibility, and include a mix of outputs, outcomes, and impacts of policies.

The proposed framework focuses on indicators at the measure level, treating city level indicators not as cumulative outcomes of the introduction of packages of measures, but as the context in which the measures are selected and applied. It also incorporates indicators about the governance and feasibility of the policies, and includes only outcomes and impacts of policies, not direct outputs.

The indicators were identified from an extensive search of existing sets of indicators currently used by cities and from the literature, including Sustainable Urban Mobility Plans (SUMPs) of European cities, other policy documents released by European and non-European cities, reports, and academic literature. The selection of the indicators was based on how well they align with the EIT Urban Mobility strategic objectives and with the other two methods developed in the EIT Innovation Pathway activity.

The **city-level context** group includes 25 indicators, related to demography; urban structure; economy; governance; transport and its effects; and political priorities.

The **governance and feasibility** group includes 12 indicators, related to management, financial aspects, risks, and public acceptability of policies.

The **outcomes and impacts** group includes 18 indicators split into two-subgroups: a core set of 12 indicators and another 6 indicators, where relevant to cities and specific measures and if data is readily available. The indicators cover the effects of individual policy measures on mobility, society, and environment.

The framework is designed to be integrated into the other two methods developed in the EIT Innovation Pathway activity. The indicators proposed can be used as search terms in the Pathway Tool, to select policy solutions, and as the outputs in the Urban Mobility Model, which estimates the outcomes and impacts of the policy solutions.

1. Background

This report describes a new impact assessment framework for cities to identify the policy measures (or 'solutions') that enable them to meet their vision and objectives, taking into account the local context.

The framework was developed as a part of the EIT Innovation Pathway activity (KAVA 20061). The project addresses problems currently faced by cities in the management of mobility of people and goods. There is a growing number of competing mobility demands in cities, due to urban growth and the emergence of new modes of transport and new mobility systems. At the same time, there is an increased concern about the impacts of mobility on the natural environment and on people's quality of life. The ability of city government and other actors to make informed decisions on mobility requires an increased awareness of the complexity of mobility demands, and of the possible impacts of mobility on economic, social, and environmental aspects. Cities need tools both to understand the challenges and to choose the right solutions to address them.

The EIT Innovation Pathway activity has developed three methods to guide cities to select and assess policy measures to achieve their vision and objectives related to mobility. Policy measures include interventions and regulations (affecting transport, land use, or other domains), and the provision of products and services (e.g. e-mobility, mobility as a service, personalised service apps).

The three methods are as follows:

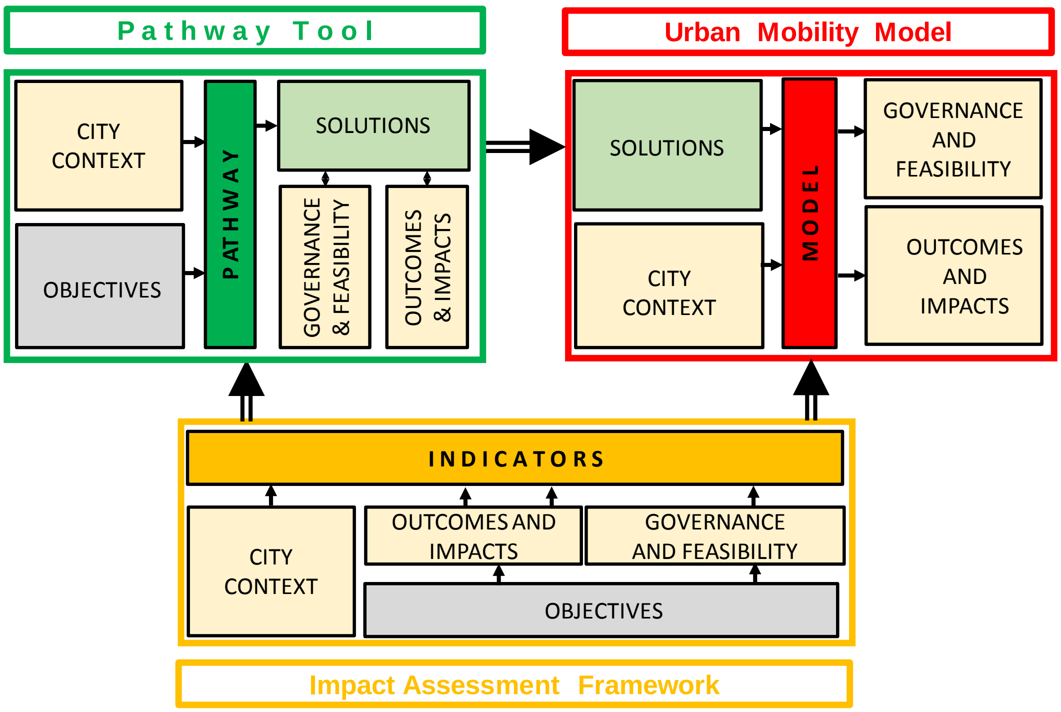
- The **Impact Assessment Framework**, the subject of this report, is a set of indicators defining criteria against which cities can judge how policy measures meet their objectives.
- The **Pathway Tool** allows cities to select options for policy measures, identifying pathways (i.e. Cause-effect relationships) through which they can contribute to achieve the city's objectives, given the local context. The tool uses information from a library of best practices in mobility in cities around the world.
- The **Urban Model** is a model of the pathways through which different policy measures, and combinations of measures, affect objectives at different time scales. The model enables cities to estimate how well each measure performs, compared with the alternatives.

Figure 1 shows how the three methods relate. The Impact Assessment Framework includes three sets of indicators. One set characterizes the city context, i.e. the conditions in which policy measures are applied. The other two sets characterize the process of implementing the measures themselves (i.e. aspects of governance and feasibility) and their outcomes and impacts. The characteristics are aligned with specific policy objectives.

The indicators are used as search terms in the Pathway Tool, to select policy solutions. The tool returns solutions that are adequate for the city context and that can achieve the desired outcomes and impacts and have suitable governance and feasibility characteristics, identified by the indicators.

The indicators are also used as variables in the Urban Mobility Model. The model estimates the relationships between the solutions (applied in the specific city context) and governance/feasibility aspects and outcomes/impacts, measured by the indicators.

Figure 1: Integration of the three tools



2. Novelty

Cities need a basis to identify the policy measures that enable them to meet their vision and objectives. In doing so, they can learn from the experiences of other cities worldwide. However, to do this, there needs to be a standard way of measuring the characteristics of the measures and of their impacts, taking into account the local context. There are several sets of indicator already in use for assessing policy measures aimed at mobility, as detailed below – but most of them are designed as city-level benchmarking tools.

The EIT Urban Mobility Strategic Agenda 2021-2027includes a list of key performance indicators related to KIC Strategic Objectives (EIT 2020, Annex 1). The indicators cover direct outputs of past measures, assessed at the city level (e.g. public realm improvements, density of public transport stations and e-mobility charging stations, coverage of traffic calming zones, percentage of population with access to cycling network and shared cycle schemes). It also covers outcomes of the policies (e.g. road fatalities, air quality, modal split, greenhouse gas emissions from the transport sector, population exposed to high levels of noise).

The World Business Council for Sustainable Development developed a set of city-level indicators measuring the potential for sustainable mobility, allowing cities to understand the current situation of their mobility system (WBCSD 2015). The set includes 19 indicators, some describing the transport system and others assessing various economic, social, and environmental aspects related to mobility.

SUMI (Sustainable Urban Mobility Indicators) (https://ec.europa.eu/transport/themes/urban/urban_mobility/sumi_en) is a set of indicators developed by the European Commission to assist cities to identify the strengths and weaknesses of their mobility system and areas for improvement. It includes 18 indicators of aspects of the mobility system, assessed at the city level.

UMAM (Urban Mobility Assessment Model) is a tool developed by the UCL Energy Institute and partners, and funded by the EIT (https://www.eiturbanmobility.eu/projects/urban-mobility-assessment-model). The tool assists cities analysing their mobility systems and identifying their strengths, weaknesses, and opportunities. The tool is based on a set of indicators characterizing the city context, including a self-assessment of policy plans, various elements of the transport supply and demand, availability of data, and social and environmental aspects – at the city level.

SUMP-PLUS, an on-going project (2019-2022) funded by the EU Horizon 2020 (https://sump-plus.eu) has produced a city typology[1] to help cities benchmark their progress in meeting mobility challenges against comparable European cities. This facilitates the process of learning the pathways that those cities have followed in their adoption of mobility measures and enables comparison and progress tracking against those cities. The typology includes indicators, grouped into various levels, of the demographic, geographic and socio-economic context of cities.

CH4LLENGE, a project co-funded by the EU (2013-2016) developed a manual to monitor and evaluate the impact of measures to improve mobility, in the context of Sustainable Urban Mobility Plans (SUMP)

[1] https://sump-plus.eu/fileadmin/user_upload/Resources/Reports_and_publications/SUMP_PLUS_D1.1_City_Typology_Final.pdf

(http://www.sump-challenges.eu/kits). The manual includes a list of indicators assessing the context, inputs, outputs, intermediate outcomes, and final outcomes of the measure.

Overall, the sets of indicators described above have three issues that limit their applicability for cities that want to select which policy measures to implement.

The first issue is that the aim of the sets of indicators is to assist city benchmarking, i.e. the evaluation of how each city progresses, or performs against others, in terms of the effects of policy measures. As such, the indicators cannot be linked to specific measures, allowing the comparison between possible alternative measures.

The second issue is that the sets of indicators do not include the characteristics of the policy measures themselves, only their effects. This excludes aspects of the process of implementing the measures, such as governance and feasibility. However, these aspects are often determinant to the success of the measures. For example, a measure for which is difficult to secure funding, or which is not supported by the local population may not be viable, even if the anticipated effects are positive.

The third issue is that in some cases the indicators do not measure the outcomes or impacts of a policy, but only its outputs.

Outputs are a specification of the policy measure, i.e. they are what the policy measure has produced or what were the funds where spent on.

Outcomes and impacts are the effects of the measure:

Outcomes are the immediate effects of the measure over a pre-defined and limited scope (e.g. a small geographic area and time period).

Impacts are the intended or unintended indirect effects of the measure, following from its outcomes, and affecting a wider geographic area over a longer time.

As an example, the output of a policy to expand the cycling network is the number and length of new cycle lanes. The outcome of the policy might be the increase in the number of cycling trips, while the impact would be an improvement in public health.

The impact assessment framework proposed in this report addresses the three issues detailed above. The aim is to provide a wide range of information that is useful in the selection of which policy measures to implement, covering the context, characteristics, and effects of the policies

The key specifications of the framework are to:

- Focus on indicators at the measure level, treating city level indicators not as outcomes but as the context in which the measures are applied
- Incorporate indicators about governance and feasibility of the policies
- Including only outcomes and impacts of policies, not outputs

3. The Impact Assessment Framework

The Impact Assessment Framework consists of three groups of indicators. Indicators are data used to describe conditions and assess the anticipated performance of a measure against a policy objective. Indicators may be expressed on a quantitative scale that refers to an observable variable (for example, noise levels) or on a qualitative scale that refers to an expert judgment (for example, the ease of securing funds for a measure).

The indicators recommended in this report were identified from an extensive search of existing sets of indicators used by cities (including those mentioned in the previous chapter) and from the wider literature, including Sustainable Urban Mobility Plans (SUMPs) of European cities, other policy documents released by European and non-European cities, reports and academic literature.

The selection of the indicators was based on how well they align with the EIT Urban Mobility Strategic Objectives and with the requirements of the other two methods developed in the EIT Innovation Pathway activity. Feedback from the other partners developing those methods was incorporated into the indicator selection process. Some indicators were selected from some of the sets mentioned in the previous chapter (SUMI, UMAM, SUMP-PLUS, and CH4LLENGE). Others were selected and adapted following an extensive literature review, or included based on discussion among partners of the EIT Innovation Pathway activity.

The indicator set is split into three groups:

The first group (city context - Section 4) includes aggregate indicators, some at the city level and others for the area(s) where the measure/solution is applied. These indicators assess the existing conditions in which a policy measure is going to be implemented. It should be emphasized that these indicators are not understood as outcomes or impacts of policies, but simply as the context for a new policy solution – which are likely to work best, in that context..

Two other groups comprises indicators at the measure level and assess aspects of the measure itself (governance/feasibility - Section 5) and of its effects (outcome/impact - Section 6).

In practice, not all indicators will be appropriate in all situations, depending on the types of problems to be addressed; and others may not be relevant for some cities.

4. Indicators: city context

The ‘city context’ group of indicators describe the characteristics of the city and of its transport system. "City" is understood in a broad sense: it can refer to administrative boundaries or to functional areas. It depends on the geographic area over which policies are applied and solutions are sought, in each case.

The indicators assess the suitability of the city for the application of certain policy measures and the degree to which the measures are consistent with the city's priorities. Table 1 shows the list of indicators. Some indicators are always defined at the ‘city’ level. Others are specific to the area where the solution is applied (which can be the whole city or parts of it). The indicators were selected/adapted from the UMAM and SUMP-PLUS sets or from other sources. The indicators are described in the sections that follow.

Table 1: City context indicators

Indicator		Scale	UMAM	SUMP-PLUS	OTHER
City-level aspects					
C-1	Population size	<50k; 50-500k; >500k		x	
C-2	Share of housing in CBD	%			x
C-3	Share of jobs in CBD	%			x
C-4	GDP (PPP) per capita	>0		x	
C-5	Tourism as % of GDP	%		x	
C-6	Industry as % of GDP	%		x	
C-7	Local Autonomy Index (Ladner *et al.* 2019)	0-37		x	
C-8	Share of low-emission vehicles	%			x
C-9	% of public transport delayed services	%	x		
C-10	Congestion level (TomTom Traffic Index)	>0	x		
C-11	Average commuting time	>0	x		
C-12	European Air Quality Index		x		
C-13	Share of greenhouse emissions from transport	%	x		
Area where measure/solution is to be applied					
C-14	Type of area where the measure is applied	Whole city; neighbourhood; corridor; centre; inner; outer; island			x
C-15	Degree of hilliness	1-3			x
C-16	Population density	>0		x	
C-17	Car modal share of residents	%	x	x	
C-18	Car modal share (direction of change)	-/0/+		x	
C-19	Car ownership per capita of residents	>0			x
C-20	Priority to reduce overall need for mobility	1-5			x
C-21	Priority to promote public transport	1-5			x
C-22	Priority to promote walking and cycling	1-5			x
C-23	Priority to improve the freight system	1-5			x
C-24	5-year average road mortality	>0	x		
C-25	% residents exposed to noise above standards	%	x		

4.1. 'City'-level aspects

C-1: Population size

Population size determines the scale and type of the problems cities face and the scale and type of solutions that are appropriate to solve those problems. As an example, some forms of mass public transport are only financially viable if transport demand is high enough. An underground system is not suitable in a small city. The SUMP-PLUS indicator recommends using three classes: below 50,000; 50,000 to 500,000; and over 500,000 inhabitants.

C-2/C-3: Urban structure

We recommend two indicators of the urban structure of the city. The **share of housing in the Central Business District** (CBD) (C-2) and the **share of jobs in the Central Business District** (CBD) (C-3) are indicators that affect the commuting patterns occurring in the city, which in turn determine the type of solutions that can be provided. For example, cities with a high concentration of jobs in the centre and with most of the population living outside the centre tend to have radial commuting patterns towards the centre, with a large variation in demand to and from the centre in the morning and evening peak period.

C-4 to C-6: Economy

We selected three indicators from the SUMP-PLUS city typology measuring economic aspects:

GDP (Gross Domestic Product) per capita, based on purchasing power parity (C-4) represents the city's income. Some solutions may not viable in poorer cities. For example, some forms of public transport may be unaffordable for a large part of the population. GDP per capita is also a proxy for the size of the resources that cities have to provide for the needs of its inhabitants, including mobility needs.

Tourism as a proportion of the city Gross Domestic Product (C-5) affects the travel patterns in the city. In cities with a high share of tourism, there are more seasonal patterns in the number of trips in some areas (where tourist sights and hotels are concentrated). The share of tourism also affects the geographic and time patterns of freight distribution (e.g. higher need to supply restaurants) and the type of modes of transport that should be provided (e.g. tourists may prefer using trams to underground systems, or a local cycle hire scheme, to have a better view of landmarks). It may also affect priorities given to public realm improvements.

Industry as a proportion of the city Gross Domestic Product (C-6) also affects travel patterns. For example, in industrial cities, a higher proportion of jobs are located in suburban industrial areas, and freight movements may be given a high priority.

C-7: Local autonomy index

The Local Autonomy Index has been selected from the SUMP-PLUS city typology. The autonomy of local governments is important because it affects the range of policy measures that local governments can adopt, and access to funding and ease of implementation.

This indicator was developed by Ladner et al. (2015) for the European Commission and it is a standardised score representing the degree of local government autonomy, at country level. The indicator varies from 0 to 37 and measures the policy and fiscal autonomy of municipal governments relative to regional and national administrations.

C-8: Share of low-emission vehicles

The current value of the share of low-emission vehicles refers to cars, vans, buses and trucks. It is a further indicator of how sustainable the city's transport system currently is.

C-9: Proportion of public transport delayed services

The proportion of public transport delayed services is included in the UMAM framework and is an aspect of the current efficiency of the public transport system. Measures that improve this efficiency may be less suitable, per unit of investment, in cities where efficiency is currently low, compared with those where efficiency is already high.

C-10 to C-13: Transport effects

We selected four indicators from the UMAM framework measuring the current level of the economic, social, and environmental effects of transport. These indicators are important because cities where the negative effects are severe require more radical measures than cities where those effects are more moderate. The indicators are as follows:

- **Congestion level**, using the TomTom Traffic Index (https://www.tomtom.com/en_gb/traffic-index/ranking) (C-10). This measures extra travel time as a percentage of travel time during uncongested conditions.
- **Average commuting time** (C-11) for the employed population and students, by any mode of transport
- **Air quality**, measured by the European Air Quality Index (C-12) (https://airindex.eea.europa.eu/Map/AQI/Viewer/#). This index is based on concentration of up to five pollutants (PM10, PM2.5 O3, NO2, and SO2).
- **Share of the city's greenhouse emissions from transport** (C-13)

4.2. Area where measure is to be applied

C-14: Type of area

The **type of area** where the policy measure is applied is important because some policy measures are only suitable in certain areas. For example, in city centres there is usually a higher concentration of jobs and lower car ownership and car use rates. Type of area is, for example, one of the search criteria of the KONSULT Option Generation tool (http://www.konsult.leeds.ac.uk/mog/), where it is shown that some policies measures are only suitable in some areas. We assume seven possible values for this indicator: whole city; neighbourhood; corridor; city centre; inner city; outer city: island.

C-15: Degree of hilliness

The average degree of hilliness of the area where the measure is applied is relevant because some modes of transport (e.g. cycling or walking) may be less suitable in hilly areas. We recommend a 3-point qualitative scale for this indicator, assigned based on data on average slopes.

C-16: Population density

Population density (number of inhabitants per km2) comes from the from the SUMP-PLUS city typology. It can be adapted to refer to the area where the measure is applied. Less dense areas have more problems of access to jobs and facilities and are less suitable for walking and cycling (because travel destinations are further apart) and for supporting high frequency public transport services (which are less financially viable because of the lower concentration of demand along corridors and the longer distances). On the other hand, denser areas are more prone to traffic congestion.

C-17: Car modal share of residents

The current value of the car modal share of residents of the area where the measure is applied represents the situation in terms of level of sustainable mobility. This is included both in the UMAM framework and in the SUMP-PLUS city typology.

C-18: Car modal share of residents (direction of change)

The **historical direction of change in the car modal share of residents** is also included in the SUMP-PLUS city typology. It can be adapted to refer to the area where the measure is applied. The indicator can assume three values: negative (i.e. decreasing), stable, or positive (i.e. increasing). This indicator represents the area's position along the path to promote sustainable mobility. This is relevant because low car shares can be observed both in areas where car use is low but growing rapidly and in areas where car use is declining. The suitable policy measures would differ in these two cases.

C-19: Car ownership per capita of residents

Car ownership per capita is important because it may affect the population's propensity to use alternative modes of transport (e.g. public transport, cycling).

C-20 to C-23: Transport priorities

We recommend four indicators of the political priorities regarding the transport system in the area where the measure is applied. The indicators are expressed on a 5-point qualitative scale. Measures are only suitable if they are consistent with the vision and objectives of the city. Four types of priority can be considered:

- **Priority to reduce overall need for mobility** (C-20)
- **Priority to promote public transport** (C-21)
- **Priority to promote walking and cycling** (C-22)
- **Priority to improve the freight system** (C-23)

In all cases, the indicator relies on expert judgement, based on the city's priorities as stated in official documents (e.g. strategic plans, sustainable urban mobility plans).

C-24/C-25: Local transport effects

We selected two indicators from the UMAM framework measuring the current level of the economic, social, and environmental effects of transport - in this case referring to the area where the measure is applied:

- **5-year average road traffic mortality** expressed per 100,000 population (C-24)
- **Proportion of the area's residents exposed to noise level above standards**. (C-25). This refers to the European standards: 55 dB averaged across the day, evening and night periods (the Lden indicator) and 50 dB averaged across the night period (the Lnight indicator) (https://www.eea.europa.eu/airs/2018/environment-and-health/environmental-noise)

5. Indicators: governance and feasibility

Aspects related to governance and feasibility affect the suitability and feasibility of introducing certain policy measures and may prevent their successful implementation, even when the anticipated effects of the measures are positive. In this chapter, we suggest 12 indicators of governance and feasibility, based on aspects mentioned in guidelines for project appraisal and evaluation in several countries (NAO 2006, 2019; JICA 2004; HM Treasury 2018; DfT 2013, 2017).

Table 2 shows the list of governance and feasibility indicators. The indicators are described in more detail in the sections that follow the table. All indicators are based on expert assessment, in most cases translated into qualitative scales.

Table 2: Governance and feasibility indicators

Indicator		Scale
Management		
GF-1	Complexity of implementation process	5-point scale
GF-2	Time required for preparation	>0
GF-3	Time required for construction/implementation	>0
Financial		
GF-4	Capital costs of construction/implementation	5-point scale
GF-5	Net operating costs or revenues	-3 to +3
GF-6	Ease of securing funds	5-point scale
Risks		
GF-7	Risk of cost overruns	3 point scale
GF-8	Extent of disruption during construction	3 point scale
GF-9	Certainty of outcomes	3 point scale
Public acceptability		
GF-10	Degree of support from users	5-point scale
GF-11	Degree of citizen acceptability	5-point scale
GF-12	Degree of business acceptability	5-point scale

GF-1: Complexity of implementation process

The implementation of a measure can be complex due to the need for establishing processes that can be lengthy and costly, such as gaining planning permission, arranging for the provision of services, assembling an implementation team with the suitable skills and experience, allocating roles and responsibilities, setting up inter-organization agreements, and conducting preliminary assessments of the project. The organizations implementing the project may also not be legally able to carry out some of the tasks, and their geographic jurisdiction may be too small. We suggest an indicator with a 5-point scale for the indicator of complexity of the implementation process.

GF-2: Time required for preparation

The time required for preparation includes time for obtaining approvals, designing the measure, conducting public consultations, and mobilising resources. Long times may compromise the feasibility of the measure, especially if the measure cannot be delivered within an electoral cycle.

GF-3: Time required for construction and implementation

The time required for construction and implementation can also be a constraint to the success of a policy measure. There is a risk that the measure delivers a solution that arrives too late to meet the mobility problems it intends to solve, or a political imperative.

GF-4: Capital costs of construction/implementation

High capital costs of construction/implementation are a major constraint to the adoption of a policy measure, especially when funds are scarce or difficult to secure. In some cases, alternative measures can achieve the same objectives with smaller costs. We suggest a 5-point scale for this indicator.

GF-5: Net operating costs or revenues

High net operating costs or low revenues also compromise the feasibility of a policy measure, as they do not provide incentives for the involvement of the private sector. We suggest a 7-point scale, from -3 to +3 for the indicator of net operating costs or revenues.

GF-6: Ease of securing funds

The availability of funding to implement the measure (grants, loans taxes, debt instruments, and user charges) is a crucial aspect, without which the measure cannot be applied. We suggest a 5-point scale for the indicator of the ease of securing funds.

GF-7: Risk of cost overruns

The risk of cost overruns may affect the suitability of the policy measure, as it affects the ease of securing funds especially from the private sector, and may pose a burden to public finances. We suggest a 3-point scale for this indicator.

GF-8: Extent of disruption during construction

Disruption during construction is a negative effect that is seldom included in policy appraisals, which tend to focus on the effects of the policy after implementation. However, the construction phase often generates substantial environmental impacts (noise, air pollution, dust) and disrupts road traffic flows and underground utilities, and may cause public resentment. We suggest a 3-point scale for this indicator.

GF-9: Certainty of outcomes

The intended outcomes of a measure may not materialize, due to technical failures, incorrect estimation of future demand, future changes in supply (e.g. introduction of new modes), or disruptive factors such as financial crises or political events. We suggest a 3-point scale for this indicator.

GF-10: Degree of support from users

Lack of support from users of the mobility system may undermine the political feasibility of the measure. Users may be concerned with aspects such as the cost of new or improved transport modes, increased congestion, reduction of parking spaces, and disruption during construction. We suggest using a 5-point scale (a usual scale in studies of public acceptability).

GF-11: Degree of citizen acceptability

The broader public may also show a low degree of acceptability of the measure, even when they are not users of the new or improved mobility services, if they are concerned with aspects such as expropriations, environmental impacts during and after implementation. We suggest a 5-point scale for this indicator.

GF-12: Degree of business acceptability

Businesses may also have protest against the measure, if the perceive it to go against their interests. This is sometimes the case of policy measures that restrict road traffic or reduce parking spaces near shops. Often business support is crucial to gaining approvals. We suggest a 3-point scale for this indicator.

6. Indicators: outcomes and impacts

The third group of indicators measures the likely outcomes and impacts of the policy measure. We selected indicators by first compiling a list of policy objectives related to mobility, drawing from the EIT Urban Mobility Strategic Agenda, Sustainable Urban Mobility Plans, and other sources mentioned in Chapter 3. We then identified, for each objective, a possible indicator that can be quantified at the measure level (i.e. that can be linked with the effects of a specific measure). We then split the indicators into two sub-groups. Core indicators (Section 6.1) are those that we recommend to be a priority in the selection of solutions and the assessments made by cities. Non-core indicators (Section 6.2) are those that can be included in selection/assessment if data is easily available.

Appendix 1 of this report includes a larger list of policy objectives and indicators, including several that were not selected for the final framework. Those were excluded because they are outputs, not outcomes/impacts, are difficult to specify, or data is either difficult to collect or difficult to link to specific policy measures.

6.1. Core indicators

Table 3 shows the recommended list of core outcomes and impacts indicators. In the type column, "O" denotes outcome and "I" denotes impact. The indicators are described in more detail in the following sections. Not all indicators will be relevant for each type of policy measure.

OI-1: Average travel time for commuting trips

Reducing travel time is a mobility-related objective common to all cities. In most cases, travellers prefer shorter, rather than longer travel times, as there is an opportunity cost in the time spent travelling.

We recommend using the average travel time for commuting trips (a SUMI indicator), as these are regular trips that a large proportion of the city population needs to make, and are often a source of stress. The indicator is specified as the average of the commuting times (in minutes per day), by any mode, of trips to work and to school (considering both outward and return trips), in areas/situations where these might be affected by a proposed measure

Table 3: Outcomes and impacts indicators (core)

Objective	Type	Indicator		Scale	SUMI	CH4LLENGE	OTHER
Mobility							
Reduce travel time	O	OI-1	Average travel time for commuting trips	>0	x		
Increase travel time reliability	O	OI-2	Variability in travel time for commuting trips	>0			x
Reduce travel costs	O	OI-3	Travel cost per trip	>0			x
Improve trip quality	O	OI-4	% of travellers satisfied with trip quality	%			x
Improve traffic safety	O	OI-5	Collisions/injuries/fatality rates	>0			x
Reduce road traffic levels	O	OI-6	Vehicle-km travelled (by road)	>0			x
Promote walking and cycling	I	OI-7	Modal share of walking and cycling trips	%		x	
Society							
Improve access to opportunities	I	OI-8	Number of jobs within 45 minutes of home	>0			x
Enable mobility of disadvantaged groups	I	OI-9	Trip rates for disabled, older people, women, ethnic minorities, low income (per year)	>0			x
Environment							
Improve local air quality	O	OI-10	Days exceeding critical levels of emissions	>0		x	
Reduce noise levels	O	OI-11	Noise exposure of residents	>0			x
Promote energy efficiency	O	OI-12	Fossil fuel consumption for transport per resident	>0		x	

OI-2: Variability in travel time per trip

Travel time reliability is often even more important than travel time itself. It is crucial for the freight and logistics sectors. Unreliable travel times also affect productivity and contribute to frustration and stress of transport users.

The recommended indicator is the variability of travel time for commuting trips, i.e. the standard deviation of the travel time over a year. Again, for trips made in parts of the city likely to be affected by the measure.

OI-3: Travel cost per trip

Reducing travel cost is a mobility-related objective common to all cities. The recommended indicator is travel cost per trip, in areas of the city/situations likely to be affected

OI-4: Proportion of travellers satisfied with trip quality

Trip quality is the subjective experience of all aspects of trips other than cost and travel time. This includes comfort, convenience, use of travel time, and information. Other aspects apply to specific modes. For example, trip quality for public transport trips depends on facilities at stations/bus stops, crowding, in-vehicle amenities, cleanliness, and physical accessibility. For walking, it depends on pavement width and condition, obstructions, amenities, and provision for the mobility-impaired. For cycling, it depends on the level of segregation from motorised traffic, pavement condition, etc. Trip quality has become a bigger priority in recent years, as governments start to put emphasis on aspects of wellbeing and urban liveability.

We recommend as indicator the proportion of travellers satisfied with trip quality, assessed on a 5-point qualitative scale. This is a SUMI indicator. The indicator can be disaggregated by travel mode, and applies to the modes affected by a policy measure.

OI-5: Collisions/injuries/fatality rates

Improve traffic safety is a mobility-related objective common to all cities. We recommend the rates of traffic collisions, injuries, and fatalities, as a composite indicator. These rates are the numbers of collisions, injuries, and fatalities expressed as a ratio of the number of km travelled, over a period. The indicators can be disaggregated by travel mode – where relevant to intervention and the focusing on the relevant parts of the city.

OI-6: Vehicle-km travelled (by road)

Reduce road traffic levels (of motorised vehicles) is important to reduce local environmental effects (noise, air pollution) and other effects on the natural environment (soil, water).

The recommended indicator is vehicle-km travelled by road-based motorised modes. Here this is not a city-level indicator, but focussing on vehicle-based trips affected by a policy measure.

OI-7: Modal share of walking and cycling trips

Promoting walking and cycling is a central objective of transport policy in many cities. These two modes are important because they have a minimal environmental impact and have positive effects for physical and mental health and subjective wellbeing.

We recommend as an indicator the modal share of walking and cycling trips (a CH4LLENGE indicator), in areas impacted by a policy measure (and where relevant).

OI-8: Number of jobs within 45 minutes of home

Public policy has been shifting from a focus on mobility (increase or improve movement) to accessibility (increase accessibility to opportunities, i.e. employment, education, shopping leisure). This is evident in documents published by several cities, e.g. London (TfL 2016). Increasing accessibility requires coordinated efforts from transport and land use policies, to ensure that opportunities are located close to people or, if they cannot be close, that they can be reach easily and as fast as possible using the transport network.

The recommended indicator is the number of jobs within 45 of home, averaged for the active population of the city. The indicator can be split into number of jobs reached private and public transport. Again, this indicator will be focused on the affected parts of a city and may not be relevant in all cases.

OI-9: Trip rates for disabled, older people, women, low income (per year)

Enabling the mobility of disadvantaged groups is a policy objective due to the recognised role of transport and mobility as factors reducing social inequalities and promoting equity (Di Ciommo and Shiftan 2017). Transport can increase the ability of disadvantage groups to access employment, education, healthcare, and recreation, decreasing their risk of social exclusion. The mobility of disadvantage groups can be improved, for example, through the provision of good-quality and affordable public transport and of safe walking and cycling infrastructure and public spaces, including facilities for people with disabilities.

Only a few cities conduct detailed quantitative analyses of equity in accessibility or look at destinations other than jobs, as found in the review of Boisjoly and El-Geneidy (2017). We recommend as indicators the trip rates (i.e. per person) for disabled, older people, women, ethnic minorities, and low-income households, over a year. Again, targeted on those likely to be affected (positively or negatively) by a proposed measure.

OI-10: Days exceeding critical levels of emissions

Air pollution is one the main negative environmental impacts of transport at the local level and is usually included in the assessment of plans for new transport infrastructure or for changes in existing infrastructure or traffic policies.

The recommended indicator is the number of days exceeding critical levels of emissions (a CH4LLENGE indicator), within affected parts of the city.

OI-11: Noise exposure of residents

Noise is one of the main negative environmental impacts of transport at the local level and is usually included in the assessment of plans for new transport infrastructure or for changes in existing infrastructure or traffic policies.

Our recommended indicator is the level of noise exposure of residents living around a certain distance of the road, railway, or other transport infrastructure in question, in affected parts of the city. The exposure can be disaggregated by time of day (daytime vs. nighttime).

OI-12: Fossil fuel consumption for transport per resident

Promote energy efficiency is an objective common to many city governments. The recommended indicator is fossil fuel consumption for transport per resident (a CH4LLENGE indicator), where this is likely to be affected by a policy measure

6.2. Non-core indicators

Table 4 shows the recommended list of non-core outcomes and impacts indicators.

Table 4: Outcomes and impacts indicators (non-core)

Objective	Type		Indicator	Scale	SUMI	CH4LLENGE	OTHER
Mobility							
Increase public transport patronage	O	OI-13	Modal share of public transport trips	%			x
Improve freight distribution	O	OI-14	Average delay to freight distribution trips	>0			x
Society							
Reduce community severance	O	OI-15	Indicator of barrier effect (Anciaes and Jones 2020)	%			x
Improve personal security	O	OI-16	Perceived risk of crime in transport	1-5	x		
Promote street activities	O	OI-17	Total duration of street activities	>0			x
Improve health	I	OI-18	Proportion of residents achieving minimum physical activity requirements	%			x

OI-13: Modal share of public transport trips

Increase public transport patronage is central to sustainable mobility plans of many cities, assuming that this will reduce car trips and in turn reduce tendencies for urban sprawl.

The recommended indicator is the modal share of public transport trips, for affected groups in relevant parts of the city .

OI-14: Delays to freight distribution trips

Improve freight distribution is becoming a crucial aspect of urban mobility, given the fast growth in home deliveries. National and international institutions have started to produce guidelines with indicators to assess the performance of freight transport in cities (e.g. European Commission 2017).

The recommended indicator is the average delay (per trip) to freight distribution trips, for affected trips in relevant parts of the city.

OI-15: Indicator of barrier effect

Community severance denotes the situation when transport infrastructure (e.g. motorways, railways), or traffic are a physical or psychological barrier to the mobility of pedestrians and cyclists (Anciaes et al. 2016). There are no indicators of community severance currently used for routine assessment of transport projects.

We recommend the indicator developed by Anciaes and Jones (2020), which assigns a community severance value, on a 0-100 scale, to different types of road, depending on the number of lanes, presence and width of a median strip, traffic density, traffic speed, and type and distance to crossing facilities. The indicator can be combined with the number of people affected. The indicator is applied when a proposed policy measure is intended – or likely – to affect severance on major urban roads.

OI-16: Perceived risk of crime in transport

Personal security is important because of the material and human losses due to crime incidents (e.g. on streets and public transport) but also because fear of crime is a source of stress and reduces the propensity for people to travel and to spend time in public places, which reduces quality of life.

We recommend as indicator the level of perceived risk of crime in transport (regardless of mode). This is a SUMI indicator. It includes perceptions about freight and public transport, public spaces, cycle lanes, and parking areas. This indicator is more suitable than number of crime incidents because these are difficult to forecast and do not fully capture the effects of fear of crime. For example, some places may have little crime because they are used by few people, precisely because they fear crime. It would apply to affected modes, streets and public spaces in affected parts of the city.

OI-17: Total duration of street activities

Streets are not only used for movement but also as places used by travellers, local residents/workers, and visitors, for a variety of activities, such as outdoor dining, sitting, window-shopping, and social interactions. The promotion of street activities is high on the agendas of many governments, as the intensity and quality of these activities contributes to wellbeing (Cattell et al. 2008, Walton 2014).

The recommended indicator is the total duration of street activities on a given street section, where appropriate and in relevant parts of the city.

OI-18: Proportion of residents achieving minimum physical activity requirements

Addressing the relationships between transport and health has become a key focus of transport policy in many cities. City strategies and policy measures that give priority to non-motorised modes (walking and cycling), in detriment of car traffic, are applied because of the positive impact on health. This is because those modes of travel are also physical activities, which is associated with physical and mental health. As an example of increased priority to health, transport authorities in London have produced several plans and developed methods to assess the health impact of transport policies (TfL 2014, 2017).

Our indicator to assess health impact of policy measures is the proportion of residents achieving the recommended minimum physical activity requirements (measured in minutes per week); again, where appropriate for the policy measure and among selected groups in relevant parts of the city.

7. Validation with EIT Urban Mobility City Club

The proposed impact assessment framework was validated by seeking feedback from the members of the EIT Urban Mobility City Club, using a self-completion questionnaire and a workshop.

A questionnaire was sent to the City Club asking for feedback on the three sets of indicators. The questionnaire included a brief overview of the Innovation Pathway activity and of the impact assessment framework and asked cities to rate each indicator on a 5-point scale, and to give further comments. Five cities returned the questionnaire. Appendix 2 of this report contains the questionnaire.

For the city context indicators, cities were asked to rate the relevance of the indicator in selecting appropriate mobility solutions for the city (1=not relevant, 5= very relevant), and the ease of collecting data in the city (1=very difficult, 5= very easy). They were also asked if there were any key indicators missing from the list.

For the outcomes and impacts indicators, cities were asked to rate the importance of the indicator for achieving the city's objectives (1=not important, 5= very important) and if there any outcomes/impacts missing from the list.

For the governance and feasibility indicators, cities were asked to rate the importance of the indicator for the city's circumstances (1=not important, 5= very important) and if there any aspects missing from the list.

A workshop was also organised, to gather further feedback. The workshop was held online on 17th December 2021, with representatives of 9 City Club cities. The three sets of indicators were presented by UCL. The cities gave feedback on each set separately, making comments on the suitability of the indicators, and suggestions on indicators that they thought could be added to the list.

7.1. City context

Table 5 shows the average ratings given by cities to the city context indicators. Indicator C-8 (share of low-emission vehicles) is not included as it was not in the original version of the set of indicators. It was included after gathering the cities' feedback, as noted below.

Note that the distinction between city-wide and area indicators shown in Table 5 was not made in the questionnaire (Appendix 2), as it arose during discussions with the cities.

Table 5: City context indicators: feedback from City Club

Indicator		Relevance for your city in selecting appropriate mobility solutions (1=not relevant; 5= very relevant)	Ease of collecting data in your city (1=very difficult; 5= very easy)
City-level aspects			
C-1	Population size	4.2	4.8
C-2	Share of housing in CBD	3.4	3.8
C-3	Share of jobs in CBD	3.6	3.3
C-4	GDP (PPP) per capita	3.4	3.2
C-5	Tourism as % of GDP	3.2	3.0
C-6	Industry as % of GDP	3.0	3.0
C-7	Local Autonomy Index	3.3	3.3
C-9	% of public transport delayed services	3.8	4.2
C-10	Congestion level (TomTom Traffic Index)	3.8	3.6
C-11	Average commuting time	4.0	3.4
C-12	European Air Quality Index	4.6	3.6
C-13	Share of greenhouse emissions from transport	5.0	4.0
Area where measure is applied			
C-14	Type of area	4.0	N/A
C-15	Degree of hilliness	2.4	3.0
C-16	Population density	4.4	4.4
C-17	Car modal share	4.5	4.3
C-18	Car modal share (direction of change)	4.5	4.3
C-19	Car ownership per capita	4.4	4.8
C-20	City priority to reduce overall need for mobility	3.4	3.4
C-21	City priority to promote public transport	4.6	3.6
C-22	City priority to promote walking and cycling	4.8	3.8
C-23	City priority to improve the freight system	4.0	3.4
C-24	5-year average road mortality	4.8	4.6
C-25	% of residents exposed to noise level above standards	4.6	4.0

In general, the relevance of the indicators was rated highly. One indicator (share of greenhouse emissions from transport) was given the maximum rating of 5 by all cities. Several other indicators were given average ratings above 4, and all but one indicator were given ratings above 3. The sole exception was degree of hilliness, which was given an average of 2.4. This could be because four of the cities answering the questionnaire were generally flat and the other one was flat in most central neighbourhoods. Most indicators were judged to be easy to collect, with average ratings above 3 in all cases.

Additional feedback was provided by cities during the workshop. Participants agreed that all indicators were crucial to understand the differences between cities and areas. For example, aspects such as high density and the importance of tourism were seen as determinant for some cities to find the best mobility solutions. One city mentioned that it struggles to make the movement patterns of tourists and residents more compatible. The degree of hilliness was also mentioned as being important locally, as it affects the solutions provided for walking and cycling, and varies from neighbourhood to neighbourhood.

It was agreed that this and several other indicators need to be specific for the areas where the solution applies, as conditions vary in different neighbourhoods. Furthermore, data exists already at a suitable level of disaggregation. In response to this comment, we reformulated the original list of indicators (which were all defined at the city level), splitting it into city-level and area-level indicators. Table 1 in Chapter 4 is the final version, incorporating this change.

A question was raised on whether it is possible to use the framework considering two different areas. This is possible by running separate impact assessments i.e. by running the Pathway Tool and the Urban Mobility Model (described in Chapter 1) twice. In each run, the indicators that are defined at the area level would change.

Participants also mentioned that it is easy to collect the data for almost all indicators. Most data is even available openly. However one participant mentioned that commuting time and modal share are not collected often in their city: only once every 5 years. In contrast, in other cities, it is collected annually. In addition, in some cities, commuting time and modal-split are also collected at a broader, regional level, including commuters from outside the city.

Another possible problem is that average commuting time refers only to trips by workers and students, not to leisure trips. While this is true, in practice it is difficult to collect city-level data on travel time for leisure trips, as these trips are not regular trips and have much more diverse origins and destinations. For example, population census ask about commuting time but not travel time for leisure trips.

Possible additional/modified indicators suggested by participants included:

- Share of low-emission vehicles - this was added to the list of indicators (it was not in the original version). Table 1 in Chapter 4 reflects this
- % of residents exposure to poor air quality - this would be an alternative to C-12 (European Air Quality Index)
- The proportion of fully-cancelled public transport services. This could be an alternative to C-9 (proportion of public transport delayed services) when data is not available on delays. For example, in one of the cities participating in the workshop, data is only collected on fully-cancelled services.

7.2. Governance and feasibility

Figure 6 shows the average ratings given by cities to the governance and feasibility indicators. All indicators were rated above the mid point of the scale, from 3.2 to 4.0.

Table 6: Governance and feasibility indicators: feedback from City Club

Indicator		Importance for the city's circumstances (1=Not important; 5= Very important)
Management		
GF-1	Complexity of implementation process	3.4
GF-2	Time required for preparation	3.6
GF-3	Time required for construction/implementation	3.8
Financial		
GF-4	Capital costs of construction/implementation	3.8
GF-5	Net operating costs or revenues	3.8
GF-6	Ease of securing funds	3.8
Risks		
GF-7	Risk of cost overruns	3.6
GF-8	Extent of disruption during construction	3.2
GF-9	Certainty of outcomes	3.6
Public acceptability		
GF-10	Degree of support from users	4.0
GF-11	Degree of citizen acceptability	3.6
GF-12	Degree of business acceptability	3.4

This was confirmed in the workshop: all indicators were seen as important. However, a question was raised about whether the indicators could reflect the degree of local autonomy. This affects all indicators. For example, if funding and implementation depends only on local authorities or also (or only) on central or regional authorities. This is partly covered by indicator C-7 (Local Autonomy Index) in the city context set.

7.3. Outcomes and impacts

Table 7 and Table 8 show the average ratings given by cities to the outcomes and impacts indicators. In general, the importance of the indicators was rated highly. Two core indicators (average travel time for commuting trips and modal share of walking and cycling trips) and one non-core indicator (modal share of public transport trips) were given the maximum rating of 5 by all cities. Several other indicators were given average ratings above 4, and all but one indicator (total duration of street activities) were given ratings above 3.

Table 7: Outcomes and impacts indicators (core) : feedback from City Club

Objective	Indicator		Importance for the achieving your city's objectives (1=not important; 5= very important)
Mobility			
Reduce travel time	OI-1	Average travel time for commuting trips	5.0
Increase travel time reliability	OI-2	Variability in travel time for commuting trips	3.8
Reduce travel costs	OI-3	Travel cost per trip	3.6
Improve trip quality	OI-4	% of travellers satisfied with trip quality	4.2
Improve traffic safety	OI-5	Collisions/injuries/fatality rates	4.6
Reduce road traffic levels	OI-6	Vehicle-km travelled (by road)	4.4
Promote walking and cycling	OI-7	Modal share of walking and cycling trips	5.0
Society			
Improve access to opportunities	OI-8	Number of jobs within 45 minutes of home	3.3
Enable mobility of disadvantaged groups	OI-9	Trip rates for disabled, older people, women, ethnic minorities, low income (per year)	3.8
Environment			
Improve local air quality	OI-10	Days exceeding critical levels of emissions	4.0
Reduce noise levels	OI-11	Noise exposure of residents	4.4
Promote energy efficiency	OI-12	Fossil fuel consumption for transport per resident	3.6

Table 8: Outcomes and impacts indicators (non-core) : feedback from City Club

Objective		Indicator	Importance for the achieving your city's objectives (1=not important; 5= very important)
Mobility			
Increase public transport patronage	OI-13	Modal share of public transport trips	5.0
Improve freight distribution	OI-14	Average delay to freight distribution trips	4.2
Society			
Reduce community severance	OI-15	Indicator of barrier effect (Anciaes and Jones 2020)	4.4
Improve personal security	OI-16	Perceived risk of crime in transport	3.2
Promote street activities	OI-17	Total duration of street activities	2.8
Improve health	OI-18	Proportion of residents achieving minimum physical activity requirements	3.2

Additional indicators suggested by cities in the questionnaire included:

- Average pavement condition score
- Average bridge condition score
- Traffic area per inhabitant
- Proportion of low-emission passenger cars
- Passenger numbers
- Bicycle traffic volume
- Vehicle fleet of car sharing providers
- Proportion of barrier-free rapid transit stops

In the workshops, the proportion of low-emission vehicles was also proposed as an additional indicator. This is partly an output indicator and the resulting outcomes are partly covered by OI-10 (Improve local air quality) and OI-12 (fossil fuel consumption for transport per resident), as the objectives of increasing the proportion of low-emission vehicles are to improve air quality and promote energy efficiency.

In the workshop, it was also noted that the street barrier effect depends on the size of the population affected and on land use (i.e. what destinations pedestrians cannot access because of the barrier effect of transport infrastructure). These aspects are included in the proposed barrier effect indicator.

The number, duration, and time patterns of street activities also varies much from city to city, depending on aspects like weather, or from area to area within a city.

The number of jobs within 45 minutes of home could also be split for city residents and residents in the surrounding areas, as the mode of transport used is different. This is possible by doing separate assessments using the framework, one for each area.

8. Conclusions and lessons learnt

This report described a new impact assessment framework to help cities identify the policy measures that enable them to meet their vision and objectives, taking into account the local context. The framework consists of three groups of indicators, describing: i) the city-level context in which the policy measures are applied, ii) the characteristics of the process through which the policies are implemented, and iii) the likely outcomes and impacts of the policy measure.

The framework adds to existing sets of indicators by: i) focusing on indicators at the measure level, rather than a benchmarking exercise at the city level, treating city level indicators not as outcomes but as the context in which the measures are applied; ii) incorporating indicators about governance and feasibility of the policies, and iii) including outcomes and impacts of policies, not outputs

The proposed impact assessment framework was validated by seeking feedback from the members of the EIT Urban Mobility City Club, using a self-completion questionnaire and a workshop. Cities agreed that indicators were relevant to their situation and suggested additional indicators and raised questions about the practicalities of using some of the indicators. This feedback was incorporated in the final version of the framework.

The framework can be integrated into the other two tools developed as part of the EIT Innovation Pathway activity. The indicators proposed can be used as search terms in the Pathway Tool, to select policy solutions, and as the outputs in the Urban Mobility Model, which estimates the outcomes and impacts of the policy solutions.

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Appendix 1: Full list of objectives and indicators reviewed in this study

Note: The objectives that were selected for inclusion in the impact assessment framework are highlighted in blue.

POLICY OBJECTIVES		**INDICATORS OF PERFORMANCE**				
Identified Objectives	*Exemplary References*	*Identified Indicators*	*Explanation*	*Exemplary References*	*Identified Proxy Indicators*	*Exemplary References*
Stimulate new employment opportunities	London - TfL (2018)	Number of (permanent and temporary) Jobs created				
Promote investment	London - TfL (2018)	Economic vitality	Vitality index, calculated based on mix of indicators such as population growth, education, house prices; available is some countries from regular reporting	Gühnemann (2016)	• Total amount of future investments in the area • Changes in land use (in terms of purpose and intensity of usage) and value	
Raise productivity (e.g. through agglomeration)	London - MoL (2018) & TfL (2018)	GDP	increased regional GDP per capita and per occupied person		economic density/agglomeration index	Uchida and Nelson (2010)
		Business satisfaction	% of businesses rating transport provision satisfactory	Gühnemann (2016)		
Facilitate new housing provision	London - MoL (2016)	Total number of houses provided			Urban growth rate, housing investment, housing stock, residential mobility	Turner (1993)

Support Transit-Oriented Development	London - MoL (2016 and 2018); Washington DC, USA				• Population density • Employment density (e.g. number of jobs per acre) • Building/dwellings density • Number of bus, ferry, shuttle, or jitney services connecting to transit station	Galelo et al. (2014)
Improve local air quality	London - TfL (2014 and 2017); Amsterdam CoA (2020); Burgos, Spain; Howatson (2018);	Air pollutant emissions indicator	https://ec.europa.eu/transport/themes/air-pollutant-emissions-indicator_en	WBCSD (2015); EC (2020)		
		Greenhouse gas emissions indicator	https://ec.europa.eu/transport/themes/greenhouse-gas-emissions-indicator_en	WBCSD (2015); EC (2020)		
Reduce emissions from vehicles	London - MoL (2018); Burgos, Spain; Washington DC, USA; Canberra, Australia	Days exceeding critical levels of emissions	Number of days in which critical levels for local pollutants are exceeded	Gühnemann (2016)		
		Emissions of CO2 from transport		Gühnemann (2016)		
Promote energy efficiency		Energy efficiency indicator	https://ec.europa.eu/transport/themes/energy-efficiency-indicator_en	WBCSD (2015); EC (2020)	• Total fuel consumption [t fuels/year] • Relative fuel consumption per distance [t fuels/100km] • Proportion of renewable energy [%] • Proportion of electric vehicles or zero emission vehicles in vehicle fleet [%]	MORE Project (2019)
Support Carbon Reduction	Singapore	Fossil fuel intensity	Fossil fuel consumption for transport per resident	Gühnemann (2016)		
		Use of renewable energy sources	Share of regenerative energies of energy consumption of motorised traffic	Gühnemann (2016)		
Reduce noise levels	London - TfL (2014 and	Noise hindrance indicator	https://ec.europa.eu/transport/themes/noise-hindrance-indicator_en	WBCSD (2015); EC (2020)		

	2017) & MoL (2018); Amsterdam CoA (2020); Burgos & Vitoria-Gasteiz, Spain; Howatson (2018);	traffic noise during peak hours	traffic noise based on peak hour motorised traffic volumes	London - TfL (2014 and 2017)		
		Noise exposure of residents	Noise mapping to determine the % of residents exposed to excessive noise levels	Gühnemann (2016)		
		Average rating of transport related noise		London - TfL (2014)		
Reduce negative impacts of transport on water quality	Washington DC, USA	Biological integrity	Percentage of rivers with healthy aquatic communities	EPA (1996)		
Preserve/enhance the natural environment	MORE Project (2019)	Conservation of natural / green spaces	Net loss / gain of green space	Gühnemann (2016)	Size of affected areas [m²], number of cut (and so far connected) habitat areas for certain species, qualitative indicators	MORE Project (2019)
Increase resilience to the impacts of extreme weather events	London - MoL (2018); Washington DC, USA	Resistance for disasters and ecological/social disruptions	Emergency response (time) and resilience of the transport system in case a major part of the network cannot be used or is damaged due to a disaster or disruption	WBCSD (2015)		
Improve the quality and quantity of street environment facilities (e.g. Seating, shade and shelter, green space, lighting, etc.)	London - TfL (2014 and 2017); Amsterdam - CoA (2020); Maleki et al. (2014); Howatson (2018); NARC (2009); Gehl (2010)	Community satisfaction	surveys to establish the average satisfaction with local community	Gühnemann (2016)	• Presence of adequate facilities • Limited distance between resting points and sheltered areas	TfL & Mayor of London - Guide to the Healthy Streets Indicators; Montgomery Planning (2018)
		Quality of public spaces indicator	https://ec.europa.eu/transport/themes/quality-public-spaces-indicator_en	WBCSD (2015); EC (2020)		
		Place Quality	Surveys aimed at measuring the perceptions about the quality of a place	Anciaes and Jones (2020)		

Provide adequate facilities for parking and loading	London - TfL (2014 and 2017); Amsterdam - CoA (2020);	Community satisfaction	surveys to establish the average satisfaction with local community			
		loading/parking capacity survey	Survey to establish if there is sufficient capacity to accommodate the expected demand			
Reduce community severance/reduce the number of physical barriers dividing space and people.	London - TfL (2014 and 2017); Vitoria-Gasteiz, Spain				Origin-Destination surveys, observation of pedestrian behaviour, walking opportunities index, crossability index of streets, surveys carried out amongst people to map people's perceptions, cognitions, attitudes and behaviours in the face of barriers	Anciaes et al. (2014)
Reduce the visual intrusion caused by transport infrastructure	Anciaes and Jones (2020)	Estimation of view sheds	calculation of the area of land that is visible from a location, combined with indicators of exposure (e.g. proximity, number of people affected, and duration)	Anciaes and Jones (2020)		
Provide good pedestrian footways and bicycle lanes	London - TfL (2014 and 2017); Amsterdam - CoA (2020); Howatson (2018);	Perception of infrastructure quality for walking and cycling	Share of population expressing satisfaction with quality of walking and cycling infrastructure, including availability, directness, security	Gühnemann (2016)	• Effective width for cycling; • Effective width for walking; • Quality of footway/bike lane surfaces; • Impact of kerbside activity on walking/cycling;	TfL & Mayor of London - Guide to the Healthy Streets Indicators MORE Project (2019)
Provide sufficient space for public transport	Amsterdam - CoA (2020); Vitoria-Gasteiz, Spain				Share of street sections with dedicated lanes for public transport	MORE Project (2019)

Improve access to good and services	London - MoL (2018)	Non-car accessibility to main services	% of non-car households within 30 or 60 minutes of city centre or main suburban centre with shopping and medical service provision	Gühnemann (2016)		
		Access to opportunities and services (ATOS) score	ATOS indicates how easy it is to access essential key services and employment locations, using public transport or by foot.	TfL (2016)	Walkability indicator - Based on street connectivity, dwelling density and accessibility to public transport stops and supermarkets	Higgs et al. (2019)
Improve access to the public transport system networks	London - TfL (2014 and 2017) & MoL (2018); Burgos, Spain; Bristol, UK; Canberra, Australia; NARC (2009)	access to mobility services indicator	https://ec.europa.eu/transport/themes/access-mobility-services-indicator_en	WBCSD (2015); EC (2020)		
		Public Transport Accessibility Level (PTAL), Calculator of Public Transport Access in London (CAPITAL)	The PTAL measure which rates a selected place based on how close it is to public transport and how frequent services are in the area	TFL (2016)		
		Public transport catchment area	Share of residents inside radius around PT stops	Gühnemann (2016)		
Reduce land use by transport (infrastructure and parked cars)	London - TfL (2014 and 2017);				- level of occupation of parking spaces; car ownership statistics - land-use diversity index, land use intensity index	Gühneman n (2014)
Promote urban regeneration	MoL (2018)				• Land development multiplier • Urban growth rate • Infrastructure expenditures	Galelo et al. (2014)
Protect/enhance the historical / cultural heritage	MoL (2018)	Conservation of historical sites	Net loss of sites of historical / cultural importance	Gühnemann (2016)		

Improve personal security and reduce crime	London - TfL (2014 and 2017) & MoL (2018); Amsterdam - CoA (2020); Howatson (2018)	Security indicator	https://ec.europa.eu/transport/themes/security-indicator_en	WBCSD (2015); EC (2020)		
		crime rate	Crime Data	Gühnemann (2016)	• Monitoring of crime • Existence of surveillance of public spaces • Number of street lights, distance between street lights	MORE Project (2019)
		Perceived attractiveness/safety of street environment/public transport system	surveys/audits done by governments or transport operators concerning levels of personal safety from crime or threatening behaviour at bus stops/train stations/metro stations	Anciaes and Jones (2020); Gühnemann (2016)		
Promote street activities (e.g. outdoor dining, sitting, window shopping)	London - TfL (2017)	street activities indicator	street audit tools and statistics on the number and diversity of users and activities that take place on a place	Anciaes and Jones (2020)		
Encourage social interaction in streets and urban public space	London - TfL (2014 and 2017) & MoL (2018); Howatson (2018); Maleki et al. (2014); Gehl (2010); NARC (2009)	street activities indicator	street audit tools and statistics on the number and diversity of users and activities that take place on a place	Anciaes and Jones (2020)	• Number, types and duration of necessary activities • Number, types and duration of social activities (talk, sing, play, work, meet, engage in cultural activities etc.) • Number, types and duration of optional activities (wait, work, eat, drink, window shop, use mobile devices, etc.)	MORE Project (2019)
		Urban functional diversity indicator	https://ec.europa.eu/transport/themes/urban-functional-diversity-indicator_en	WBCSD (2015); EC (2020)		
		Share of liveable streets	Share of streets considered pleasant + safe environment for walking and social interaction	Gühnemann (2016)		

Promote physical activity	London - TfL (2014 and 2017); Amsterdam - CoA (2020); Washington DC, USA; Canberra, Australia				Survey amongst population	
Reduce stress (car drivers, user of public transport)		Comfort and pleasure	The physical and mental comfort of urban transport and services for all people	WBCSD (2015)	survey to monitor satisfaction of people with the transport network/public transport system	
Improve general health	London - TfL (2014 and 2017) & MoL (2018); Washington DC, USA	Health Economic Assessment Tool (HEAT)	HEAT calculates the reduced mortality risk that results from more regular physical activity and reduced road crashes and air pollution	Anciaes and Jones (2020)		
Improve wellbeing	London - TfL (2014 and 2017) & MoL (2018); Washington DC, USA	Quality-adjusted life-year (QALY)	QALY is a generic measure of disease burden, including both the quality and the quantity of life lived. It is used in economic evaluation to assess the value of medical interventions. One QALY equates to one year in perfect health.	Sassi (2006)		
Promote physical access to transport (e.g. step-free access to buses) and public - especially for disabled and older people	London - TfL (2014 and 2017) & MoL (2018); Sydney, Australia	accessibility for mobility-impaired groups indicator	https://ec.europa.eu/transport/themes/accessibility-public-transport-mobility-impaired-groups-indicator_en	WBCSD (2015); EC (2020)	Monitor infrastructure and service compliance with national disability standard	Sydney, Australia
		people satisfaction level	survey to monitor satisfaction of people with disabilities	Canberra, Australia		
		Accessibility for disabled people	Share of residents inside radius around barrier free public transport stops	Gühnemann (2016)	Number of buses, train coaches, train/metro	

					stations and bus stops which are accessible	
Reduce social inequalities (e.g. income, ethnicity, gender, age) and promote social inclusion	London - MoL (2018);	disaggregation of transport impacts	Disaggregation of transport impacts according to social groups.	Anciaes and Jones (2020)		
Ensure affordability of transport services	Amsterdam - CoA (2020); London - MoL (2018)	Public Transport Affordability Indicator (PTAI)	PTAI measures the percentage of household income spent on public transport	World Bank (2005)		
		affordability of public transport for the poorest people indicator	https://ec.europa.eu/transport/themes/affordability-public-transport-poorest-group-indicator_en	WBCSD (2015); EC (2020)		
Promote cycling and walking	London - TfL (2014 and 2017); Amsterdam - CoA (2020); Washington DC, USA; Canberra, Australia	opportunities for active mobility indicator	https://ec.europa.eu/transport/themes/opportunity-active-mobility-indicator_en	WBCSD (2015); EC (2020)	[min moderate/intense physical activity per week], for specific person groups such as children, adults or seniors [min walking/cycling travel per week]	MORE Project (2019)
		Share of sustainable modes	Share of trips by non-motorised modes and public transport	London - MoL (2018); Gühnemann (2016)		
		- Travel time by walking/cycling to some strategic destinations - Travel time ratio bicycle/car to some strategic destinations				
		Percentage of trip		London - TfL		

		stages walked or cycled		(2014)		
		number of users of the bicycle load system		Burgos, Spain		
		visual Accounting of number of bicycles/pedestrians		Burgos, Spain		
		survey amongst citizens		London - MoL (2018)		
Increase public transport patronage	London - TfL (2014 and 2017); Amsterdam CoA (2020); Washington DC, USA; Canberra, Australia; Vitoria-Gasteiz, Spain	Share of sustainable modes	Share of trips by non-motorised modes and public transport	London - MoL (2018); Gühnemann (2016)	• Provision of adequate public transport information; • helpfulness of drivers	TfL & Mayor of London - Guide to the Healthy Streets Indicators
		survey regarding customers' expectation and satisfaction levels over dependability, travel time, accessibility, efficiency of public transport services				
		Statistics regarding the number of public transport users		Burgos, Spain		
		Distance to nearest bus stop				
		Average public transport occupancy	Average number of passengers per public transport vehicle travelling in city / region, potentially broken down by type of public transport	Gühnemann (2016)		

Make the public transport network easier and more pleasant to use	Amsterdam - CoA (2020); London - MoL (2018)	access to mobility services	https://ec.europa.eu/transport/themes/access-mobility-services-indicator_en	WBCSD (2015); EC (2020)		
		Comfort and pleasure	The physical and mental comfort of urban transport and services for all people	WBCSD (2015)		
		trip quality	Survey regarding the quality of the PT service	Burgos, Spain; Sydney, Australia; Anciaes and Jones (2020)		
		Satisfaction with public transport indicator	https://ec.europa.eu/transport/themes/satisfaction-public-transport-indicator_en	EC (2020)		
Provide adequate public transport capacity to meet demand	London - TfL (2014 and 2017); Amsterdam CoA (2020)	Average public transport occupancy	Average number of passengers per public transport vehicle travelling in city / region, potentially broken down by type of public transport	Gühnemann (2016)		
Improve public transport system service integration (e.g. train, metro, bus services)	London - MoL (2018)	Intermodal connectivity & Intermodal integration indicators	Intermodal connectivity of city transport offered by the physical presence of intermodal interchanges in the transport network & Quality of the interchange facilities between different transport modes	WBCSD (2015)		
		Multimodal integration indicator	https://ec.europa.eu/transport/themes/multimodal-integration-indicator_en	EC (2020)		
Improve public transport efficiency and reliability	Washington DC, USA	Public transport punctuality	Share of public transport services arriving at stops within set punctuality limits	Gühnemann (2016)		
		frequency of bus/tube/rail services				
		travel time savings/monetisation of travel time		Anciaes and Jones (2020)		

Reduce travel time		Commuting travel time indicator	https://ec.europa.eu/transport/themes/commuting-travel-time-indicator_en	EC (2020)		
Reduce travel costs		travel costs				
Increase travel time reliability		Average time lost per passenger / ton km	Average difference between time required to travel in free flow and actual conditions for motorised traffic and average pedestrian / cyclist delay at traffic signals / crossings per km	Gühnemann (2016)		
		Journey time reliability	Average delay [min] or [€/year], frequency of delays above specific thresholds	MORE Project (2019)		
Improve trip quality (comfort, convenience and use of travel time)		Comfort and pleasure	The physical and mental comfort of urban transport and services for all people	WBCSD (2015)		
Reduce the need for travel (fewer and shorter trips)		Transport Demand Model		https://www.rand.org/randeurope/research/projects/developing-a-new-transport-demand-model-for-the-london-area.html		
		Occupancy rate	Average load factor of vehicles of all modes of city transport	WBCSD (2015)		
		Mobility space usage indicator	https://ec.europa.eu/transport/themes/mobility-space-usage-indicator_en	EC (2020)		

Reduce traffic congestion	London - TfL (2014 and 2017); Canberra, Australia	Speed, delays	[km/h] [minutes delay per km driven] [km] of street sections with certain speed limits	MORE Project (2019)		
		Congestion and delays indicator	https://ec.europa.eu/transport/themes/congestion-and-delays-indicator_en	EC (2020)		
		Commuting travel time indicator	https://ec.europa.eu/transport/themes/commuting-travel-time-indicator_en	EC (2020)		
		Reliability	Average delay [min] or [€/year], frequency of delays above specific thresholds	MORE Project (2019)		
		Road capacity utilisation index	Share of street length where flows exceed Level-Of-Service capacity threshold (e.g. 85%)	Gühnemann (2016)		
		Transport intensity	Passenger / Ton km / GDP	Gühnemann (2016)	Traffic volumes (all user groups) [veh.-km] [veh.-trips] [ped.-trips] etc Examples for quantitative indicators used as the basis for computing LOS: Traffic density [vehicle/km] Utilisation rate [vehicle/hour over capacity] Waiting times at junctions [min] monetisation of gains and losses in travel times [£/year] average delay [min], frequency of delays above specific thresholds	MORE Project (2019)

Reduce traffic levels	MORE Project (2019)	traffic levels/ volumes and types of vehicles				
Reduce speeds of motorised traffic	MORE Project (2019)				[km] of street sections with certain speed limits	
Improve the traffic safety of streets	London - TfL (2014 and 2017); Amsterdam - CoA (2020); Burgos & Vitoria-Gasteiz, Spain; Milan, Italy; New York, USA; Washington DC, USA	traffic safety indicator	Road and rail transport accidents in the city and damage caused	WBCSD (2015)	• ease of crossing side roads for people walking • type and suitability of pedestrian crossings away from junctions	
		Road deaths indicator	https://ec.europa.eu/transport/themes/road-deaths-indicator_en	EC (2020)		
		Traffic safety active modes indicator	https://ec.europa.eu/transport/themes/traffic-safety-active-modes-indicator_en	EC (2020)	Total number of accidents/injured per year (per 3 years for accidents with personal injury) Number of accidents/injured per length of infrastructure [km] Number of accidents/injured per length of infrastructure [km] and traffic volume [veh.-km] All the above indicators might be monetised (absolute accident cost, accident cost per km / veh.-km) Percentage reduction of accidents/ accident cost [%]	MORE Project (2019)
		Perceived safety by mode	Number of people rating it safe to use transport	Gühnemann (2016)		
		Accidents by mode	Total number of accidents by mode	Gühnemann (2016)		
Improve freight distribution	London - MoL (2018)	Road occupancy per hour	number of vehicles involved in deliveries and pick-ups per hours per type per size	EC (2017)		

		Analysis of logistics rules/context	• Availability of loading/unloading areas • Size limitations (length, height) • Weight limitation • Presence of urban consolidation centres			
		Delivery reliability, Transportation cost estimation in freight distribution				

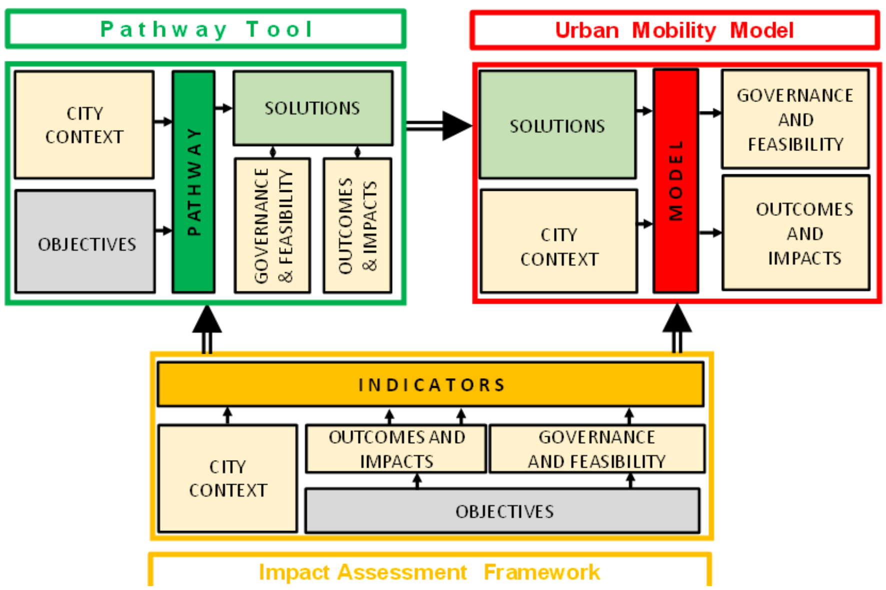
Appendix 2: Questionnaire to City Club

Impact Assessment Framework for urban mobility solutions

UCL (University College London), funded by EIT Urban Mobility, has produced a new Impact Assessment Framework to help cities identify solutions (e.g. policies, products, services) that would enable them to meet their sustainable urban mobility vision and objectives.

It forms part of a suite of tools currently under development, as illustrated below. The Impact Assessment Framework has developed sets of indicators that feed into:

- A Pathway Tool (being developed by TU/e), that suggests specific solutions to address the problems that cities face; and
- An Urban mobility Model (being developedby TUM), which indicates the likely outcomes and impacts of introducing a solution in a particular city context.



The Impact Assessment Framework consists of three types of indicators:

1. **City Context**: these indicators describe the characteristics of your city, which may influence the types of solutions that are likely to be most effective
2. **Outcomes and Impacts**: these describe the likely effects of introducing a particular solution – and how they relate to your priority city objectives; and
3. **Governance and Feasibility**: these give an indication of how easy or challenging it might be to implement a solution in your city, depending on funding, risk appetite, etc.

We would like to hear your views about this framework and, in particular, how appropriate you think the three sets of indicators are for your city. It would be helpful if you could complete the three tables below.

Part 1: City-level context

The ‘city context’ set of 24 indicators describes the demographic, economic and mobility characteristics of the city, and its political priorities. These indicators help experts to judge the suitability of possible solutions, given a city's characteristics and priorities.

Please fill in the table below, indicating:

- How relevant you think each indicator is in representing the unique features of your city, that might affect the relevance of different solutions: and
- Whether you already have this information, or how easy it would be to collect data to measure that indicator

Indicator	Relevance for your city in selecting appropriate mobility solutions (1=not relevant 5= very relevant)	Ease of collecting data in your city (1=very difficult 5= very easy)
Population size		
Population density		
Share of housing in CBD		
Share of jobs in CBD		
Type of area where the solution is applied		N/A
GDP (PPP) per capita		
Tourism as % of GDP		
Industry as % of GDP		
Local autonomy		
Car modal share		
Car modal share (direction of change)		
% of public transport delayed services		
Car ownership per capita		
City topology: degree of hilliness		
City priority to reduce overall need for mobility		
City priority to promote public transport		
City priority to promote walking and cycling		
City priority to improve the freight system		
Congestion level		
Average commuting time		
5-year average road mortality		
European Air Quality Index		
Share of greenhouse emissions from transport		
% of residents exposed to noise level above standards		

Are there any key indicators missing from the table above? If so, please describe.

Part 2: Potential effects of the solutions (outcomes and impacts)

Potential solutions to improve mobility in your city may have positive or negative, intended or unintended effects not only on mobility, but also on wider economic, social, environmental aspects. Our framework includes includes 18 indicators/objectives to measure these aspects.

Please fill in the table below, stating how important each indicator is for your city.

Indicator	Importance for the achieving your city's objectives (1=not important 5= very important)
Average travel time for commuting trips	
Variability in travel time for commuting trips	
Travel cost per trip	
% of travellers satisfied with trip quality	
Collisions/injuries/fatality rates	
Vehicle-km travelled (by road)	
Modal share of walking and cycling trips	
Number of jobs within 45 minutes of home	
Trip rates for disabled, older people, women, ethnic minorities, low income (per year)	
Days exceeding critical levels of emissions	
Noise exposure of residents	
Fossil fuel consumption for transport per resident	
Modal share of public transport trips	
Average delay to freight distribution trips	
Barrier effect of roads on pedestrians	
Perceived risk of crime in transport	
Total duration of street activities	
Proportion of residents achieving minimum physical activity requirements	

Are there any effects missing from the table above? If so, please describe.

Part 3: Governance and feasibility of the solutions

Features associated with the governance and feasibility of different solutions may prevent their successful implementation, even when their anticipated effects are positive. Our framework includes 12 indicators reflecting governance and feasibility considerations.

These indicators may help cities to judge how easy it would be to implement each alternative solution, to solve a given mobility problem.

Please fill in the table below, stating how important each indicator is for the city.

Indicator	Importance for the city's circumstances (1=Not important 5= Very important)
Complexity of implementation process	
Time required for preparation	
Time required for construction/implementation	
Capital costs of construction/implementation	
Net operating costs or revenues	
Ease of securing funds	
Risk of cost overruns	
Extent of disruption during construction	
Certainty of outcomes	
Degree of support from users	
Degree of citizen acceptability	
Degree of business acceptability	

Are there any aspects missing from the table above? If so, please decribe.

Name of city completing this survey (optional): ....

THANK YOU FOR YOUR CO-OPERATION!

Once completed, please return to Paulo Anciaes: p.anciaes@ucl.ac.uk