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Part 1: Description of Key Performance Indicators

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Contents

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Foreword

This Technical Specification (TS) has been produced by ETSI Technical Committee Access, Terminals, Transmission and Multiplexing (ATTM).

The present document is part 1 of a multi-part deliverable covering Key Performance Indicators (KPIs) for Sustainable Digital Multiservice Areas (Smart Areas both urban and rural) expressing sustainability performance in terms of People, Planet, Prosperity and Governance as identified below:

Part 1: "Description of Key Performance Indicators";

Part 2: "Global KPIs for Sustainable Digital Multiservice Areas".

Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the ETSI Drafting Rules (Verbal forms for the expression of provisions).

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Executive summary

The present document describes the selection of indicators for assessing indicators on city level. Starting from the definition of a smart city, indicators have been selected that can function as Key Performance Indicators for tracking the progress towards city objectives.

The indicators for smart cities focus on monitoring the evolution of a city towards an even smarter city. The time component -"development over the years"- is an important feature. The city indicators may be used to show to what extent overall policy goals have been reached, or are within reach. With a starting point in the smart city definition, and taking into account the wishes of cities and citizens with regard to smart city indicators, the indicators are arranged in an extended triple bottom line sustainability framework, including the themes people, planet, prosperity, governance and propagation, and completed with specific smart city indicators. Under the main themes subthemes conforming to major policy ambitions have been identified. Under these subthemes in total 73 city indicators have been selected. The selection has been based on an inventory of 43 existing indicator frameworks for cities indicators. The majority of the indicators in the ICT users selection have been derived from existing indicator frameworks. New indicators have been suggested to fill gaps in existing frameworks.

Annex A of the present document presents the selection of indicators for ICT users.

Introduction

ICT users aim to speed up the transition to low carbon, resource-efficient cities by facilitating and enabling stakeholders in smart cities to learn from each other, create trust in solutions, and monitor progress, by means of a common performance measurement framework. The ultimate goal is to support the wide-scale deployment of smart city solutions and services in order to create impact on major societal challenges related to the cities' fast growth and the Union's 20/20/20 energy and climate targets. The expected benefits for different stakeholders can be summarized as follows:

- Cities will benefit from the ICT users results as they support their strategic planning and allow measuring their progress towards smart city goals. In addition, benefits are created from the enhanced collaboration within and between cities, providing the possibility to compare solutions and to find best practices.
- Policy makers will benefit from the indicators that help to set policy targets and monitor their achievement. ICT users KPI framework's sub-themes are formulated as policy goals and thereby the use of the indicators and therefore the indicators are especially useful to follow progress towards policy goals.
- Solution providers will benefit from better insight into business opportunities for their products and services, and into the possibilities for replication in a different city or context.
- Industrial stakeholders will benefit from the recommendations for new business, e.g. based on open data. Citizens will benefit from the indicators as they may help to get a better understanding of complex projects and their impacts.

All these opportunities should bring environmental benefits such as reduction of CO_2 emissions, increased energy efficiency, increased share of renewables, as well as improve the quality of life through better mobility, better communication between local authorities and their citizens, empowerment of citizens (i.e. smart citizens). For the development of the performance measurement framework, ICT users are building on existing smart city and sustainable city indicator systems. The bases of the ICT users indicator framework (Based on CITYkeys deliverable 1.4 [i.1]) are the traditional sustainability impact categories **People, Prosperity and Planet**, but the performance measurement framework includes specific smart city KPIs that go beyond the traditional categories in showing not only the impact but also indices of the success factors for smart city endeavours and the suitability for dissemination to other cities and circumstances. The transparent and flexible ICT Users 'performance measurement framework will be able to handle different sizes of cities in different smart city development stages and thereby support different development strategies of smart cities and -initiatives over a wide range of characteristics.

1 Scope

The present document defines indicators (KPIs) for Smart Cities expressing city level in terms of People, Planet, Prosperity, Governance and Propagation.

2 References

2.1 Normative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

Referenced documents which are not found to be publicly available in the expected location might be found at https://docbox.etsi.org/Reference.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are necessary for the application of the present document.

[1] Recommendation ITU-T L.1440: "Methodology for environmental impact assessment of information and communication technologies at city level".

[2] Recommendation ITU-T L.1430: "Methodology for assessment of the environmental impact of information and communication technology greenhouse gas and energy projects".

[3] ISO 1996-2:1987: "Acoustics -- Description and measurement of environmental noise - Part 2: Acquisition of data pertinent to land use".

[4] ISO 37120:2018: "Sustainable cities and communities -- Indicators for city services and quality of life".

2.2 Informative references

References are either specific (identified by date of publication and/or edition number or version number) or non-specific. For specific references, only the cited version applies. For non-specific references, the latest version of the referenced document (including any amendments) applies.

NOTE: While any hyperlinks included in this clause were valid at the time of publication, ETSI cannot guarantee their long term validity.

The following referenced documents are not necessary for the application of the present document but they assist the user with regard to a particular subject area.

[i.1] European project CITYkeys deliverable D1.4: "D1.4-CITYkeys-D14-Smart-City-KPIs-Final-20160201".

NOTE: Available at http://citykeys-project.eu/citykeys/resources/general/download/CITYkeys-D1-4-Smart-City-smart-project-KPIs-and-related-methodology-final-WSWE-A7LN3E.

[i.2] ETSI GS OEU 019: "Operational energy Efficiency for Users (OEU); KPIs for Smart Cities".

[i.3] ITU, 2014: "Key performance indicators (KPIs) definitions for smart sustainable cities". ITU focus group on smart sustainable cities.

[i.4] ISO 14000 series: "Environmental management".

[i.5] OECD Frascati Manual 2002: "Proposed Standard Practice for Surveys on Research and Experimental Development".

NOTE: Available at http://www.oecd-ilibrary.org/science-and-technology/frascati-manual-2002_9789264199040-en.

[i.6] Eurostat Urban audit (urb) Reference Metadata in Euro SDMX Metadata Structure (ESMS).

NOTE: Available at http://ec.europa.eu/eurostat/cache/metadata/en/urb_esms.htm.

[i.7] European Environment Agency: "Urban Atlas".

NOTE: Available at https://www.eea.europa.eu/data-and-maps/data/copernicus-land-monitoring-service-urban-atlas.

[i.8] Department of Energy & Climate Change: "Electricity Generation Costs", 2013.

NOTE: Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/223940/DECC_Electricity_Generation_Costs_for_publication_-_24_07_13.pdf.

[i.9] ECM: "European Cities Marketing Benchmarking report", 2015.

NOTE: Available at http://www.europeancitiesmarketing.com/.

[i.10] ISO 14001: "Environmental management systems".

[i.11] UNEP 2008 annual report.

NOTE: Available at http://wedocs.unep.org/bitstream/handle/20.500.11822/7742/-UNEP%202008%20Annual%20Report-2009837.pdf?sequence=3&isAllowed=y.

3 Definition of terms, symbols and abbreviations

3.1 Terms

For the purposes of the present document, the following terms apply:

CITYkeys: european project funded by European Union, programme H2020

3.2 Symbols

Void.

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

CAQI	Common Air Quality Index
CO_2	Carbon dioxide
DE	Domestic Extraction
DECC	Department of Energy and Climate Change
DMC	Domestic Material Consumption
DMI	Direct Material Input
EC	European Commission
ECM	European Cities Marketing
EEA	European Environment Agency
ESPON	European Spatial Planning Observation Network
GDP	Gross Domestic Product
GERD	Gross domestic Expenditure on R&D

GJ	GigaJoule
GPP	Green Public Procurement
ICT	Information and Communications Technology
ISWA	International Solid Waste Association
ITU	International Telecommunications Union
KPI	Key Performance Indicators
LIHC	London Intercommunity Health Centre
OECD	Organization for Economic Co-operation and Development
PM	Particle Matter
PNP	Private Not-for-Profit institutions
SHP	Shape files (GIS file format)
TOE	Tonne of Oil Equivalent

NOTE: 1 TOE = 41,868 GJ.

UHI	Urban Heat Island
UNEP	United Nations Environment Programme
WEI	Water Exploitation Index
WHO	World Health Organization

4 Indicators for smart cities

4.1 Generalities

From the long list of city indicators, based among others on CITYkeys deliverable D1.4 [i.1] and ETSI GS OEU 019 [i.2], an indicator was chosen. If several indicators were equally suitable, the preference went to an indicator that cities already use and/or are familiar with. In the next clauses, the tables of selected city indicators are shown, discussing the title, the unit, a short description, the source framework(s) and the type of indicator:

- The title of the city indicator is phrased as evaluating a static situation. A static indicator, assessing the situation at a certain recurrence in time, will allow monitoring over various time periods.
- Important in the choice for the unit of the indicator is the comparability of indicators across a variety of cities differing in size, demography, dominant type of companies/sectors, etc. Here too, absolute values are not suitable. Consequently, most city indicators are defined as '%' or use a Likert scale, for instance, the share of population with good access to public transport expressed in percentage.
- For the city indicator set the traditional quantitative indicator was judged feasible.
- The short description explains the indicator into more detail. More elaborate descriptions of the city indicators can be found in annex A.
- Also for city indicators, existing indicators of already developed frameworks have been used for the ICT users' framework when available. For these indicators, the original frameworks are mentioned in the description as the 'source framework'. In addition, new indicators have been developed by the consortium members when they felt this was necessary for performing a complete evaluation of smart cities. The indicator titles of these indicators are marked in red.

Some of these indicators have been defined on current Recommendation ITU-T L.1430 [2], Recommendation ITU-T L.1440 [1] and ITU deliverables on KPIs definitions for Smart and Sustainable Cities [i.3].

Main indicators defined in the present document are presented as follow:

a) People:

- Encouraging a healthy lifestyle.
- Cybersecurity.
- Data privacy.

- Digital literacy.
- Ground floor usage.

b) Planet:

- Domestic material consumption.
- Brownfield use.
- Local food production.
- Urban heat island.

c) Prosperity:

- Share of certified companies.
- Innovation hubs in the city.
- Open data.

d) Governance:

- Smart city policy.

4.2 People

4.2.1 Health

Table 1

Indicator title	Indicator unit	Definition
Access to basic health care services	% of people	Share of population with access to basic health care services within 500 m
Encouraging a healthy lifestyle	Likert	The extent to which policy efforts are undertaken to encourage a healthy lifestyle

4.2.2 Safety

Table 2

Indicator title	Indicator unit	Definition
Traffic accidents	#/100 000	Number of transportation fatalities per 100 000 population
Crime rate	#/100 000	Number of violence, annoyances and crimes per 100 000 population
Cybersecurity	Likert	The level of cybersecurity of the cities' systems
Data privacy	Likert	The level of data protection by the city

4.2.3 Access to (other) services

Table 3

Indicator title	Indicator unit	Definition
Access to public transport	% of people	Share of population with access to a public transport stop within 500 m
Access to vehicle sharing solutions for city travel	#/100 000	Number of vehicles available for sharing per 100 000 inhabitants
Length of bike route network	% in km	% of bicycle paths and lanes in relation to the length of streets (excluding motorways)
Access to public amenities	% of people	Share of population with access to at least one type of public amenity within 500 m
Access to commercial amenities	% of people	Share of population with access to at least six types of commercial amenities providing goods for daily use within 500 m
Access to high speed internet	#	Fixed (wired)-broadband subscriptions per 100 inhabitants
Access to public free Wi-Fi	% of m²	Public space Wi-Fi coverage
Flexibility in delivery services	Likert	The extent to which there is flexibility in delivery services

4.2.4 Education

Table 4

Indicator title	Indicator unit	Definition
Access to educational resources	Likert	The extent to which the city provides easy access (either physically or digitally) to a wide coverage of educational resources
Environmental education	% of schools	The percentage of schools with environmental education programs
Digital literacy	% of people	Percentage of target group reached

4.2.5 Diversity and social cohesion

No indicators identified at city level.

4.2.6 Quality of housing and the built environment

Table 5

Indicator title	Indicator unit	Definition
Diversity of housing types	Simpson Diversity Index	Simpson Diversity Index of total housing stock in the city
Preservation of cultural heritage	Likert	The extent to which preservation of cultural heritage of the city is considered in urban planning
Ground floor usage	% of m²	Percentage of ground floor surface of buildings that is used for commercial or public purposes as percentage of total ground floor surface
Public outdoor recreation space	m²/cap	Square meters of public outdoor recreation space per capita
Green space	hectares/100 000	Green area (hectares) per 100 000 population

4.3 Planet

4.3.1 Energy and mitigation

Table 6

Indicator title	Indicator unit	Definition
Energy consumption/demand		
Annual final energy consumption	MWh/cap/yr	Annual final energy consumption for all uses and forms of energy
Renewable energy production		
Renewable energy generated within the city	% of MWh	The percentage of total energy derived from renewable sources, as a share of the city's total energy consumption
CO_2 -emissions		
CO_2 emissions	t CO_2/cap/yr	CO_2 emissions in tonnes per capita per year
Local freight transport fuel mix	%	The ratio of renewable fuels in the local freight transport fuel mix

4.3.2 Materials, water, land

Table 7

Indicator title	Indicator unit	Definition
Materials		
Domestic material consumption	t/cap/year	The total amount of material directly used in the city per capita
Water		
Water consumption	litres/cap/year	Total water consumption per capita per day
Grey and rain water use	% of houses	Percentage of houses equipped to reuse grey and rain water
Water Exploitation Index	% of m^3	Annual total water abstraction as a percentage of available long-term freshwater resources in the geographically relevant area (basin) from which the city gets its water
Water losses	% of m^3	Percentage of water loss of the total water consumption
Land		
Population density	#/km^2	Number of people per km^2
Local food production	% of tonnes	Share of food consumption produced within a radius of 100 km
Brownfield use	% of km^2	Share of brownfield area that has been redeveloped in the past period as percentage of total brownfield area

4.3.3 Climate resilience

Table 8

Indicator title	Indicator unit	Definition
Climate resilience strategy	Likert scale	The extent to which the city has developed and implemented a climate resilient strategy
Urban Heat Island	°C	Maximum difference in air temperature within the city compared to the countryside during the summer months

4.3.4 Pollution and waste

Table 9

Indicator title	Indicator unit	Definition
Air quality		
Nitrogen dioxide emissions (NO_2)	g/cap	Annual nitrogen dioxides emissions per capita
Fine particulate matter emissions (PM 2,5)	g/cap	Annual particulate matter emissions (PM 2,5) per capita
Air quality index	-	Annual concentration of relevant air pollutants
Miscellaneous		
Noise pollution	% of people	Share of the population affected by noise > 55 dB(a) at night time
Waste		
Recycling rate	% of tonnes	Percentage of city's solid waste that is recycled
Municipal solid waste	t/cap/yr	The amount of municipal solid waste generated per capita annually

4.3.5 Ecosystem

Table 10

Indicator title	Indicator unit	Definition
Share of green and water spaces	% in km²	Share of green and water surface area as percentage of total land area
Native species	% of species	Percentage change in number of native species

4.4 Prosperity

4.4.1 Employment

Table 11

Indicator title	Indicator unit	Definition
Unemployment rate	% of people	Percentage of the labour force unemployed
Youth unemployment rate	% of people	Percentage of youth labour force unemployed

4.4.2 Equity

Table 12

Indicator title	Indicator unit	Definition
Fuel poverty	% of households	The percentage of households unable to afford the most basic levels of energy
Affordability of housing	% of people	% of population living in affordable housing

4.4.3 Green economy

Table 13

Indicator title	Indicator unit	Definition
Share of certified companies	% of companies	Share of companies based in the city holding an ISO 14001 [i.10] certificate
Share of Green Public Procurement	% in M euros	Percentage annual procurement using environmental criteria as share of total annual procurement of the city administration
Green jobs	% of jobs	Share of jobs related to environmental service activities that contribute substantially to preserving or restoring environmental quality
Freight movement	#	Freight movement is defined as the number of freight vehicles moving into an area (e.g. the city)

4.4.4 Economic performance

Table 14

Indicator title	Indicator unit	Definition
Gross Domestic Product	€/cap	City's gross domestic product per capita
New business registered	#/100 000	Number of new businesses per 100 000 population
Median disposable income	€/household	Median disposable annual household income

4.4.5 Innovation

Table 15

Indicator title	Indicator unit	Definition
Creative industry	% of people	Share of people working in creative industries
Innovation hubs in the city	#/100 000	# of innovation hubs in the city, whether private or public, per 100 000 inhabitants
Accessibility of open data sets	# stars	The extent to which the open city data are easy to use
Research intensity	% in euros	R&D expenditure as percentage of city's GDP
Open data	#/100 000	# of open government datasets per 100 000 inhabitants

4.4.6 Attractiveness and competitiveness

Table 16

Indicator title	Indicator unit	Definition
Congestion	% in hours	Increase in overall travel times when compared to free flow situation (uncongested situation
Public transport use	#/cap/year	Annual number of public transport trips per capita
Net migration	#/1000	Rate of population change due to migration per 1 000 inhabitants
Population Dependency Ratio	#/100	Number of economically dependent persons (net consumers) per 100 economically active persons (net producers)
International Events Hold	#/100 000	The number of international events per 100 000 inhabitants
Tourism intensity	nights/100 000	Number of tourist nights per year per 100 000 inhabitants

4.5 Governance

4.5.1 Organization

Table 17

Indicator title	Indicator unit	Definition
Cross-departmental integration	Likert	The extent to which administrative departments contribute to "smart city" initiatives and management
Establishment within the administration	Likert	The extent to which the smart city strategy has been assigned to one department/director and staff resources have been allocated
Monitoring and evaluation	Likert	The extent to which the progress towards a smart city and compliance with requirements is being monitored and reported
Availability of government data	Likert	The extent to which government information is published

4.5.2 Community involvement

Table 18

Indicator title	Indicator unit	Definition
Citizen participation	% of projects	The number of projects in which citizens actively participated as a percentage of the total projects executed
Open public participation	#/100 000	Number of public participation processes per 100 000 per year
Voter participation	% of people	% of people that voted in the last municipal election as share of total population eligible to vote

4.5.3 Multilevel governance

Table 19

Indicator title	Indicator unit	Definition
Strategies and policies		
Smart city policy	Likert	The extent to which the city has a supportive smart city policy
Budget		
Expenditures by the municipality for a transition towards a smart city	€/capita	Annual expenditures by the municipality for a transition towards a smart city
Multilevel		
Multilevel government	Likert	The extent to which the city cooperates with other authorities from different levels

4.6 Conclusions

Based on the inventory of indicators from 43 existing indicator frameworks, a set of indicators for assessing smart city performance has been designed for ICT users. The majority of indicators in the set are derived from existing urban indicator frameworks.

The majority of these indicators concern energy use, emissions from CO_2 and air pollutants, and waste generation, with some possibilities in the people and prosperity themes. The resulting indicator selection responds to the wishes of cities and citizens for the coverage of their priorities and reflects city goals. The ICT users indicator set, described in the present document, focuses on impact indicators as these can be used for all types of interventions. A number of generalized input, output and outcome indicators have been added that reflect the degree of smartness of a city.

Annex A (informative): Description of the city indicators

A.1 People

A.1.1 Health

Table A.1

Access to basic health care services	
Description incl. justification	Since good health is the foundation for all other aspects of life, an good access to health is essential for the general well-being and functioning of the society. Health care access - as measured by the ease and timeliness with which people obtain medical services - is a key indicator of quality of care. Basic health care service consists of a minimum degree of health care considered to be necessary to maintain adequate health and protection from disease and includes: • General practitioners. • Hospitals, including emergency and chronic treatments. • Baby/youth clinics. • Pharmacies. Accessibility includes e.g. to physical distance (< 500 m), 24 hours availability, e-health services, overcoming literacy and language barriers.
Definition	Share of population with access to basic health care services within 500 m.
Calculation	(population with access to basic health care services < 500 m / total population) × 100.
Strengths and weaknesses	**Strengths:** The indicator provides an absolute measure for the ease of access of public transportation. **Weaknesses:** In order to truthfully measure the accessibility of basic health care facilities, measuring only the physical dimension of accessibility is not sufficient. The social (affordability of such services) and cultural barriers would have to be measured as well, if the 'full picture' is to be shown.
Data requirements	
Expected data source	It might be possible to use city software and perform the exercise with the help of a computer. One could also obtain a map of the area, point the health care facilities, draw circles around them and use city resident information (available in city administrative documents) to analyse which buildings outside this area are houses and how many people are registered to them.
Expected availability	The required information should be easily available with the above sources.
Collection interval	Yearly.
Expected reliability	Depending on the methods of data collection and required resolution.
Expected accessibility	Information on the location of health care facilities is open information.

A.1.2 Safety

Table A.2

Traffic accidents	
Description incl. justification	Traffic accident rates and, specifically, fatality rates, can serve as indicators for the overall safety of the transportation system, the complexity and congestion of the roadway and transport network, the amount and effectiveness of traffic law enforcement, the quality of the transportation fleet (public and private), and the condition of the roads themselves (ISO 37120:2018 [4]). Traffic deaths represent the most severe type of traffic safety failure, allowing cities to focus on their most urgent traffic safety needs. This indicator includes deaths due to any transportation-related proximate causes in any mode of travel (automobile, public transport, walking, bicycling, etc.): any death directly related to a transportation incident, even if death does not occur at the site of the incident, but is directly attributable to the accident. This indicator is particularly urgent in Central-Eastern European countries, where improvements in traffic infrastructures have not kept up with the rapidly growing traffic density. Transportation fatalities are used here as a proxy for all transportation injuries. Whereas many minor injuries are never reported-and thus cannot be measured- deaths are almost always reported. It is also worth noting that differences in the quality of the roadway, the quality of motorized vehicles, and the nature of law enforcement can change the relationship between injury and fatality. Cities and countries may have different definitions of causality, specifically related to the amount of time that can elapse between a traffic incident and a death.
Definition	Number of transportation fatalities per 100 000 population.
Calculation	This indicator may be calculated as the number of fatalities related to transportation of any kind (numerator), divided by one 100 000th of the city's total population (denominator). The result may be expressed as the number of transportation fatalities per 100 000 population. The city may include in this indicator deaths due to any transportation-related proximate causes in any mode of travel (automobile, public transport, walking, bicycling, etc.). The city may count any death directly related to a transportation incident within city limits, even if death does not occur at the site of the incident, but is directly attributable to the accident.
Strengths and weaknesses	**Strengths:** This indicator is expressed as an absolute and objective value. **Weaknesses:** Traffic accidents with minor injuries or only material damage are not taken into account.
Data requirements	
Expected data source	City statistics bureau, municipal traffic department and police office. The urban audit database also contains information on the number of deaths in road accidents.
Expected availability	It is expected that this information is readily available in the above sources.
Collection interval	Yearly.
Expected reliability	The indicator is common and clearly defined and the data should be reliable.
Expected accessibility	No sensitivities expected.

A.1.3 Access to (other) services

Table A.3

Access to public transport	
Description incl. justification	It is presumed that availability of alternatives to cars will lead to less car use, thereby contributing to an accessible, green and healthy neighbourhood and moreover contributes to European policy goals for sustainable mobility and transport development. The quality, accessibility and reliability of transport services will also gain increasing importance in the coming years, inter alia due to the ageing of the population. While walking and cycling are alternative modes of transport for short distances, public transport connections are needed for longer trips. Providing access to public transport is an important means to promote its use. This indicator describes the percentage of population with nearby access to a public transport stop or connection, including all modes of public transport; train, tram, subway, bus, etc.
Definition	Share of population with access to a public transport stop within 500 m.
Calculation	(Number of inhabitants with a transportation stop < 500 m / total population) × 100 %. See note.
Strengths and weaknesses	**Strengths:** The indicator provides an absolute measure for the ease of access of public transportation. **Weaknesses:** Considering purely the geographical catchment areas as absolute measure, may exclude other important information with regards to (the quality of) mobility (e.g. attractive frequencies, comfort, reliability of services, and intermodal integration are the main characteristics of service quality). Access to sustainable modes of transport does not necessarily guarantee use. Transport mode choices have been linked to other factors besides accessibility, including perceptions of convenience, practicality, safety, comfort, individuality and cost (1). By looking singularly at the residential location of inhabitants as the source for % calculation, only the source location of movement is being taken into account, but not the main destinations. Thus the outcome may contain distortions in regards to the true situation concerning the accessibility of public transport.
Data requirements	
Expected data source	It might be possible to use city software and perform the exercise with the help of a computer. One could also obtain a map of the area, point the transportation stops (available at the public transport utilities), draw circles around them and use city resident information (available in city administrative documents) to analyse which buildings outside this area are houses and how many people are registered to them.
Expected availability	The information on location of transportation stops and dwellings should be easily available with the above sources.
Collection interval	Yearly.
Expected reliability	Depending on the methods of data collection and required resolution.
Expected accessibility	The information on location of transportation stops and dwellings is public information.
NOTE: It is calculated as the sum of buildings with a point of access within 500 m, multiplied by its inhabitants. A point of access is defined as the location where a mode of transportation can be accessed.	

A.1.4 Education

Table A.4

Access to educational resources	
Description incl. justification	Education and training is critical to enhance human creativity and social quality and to prevent social exclusion. Next to traditional education, i.e. primary, secondary and tertiary educational facilities, this indicator also emphasizes the importance of life-long learning. 'Lifelong learning' is the "ongoing, voluntary, and self-motivated" pursuit of knowledge for either personal or professional reasons. Therefore, it not only enhances social inclusion, active citizenship, and personal development, but also self-sustainability, rather than competitiveness and employability. In addition, the number of years of education is strongly associated with the health of populations in both developed and developing countries. This indicator analyses the effort made by the city to provide access for all to adequate and affordable educational services. This access includes: physical access to educational institutions, e.g. schools, universities, libraries (number and distance), and digital access (e-learning) to education resources (e.g. open, well-documented and well-indexed).
Definition	The extent to which the city provides easy access (either physically or digitally) to a wide coverage of educational resources.
Calculation	Likert scale: Not at all - 1 - 2 - 3 - 4 - 5 - very much: 1) Not at all: There are not enough basic educational amenities (schools, universities) in the city to provide easy access to or decent quality of education for the citizens. 2) Poor: The citizens have decent access to basic education (schools, universities) but the provision of additional educational resources (e.g. libraries) for (life-long) learning is poor. 3) Somewhat: The access to basic education is good and additional free educational resources are available for all through libraries and online services. 4) Good: Easy access to basic education and good coverage free educational resources for all enabling lifelong learning. 5) Excellent: Wide variety of educational resources available with easy access offline (schools, libraries, universities, museums) and online (e.g. Massive Open Online Courses); most of them provided freely to all with special attention to possibilities for lifelong learning.
Strengths and weaknesses	**Strengths:** Not applicable. **Weaknesses:** although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present. 'Educational resources' is a broad concept and can be interpreted differently.
Data requirements	
Expected data source	City administration, department on education. Many cities have open data on schools, universities and/or libraries.
Expected availability	Although some basic information such as the number of schools/100 000 inhabitants will probably be available, it remains to be seen whether the level of detail needed to fill out a score on this indicator is available.
Collection interval	Yearly.
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100 % reliable.
Expected accessibility	No sensitivities expected.

A.1.5 Diversity and social cohesion

No indicators identified at city level.

A.2 Planet

A.2.1 Energy and mitigation

Table A.5

Annual final energy consumption	
Description incl. justification	Reduced and effective energy use can create substantial savings and can enhance security of the energy supply. Reducing the energy consumption also reduces greenhouse gas emissions and the ecological footprint, which contribute to combating climate change and achieve a low carbon economy. (ISO 37120:2018 [4]). This indicator may assess the final energy consumption of the city taking into account all forms of energy (e.g. electricity, gas, fuels) and for all functions (transport, buildings, ICT, industry, etc.). The final energy consumption is the energy actually consumed by the end-user. This in contrast with primary energy use, the energy forms found in nature (e.g. coal, oil and gas) which have to be converted (with subsequent losses) to useable forms of energy, a more common indicator for evaluating energy consumption. When moving towards a renewable energy system, however, measuring the primary energy consumption loses its value. A reduction in primary energy consumption, for example, by increasing the production of renewable energy, does not directly lead to a reduction in final energy consumption.
Definition	Annual final energy consumption for all uses and forms of energy.
Calculation	Energy consumption may be calculated per year as the total use of final energy (MWh) within a city (numerator) divided by the amount of residents in city (denominator). The result indicates the total energy consumption per year in megawatt hours per capita. To facilitate the calculation of the total energy consumption, the indicator can be broken down into energy consumption of various sectors: buildings, transport, industry, public services, ICT, etc. This can, of course, be further subdivided, for example, for 'buildings', in residential buildings, commercial buildings and public buildings, or for 'transport' in public and private transport. All forms of energy need to be taken into account, including electricity consumption, natural gas or thermal energy for heating and cooling and fuels. These will be given in different units of energy (kWh, GJ, m3), but they all have to be calculated or converted to MWh of energy in order to be able to sum up the separately calculated energy consumptions and achieve the total energy consumption of the city. Relevant unit conversions are 1 W = 1 kg m2 s-3; 1 J = 1 Ws; 1 kWh= 3 600 000 J; and 1 TOE = 41,868 GJ, 11,630 kWh, or 11,63 MWh (Recommendation ITU-T L.1430 [2]). See note.
Strengths and weaknesses	**Strengths:** • High relevance with regard to policy aims. **Weaknesses:** • Data is scattered and has to be translated into one value. • The reliability of data for the different kinds of energy consumption varies. While in some cases the data is highly reliable (e.g. monitoring equipment of a building), in others this is not the case (e.g. estimations in transport sector). • The consideration of the energy consumption of buildings should take into account the fact that values of energy consumption take some years to settle down to normal operational level after the renovation. Thus calculation after the first year of operation does not provide objective data. Residential building consumption: As total energy consumption may vary considerably per household (or per user of the building) in some cases this indicator may be restricted to energy for heating, cooling, and hot water provision. These data can be more easily gathered, also in a planning stage. • For some uses (e.g. transport) there are only indirect ways to collect data for indicator calculation. Thus the data acquired and calculated are only estimations.

Data requirements	
Expected data source	Data has to be collected from many different sources: • Buildings (public, residential, commercial). • Transport (public, private). • Industry. • ICT.
Expected availability	Depending on the local situation and the type of energy consumed.
Collection interval	Yearly.
Expected reliability	The reliability varies depending on the kind of energy consumed.
Expected accessibility	Depends on the sources from which the information has to be gathered.
NOTE: All calculations need to be thoroughly recorded for transparency.	

A.2.2 Materials, water, land

Table A.6

Domestic material consumption	
Description incl. justification	The consumption of materials and resources has an impact on the environment and might contribute to depletion of resources. It is therefore beneficial to decrease the consumption as well as the consequent impacts. In this sense, the selective sorting can also be applied to materials: reduce materials consumption, use recycled materials (and make sure the materials used are recyclable again) and use renewable materials. This indicator targets the first step in this logic. The indicator 'Domestic Material Consumption' (DMC) considers the domestic material extraction (i.e. the amount of raw material extracted from the natural environment, except for water and air), including both imports (added) and exports (deducted) through their simple product weight when crossing the city limits. This makes cross-city comparisons 'asymmetric'. A city with almost no domestic extraction and importing all necessary resources indirectly in the form of mainly finished products will have a much lower DMC compared to a resource rich city.
Definition	The total amount of material directly used in the city per capita.
Calculation	Domestic Material Consumption (DMC) equals Direct Material Input (DMI) minus exports. DMI measures the direct input of materials for the use in the economy. DMI equals Domestic Extraction (DE) plus imports.
Strengths and weaknesses	**Strengths:** Improvement in resource consumption has also indirect effect by saving environmental and economic impacts. Saving the amount of natural raw-materials needed for the project implementations, saves also consequent material manufacturing processes with used energy resources and consequent emissions. **Weaknesses:** The meaning of the weight of materials, however, can be debated, since it does not say anything about the required quality for the function. Materials for different functions require different characteristics (density, elasticity, etc.). Also, renewable materials are, in general, lighter than non-renewable materials. However, efforts to decrease the use of materials are beneficial from all perspectives. Data availability (see below).
Data requirements	
Expected data source	This indicator requires a detailed material flow analysis on the city level, as the required data is usually not immediately available on the city level.
Expected availability	Very low.
Collection interval	Ad hoc.
Expected reliability	Depends.
Expected accessibility	Depends.

Water consumption	
Description incl. justification	Water consumption should be in harmony with water resources to be sustainable (ISO 37120:2018 [4]). This harmony may be achieved through improvements in water supply systems and changes in water consumption patterns. The main driver for water consumption indicator is the increased concern of water scarcity and decreased water quality. Water management and supply of safe drinking water have become a global issue. Due to changes in the climate, there has been an increase of either extreme dry and warm seasons in some countries or rainy seasons connected with floods in other areas. Water scarcity varies greatly between countries, even between regions inside the country. This indicator will need to be measured in terms of changes from year to year within a city within a range of rates due to the variability among cities.
Definition	Total water consumption per capita per day.
Calculation	The indicator may be calculated as the total amount of the city's water consumption in litres per day (numerator) divided by the total city population (denominator). The result may be expressed as the total water consumption per capita in litres/days.
Strengths and weaknesses	**Strengths:** Good availability of information and accuracy of information. Indicates the progress in the increased use of water saving equipment and changes in user behaviour. **Weaknesses:** The difference between the total use of surface and groundwater in the municipality and the volume of water released into the distribution network is caused by use of water by households and other actors not linked to the municipal water supply system.
Data requirements	
Expected data source	This information should be obtained from the main water supply companies, which maintain record on water supplied, delivered, consumed and ultimately paid by the end-users. The urban audit database also contains information on the 'Total use of water'.
Expected availability	Good.
Reporting interval	Yearly.
Expected reliability	High.
Expected accessibility	Dependent on local supply companies.

Table A.7

Grey and rain water use	
Description incl. justification	Water consumption should be in harmony with water resources to be sustainable (ISO 37120:2018 [4]). Re-using grey water and rain water lowers the demand for tap water and improves the balance of the water system. Greywater is **wastewater** generated in households or office buildings from sources such as water basins, **showers, baths,** clothes **washing machines** or dish washers (streams except for the wastewater from toilets). Grey water and rain water use may be an important aid to significantly decrease the domestic water consumption. The published literatures indicate that the typical volume of grey water varies from 90 to 120 l/p/d depending on lifestyles, living standards and other issues.
Definition	Percentage of houses equipped to reuse grey and rain water.
Calculation	
Strengths and weaknesses	**Strengths:** Not applicable. **Weaknesses:** Limited availability of information. The indicator is overlapping with domestic water consumption indicator. While grey water from baths, showers and basins is usually clean enough for flushing toilets, there are concerns about the increase of bacteria levels when nutrient rich waste water is left untreated for a period of time.
Data requirements	
Expected data source	Records of building permission authorities or surveys among households.
Expected availability	Limited. Collection of information may be time consuming.
Collection interval	Annual.
Expected reliability	The coverage of information may be limited if greywater systems are installed also without building permission.
Expected accessibility	No sensitivities expected.

Table A.8

Water exploitation index	
Description incl. justification	Water consumption should be in harmony with water resources to be sustainable (ISO 37120:2018 [4]). The earth's freshwater resources are subject to increasing pressure in the form of consumptive water use and pollution. The Water Exploitation Index (WEI) compares the volumes of water consumption to available resources.
Definition	Annual total water abstraction as a percentage of available long-term freshwater resources in the geographically relevant area (basin) from which the city gets its water.
Calculation	(Volume of water abstraction in the geographically relevant area/volume of long term freshwater resources in the geographically relevant area) × 100 % (EEA).
Strengths and weaknesses	**Strengths:** The indicator takes into account the sustainability aspect by considering not only the consumption but also the water resources. **Weaknesses:** Of limited relevance for cities, as the indicator considers a wider geographical area. Although local focus is important, it also limits the understanding about the comprehensive impact on water footprint. The 'geographically relevant area' is a vague concept and can be applied differently.
Data requirements	
Expected data source	Water abstraction: Records of water supply companies on water abstraction (groundwater, surface water) and city documents on water abstraction permits. Water resources: Local water boards and the municipal environment department.
Expected availability	Probably good, but dependent on local situation.
Collection interval	Yearly.
Expected reliability	High.
Expected accessibility	The city or region probably has to grant permission to abstract water, making abstraction volumes known and accessible.

Table A.9

Water loss	
Description incl. justification	Water consumption should be in harmony with water resources to be sustainable. Before reaching the users, a part of the water supplied might be lost through leakage or illegal tapping (ISO 37120:2018 [4]). In cities with old and deteriorating water reticulation systems, a substantial proportion of piped water may be lost through cracks and flaws in pipes - for example, up to 30 % of water is lost in this way in some countries in Eastern Europe. The percentage of water loss (unaccounted for water) represents the percentage of water that is lost from treated water entering distribution system and that is accounted for and billed by the water provider. This includes actual water losses, e.g. leaking pipes, and billing losses, e.g. delivered through informal or illegal connection.
Definition	Percentage of water loss of the total water consumption.
Calculation	This indicator may be calculated as the volume of water supplied minus the volume of customer billed water (numerator) divided by the total volume of water supplied (denominator). The result may then be multiplied by 100 and expressed as a percentage.
Strengths and weaknesses	**Strengths:** High relevance with regards to policy aims. **Weaknesses:** There are different kinds of losses. Apparent losses are produced by metering, human and management errors, and lead to consumption of water without charging. On the other hand, real losses include wasted water and can be categorized to pipe system leakage (reported and unreported bursts, and background.
Data requirements	
Expected data source	Data should be obtained from water utilities servicing the city.
Expected availability	Good.
Collection interval	Yearly.
Expected reliability	
Expected accessibility	Good, no sensitivities expected.

Population density	
Description incl. justification	Population density is an indicator usually associated with several aspects of sustainable urban development, such as the efficient operation of urban infrastructures, the share of green transport modes, street life, and soil sealing: • Efficient urban infrastructures: The higher the population density is, the easier it is to operate the public transport, but also water, communication and energy infrastructures at low cost. • There is strong statistical evidence for a positive correlation between population density and the share of green transport modes public transport, walking and biking. • Also, a higher urban population is sometimes associated with lively urban streets. • Also, a high population density reduces the footprint of urban development and prevents the development of farm land and natural areas.
Definition	Number of people per km².
Calculation	Population density is calculated as the ratio of number of inhabitants (numerator) divided by the overall area of the city (km²) (denominator).
Strengths and weaknesses	**Strengths:** • Absolute and objective indicator. • Easy to calculate. **Weaknesses:** • Limited comparability among European cities due to different traditions for metropolitan governance. • No direct link with smartness or sustainability.
Data requirements	
Expected data source	City statistics.
Expected availability	Good.
Collection interval	Every year (city records).
Expected reliability	High.
Expected accessibility	Good.

Table A.10

Local food production	
Description incl. justification	Local food production increases self-reliant and resilient food networks, enhances local economies by connecting food producers and food consumers in the same geographic region. It can reduce the carbon footprint of the urban areas by reducing energy demand of transport, stimulate the local economy, and improve citizen participation and social cohesion in the city, and stimulate the local economy.
Definition	Share of food consumption produced within a radius of 100 km.
Calculation	(Food produced in 100 km radius (tons) / Total food demand within city (tons)) × 100.
Strengths and weaknesses	**Strengths:** Indicator is a good measure for density/quantity of local producing entities and gives therefore a good overview about regions with possible self-sufficiency options. **Weaknesses:** Comparable data on the agricultural yield is only available at the NUTS2 level. The indicator therefore requires significant disaggregation of data.
Data requirements	
Expected data source	Food consumption: The yearly intake in Europe was 770 kg per person in 2000. The food demand can then be calculated by multiplying the number of citizens with 770 kg. Food production: Crop statistics and animal populations at NUTS2 level.
Expected availability	Comparable data on the agricultural yield is only available at the NUTS2 - level.
Collection interval	Yearly.
Expected reliability	Low, as NUTS2 data has to be disaggregated.
Expected accessibility	Good.

Table A.11

Brownfield redevelopment	
Description incl. justification	Brownfield is a term used in urban planning to describe "land which is or was occupied by a permanent structure, including the curtilage of the developed land and any associated fixed surface infrastructure". Many brownfields are contaminated as a result of previous industrial or commercial uses. The European Environment Agency (EEA) has estimated that there are as many as three million brownfield sites across Europe, often located and well connected within urban boundaries and as such offering a competitive alternative to greenfield investments. Brownfield remediation and regeneration represents a valuable opportunity, not only to prevent the loss of pristine countryside and reduce ground sealing, but also to enhance urban spaces and remediate the sometimes contaminated soils.
Definition	Share of brownfield area that has been redeveloped in the past period as percentage of total brownfield area.
Calculation	The indicator "brownfield redevelopment" is calculated as the brownfield area redeveloped in the last year (km^2) (numerator) divided by the total brownfield area in the city (km^2) (denominator). The result may then be multiplied by 100 and expressed as a percentage. See note.
Strengths and weaknesses	**Strengths:** • High relevance with regard to policy aims. • Easy to calculate. **Weaknesses:** • Limited comparability of data across European cities, as the understanding of the term "brownfield" may differ. • Not all cities might have brownfield space to redevelop.
Data requirements	
Expected data source	City statistics.
Expected availability	Highly different: Not all cities collect this data in a systematic way.
Collection interval	Highly different: Not all cities collect this data in a systematic way.
Expected reliability	Depending on the quality of the collected data.
Expected accessibility	Access is very often restricted to employees of the city administration/urban planning department.
NOTE: Database entries, SHP files can be used.	

A.2.3 Climate resilience

Table A.12

Climate resilience strategy	
Description incl. justification	Urban areas in Europe and worldwide are increasingly experiencing the pressures arising from climate change and are projected to face aggravated climate-related impacts in the future. Cities and towns play a significant role in the adaptation to climate change in the EU, which has been recognized by the EU Strategy on adaptation to climate change. Several cities and towns across Europe are already pioneering adaptation action and many others are taking first steps to ensure that European cities remain safe, liveable and attractive centres for innovation, economic activities, culture and social life. This indicator assesses to what extent the city has a resilience strategy and action plan.
Definition	The extent to which the city has developed and implemented a climate resilience strategy.
Calculation	The indicator provides a qualitative measure and is rated on a seven -point Likert scale. This Likert scale is based on the steps suggested by the "Mayors adapt" initiative for climate change adaptation in urban areas. No action taken - 1 - 2 - 3 - 4 - 5 - 6 - 7 - implementation, monitoring and evaluation on the way: 1) No action has been taken yet. 2) The ground for adaptation has been prepared (the basis for a successful adaptation process). 3) Risks and vulnerabilities have been assessed. 4) Adaptation options have been identified. 5) Adaptation options have been selected. 6) Adaptation options are being implemented. 7) Monitoring and evaluation is being carried out.
Strengths and weaknesses	**Strengths:** Not applicable. **Weaknesses:** The number of cities involved in the Mayors Adapt Initiative is rather limited. Therefore, the steps described in the documents of the initiative may not be familiar for many city stakeholders.
Data requirements	
Expected data source	Environmental/sustainability/climate department/service.
Expected availability	Good.
Collection interval	Yearly.
Expected reliability	Moderate, as the rating will be subjective.
Expected accessibility	Good.

Table A.13

Urban heat island	
Description incl. justification	Urban areas in Europe and worldwide are increasingly experiencing the pressures arising from climate change and are projected to face aggravated climate-related impacts in the future. Cities and towns play a significant role in the adaptation to climate change in the EU, which has been recognized by the EU Strategy on adaptation to climate change. This indicator focuses on the urban heat island (UHI) effect, the difference in air temperature between the city and its surroundings. The UHI effect is caused by the absorption of sunlight by (stony) materials, the lack of evaporation and the emission of heat caused by human activities. The effect is at its highest point after sunset and can reach up to 9 °C in e.g. Rotterdam. Due to the UHI effect, urban areas experience more heat stress than the countryside.
Definition	Maximum difference in air temperature within the city compared to the countryside during the summer months.
Calculation	Whether there is one or several measurement stations in the built environment, compare the air temperature measurements of these stations with a station outside the city which functions as a reference station, and look for the largest temperature difference (hourly average) during the summer months.
Strengths and weaknesses	**Strengths:** This indicator provides an absolute measure of the problem a city has with regards to heat stress. **Weaknesses:** Data/measurements may not be available.
Data requirements	
Expected data source	Operators of weather stations within the city and outside (e.g. meteorological institute, research organizations, weather amateurs).
Expected availability	Dependent on situation, not all cities will have air temperature measurements.
Collection interval	Yearly.
Expected reliability	If measurement stations are available the information will be highly reliable (little less with regards to weather amateurs).
Expected accessibility	No sensitivities expected.

A.2.4 Pollution and waste

Table A.14

Nitrogen dioxide emissions (NO_2)	
Description incl. justification	Improving the air quality in urban areas has been identified by the European Innovation Partnership on Smart Cities and Communities (EIP SCC) as one of the main challenges in the vertical priority area of Sustainable Urban Mobility. NO_2 (nitrogen dioxide) is a major air pollutant, which can have significant impacts on human health and the environment (ISO 37120:2018 [4]). NO_2 contributes to the formation of photochemical smog and at raised levels can increase the likelihood of respiratory problems. Nitrogen dioxide inflames the lining of the lungs, and it can reduce immunity to lung infections. This can cause problems such as wheezing, coughing, colds, flu and bronchitis. Increased levels of nitrogen dioxide can have significant impacts on people with asthma because it can cause more frequent and more intense attacks. NO_2 chemically transforms into nitric acid and contributes to acid rain. Nitric acid can corrode metals, fade fabrics, and degrade rubber. When deposited, it can also contribute to lake acidification and can damage trees and crops, resulting in substantial losses. Nitrogen dioxide is part of the exhaust gases of motor vehicles, but also emanates from other combustion processes, related e.g. to domestic heating and industrial processes.
Definition	Annual nitrogen dioxide emissions per capita.
Calculation	$\left(\frac{\mathbf{NOx\ emissions\ (g)}}{\mathbf{population}}\right) = \frac{\mathbf{g}}{\mathbf{cap}} of\ NOx$
Strengths and weaknesses	**Strengths:** Important indicator related to transport. **Weaknesses:** NO_2 emissions are directly related to energy use, especially in the transport sector. Double counting with the energy indicators occurs.
Data requirements	
Expected data source	Environmental department/service; City emission registration. Hourly average concentrations are measured by monitoring equipment and reported to Air Quality monitoring authority (i.e. City Environment Office, National Environment Office, etc.). NO_2 emissions can be derived from energy use if not directly available. The level of NO_2 emissions are varying depending mainly on the energy generation technology and type of fuel. The urban audit database also contains information on the 'number of hours nitrogen dioxide NO_2 concentrations exceed 200 µg/m^3' and the 'annual average concentration of NO_2 (µg/m^3)'.
Expected availability	Good. Many cities maintain an emission register; however the information might require further processing of data or database.
Collection interval	Annually.
Expected reliability	Emission factors may change from country to country. If results can be based on actual energy/NO_x performance and not ex-ante estimations of how the energy balance is expected change, then the results are very reliable. If based on expectations, the results are somewhat reliable.
Expected accessibility	No sensitivities expected.

Table A.15

Fine particulate matter emissions (PM 2,5)	
Description incl. justification	Improving the air quality in urban areas has been identified by the European Innovation Partnership on Smart Cities and Communities (EIP SCC) as one of the main challenges in the vertical priority area of Sustainable Urban Mobility. Fine particulate matter can cause major health problems in cities. According to the WHO, any concentration of Particulate Matter (PM) is harmful to human health. PM is carcinogenic and harms the circulatory system as well as the respiratory system. As with many other air pollutants, there is a connection with questions of environmental justice, since often underprivileged citizens may suffer from stronger exposure. The evidence on PM and its public health impact is consistent in showing adverse health effects at exposures that are currently experienced by urban populations in both developed and developing countries. The range of health effects is broad, but are predominantly to the respiratory and cardiovascular systems (ISO 37120:2018 [4]).
Definition	Annual particulate matter emissions (PM 2,5) per capita.
Calculation	The unit for this indicator should for the city level be grams per capita: $\left(\frac{\mathbf{PM2,5\ emissions\ (g)}}{\mathbf{population}}\right) = \frac{\mathbf{g}}{\mathbf{cap}} of\ PM2,5$
Strengths and weaknesses	**Strengths:** Not applicable. **Weaknesses:** Not applicable.
Data requirements	
Expected data source	Concentrations are measured by monitoring equipment and reported to Air Quality monitoring authority (i.e. City Environment Office, National Environment Office, etc.). The urban audit database contains information on the number of days particulate matter PM 10 and PM 2,5 concentrations exceed 50 µg/m^3' and the 'annual average concentration of PM10 (µg/m^3)'.
Expected availability	Since a standard is to be met amongst there is most likely data from either measurements or modelling calculations. Many cities maintain an emission register; however the information might require further processing of data or database.
Collection interval	Annually.
Expected reliability	Emission factors may change from country to country. If results can be based on actual performance and not ex-ante estimations of how the energy balance is expected change, then the results are very reliable. If based on expectations, the results are somewhat reliable.
Expected accessibility	No sensitivities expected.

Table A.16

<table>
<tr><td colspan="2">Air quality index</td></tr>
<tr><td>Description incl. justification</td><td>Improving the air quality in urban areas has been identified by the European Innovation Partnership on Smart Cities and Communities (EIP SCC) as one of the main challenges in the vertical priority area of Sustainable Urban Mobility.
Air quality is expressed in the concentration of major air pollutants. At this moment from a human health perspective most important are particulates (PM 10, PM 2,5), NO_2 (as indicator of traffic related air pollution) and ozone (important for summer smog). The concentration levels of these pollutants together define the air quality.
For the EU, the CiteAir project has defined hourly, daily and yearly indices to express in one figure air quality.
For this indicator, the year average air quality index should be used. It is a distance to target indicator that provides a relative measure of the annual average air quality in relation to the European limit values (annual air quality standards and objectives from EU directives). If the index is higher than 1: for one or more pollutants the limit values are not met. If the index is below 1: on average the limit values are met.</td></tr>
<tr><td>Definition</td><td>Annual concentration of relevant air pollutants.</td></tr>
<tr><td>Calculation</td><td>For each pollutant a subindex is calculated according to the scheme below:
<table>
<tr><th>Pollutant</th><th>Target value/limit value</th><th>Subindex calculation</th></tr>
<tr><td>NO_2</td><td>Year average is 40 µg/m^3</td><td>Year average/40</td></tr>
<tr><td>PM10</td><td>Year average is 40 µg/m^3</td><td>Year average/40</td></tr>
<tr><td>PM10daily</td><td>Max. number of daily averages above 50 µg/m^3 is 35 days</td><td>Log(number of days+1)/Log(36)</td></tr>
<tr><td>Ozone</td><td>25 days with an 8-hour average value ≥ 120 µg/m^3</td><td># days with 8-hour average ≥ 120/25</td></tr>
<tr><td>SO2</td><td>Year average is 20 µg/m^3</td><td>Year average/20</td></tr>
<tr><td>Benzene</td><td>Year average is 5 µg/m^3</td><td>Year average/5</td></tr>
<tr><td colspan="3">NOTE: CO is not calculated.</td></tr>
</table>
The overall city index is the average of the sub-indices for NO_2, PM10 (both year average and the number of days ≥ 50 µg/m^3 sub-index) and ozone for the city background index. For the traffic year average index the averages of the sub-indices for NO_2 and PM10 (both) are being used. The other pollutants (including PM 2,5) are used in the presentation of the city index if data are available, but do not enter the calculation of the city average index. They are treated as additional pollutants like in the hourly and daily indices. The main reason is that not every city is monitoring this full range of pollutants.
See note.</td></tr>
<tr><td>Strengths and weaknesses</td><td>Strengths: Not applicable.
Weaknesses: Not applicable.</td></tr>
<tr><td colspan="2">Data requirements</td></tr>
<tr><td>Expected data source</td><td>Concentrations are measured by monitoring equipment and reported to Air Quality monitoring authority (i.e. City Environment Office, National Environment Office, etc.). Many cities use a local or national variant of an air quality index, which can replace this indicator (but loosing EU comparability).</td></tr>
<tr><td>Expected availability</td><td>Good. Most pollutants are measured continuously in EU member states.
See http://www.airqualitynow.eu/comparing_home.php.</td></tr>
<tr><td>Collection interval</td><td>Annually.</td></tr>
<tr><td>Expected reliability</td><td>If the data is based on measurements the results are very reliable.</td></tr>
<tr><td>Expected accessibility</td><td>Access may be restricted to employees of the city administration.</td></tr>
<tr><td colspan="2">NOTE: Potential users of the CAQI should notify the CITEAIR partners (at caqi@airqualitynow.eu) and establish a user agreement (http://www.airqualitynow.eu/about_copyright.php). This way, users can be kept informed in case of further developments concerning the index. The use of the CAQI is free of charge for non-commercial purposes.</td></tr>
</table>

Table A.17

Noise pollution	
Description incl. justification	Prolonged exposure to noise can lead to significant health effects, both physical and mental (ISO 37120:2018 [4]). This indicator assesses the number of inhabitants exposed to noise > 55 dB(A) at night time.
Definition	Share of the population affected by noise > 55 dB(a) at night time.
Calculation	$$\left(\frac{\#\ \textbf{inhabitants exposed to noise}\ > \textbf{55 dB(A)}}{\textbf{total number of inhabitants}} \times \textbf{100}\%\right) = \textbf{share of population affetcted by noise}\ [\%]$$ Noise pollution may be calculated by mapping the noise level at night (Ln) likely to cause annoyance as given in ISO 1996-2:1987 [3], identifying the areas of the city where Ln is greater than 55 dB(A) and estimating the population of those areas as a percentage of the total city population. The result may be expressed as the percentage of the population affected by noise pollution. (ISO 37120:2018 [4]).
Strengths and weaknesses	**Strengths:** Not applicable. **Weaknesses:** Difficult to represent spatial variation in one indicator.
Data requirements	
Expected data source	Member countries of the European Union are committed to the reduction of noise pollution to those levels recommended by the WHO by the year of 2020. Member countries might therefore have measurements of noise pollution for at least official areas. Average concentrations are measured by monitoring equipment and reported to Air Quality monitoring authority (i.e. City Environment Office, National Environment Office, etc.)The urban audit database contains information on the 'number of inhabitants exposed to road/rail/air traffic noise > 65 dB(A) at day time/> 55 dB(A) at night time'.
Expected availability	Good.
Collection interval	Yearly.
Expected reliability	If the data is based on measurements the results are very reliable. If based on expectations/calculations, the results are somewhat reliable.
Expected accessibility	Data about noise pollution are to be public amongst member states.

Table A.18

Municipal solid waste	
Description incl. justification	The proper discharge, transportation and treatment of solid waste is one of the most important components of life in a city and one of the first areas in which governments and institutions should focus. Solid waste systems contribute in many ways to public health, the local economy, the environment, and the social understanding and education about the latter. A proper solid waste system can foster recycling practices that maximize the life cycle of landfills and create recycling micro-economies; and it provides alternative sources of energy that help reduce the consumption of electricity and/or petroleum based fuels. This indicator provides a measure of how much waste a city is producing and the level of service a city is providing for its collection (ISO 37120:2018 [4]). Municipal waste may refer to waste collected by or on behalf of municipalities. The data may only refer to the waste flows managed under the responsibility of the local administration including waste collected on behalf of the local authority by private companies or regional associations founded for that purpose. Municipal waste should include waste originating from: • households; • commerce and trade, small businesses, office buildings and institutions (e.g. schools, hospitals, government buildings). The definition should also include: • bulky waste (e.g. white goods, old furniture, mattresses); • garden waste, leaves, grass clippings, street sweepings, the content of litter containers, and market cleansing waste, if managed as waste; • waste from selected municipal services, i.e. waste from park and garden maintenance, waste from street cleaning services (e.g. street sweepings, the content of litter containers, market cleansing waste), if managed as waste. The definition may exclude: • waste from municipal sewage network and treatment; • municipal construction and demolition waste.
Definition	The amount of municipal solid waste generated per capita annually
Calculation	$\left(\frac{\textbf{Annual amount of generated municipal solid waste (t/yr)}}{\textbf{capita}}\right) = \frac{\frac{\textbf{t}}{\textbf{cap}}}{\textbf{yr}}\ \boldsymbol{of\ generated\ municipal\ solid\ waste}$ The total collected municipal solid waste per capita may be expressed as the total municipal solid waste produced in the municipality per person. This indicator may be calculated as the total. amount of solid waste (household and commercial) generated in tonnes (numerator) divided by the total city population (denominator). The result may be expressed as total municipal solid waste collected per capita in tonnes (ISO 37120:2018 [4]).
Strengths and weaknesses	**Strengths:** Clear unit that is easily understandable and measurable. **Weaknesses:** Not applicable.
Data requirements	
Expected data source	EU member countries are estimating their recycling rates and levels of municipal solid waste through measuring and model calculation methods. Environmental department, department responsible for waste collection. The urban audit database contains information on 'municipal waste generated (domestic and commercial)'.
Expected availability	Good.
Collection interval	Annually.
Expected reliability	The data might range from highly reliable to somewhat reliable.
Expected accessibility	Good.

Table A.19

Recycling rate	
Description incl. justification	Many cities generate more solid waste than they can dispose of (ISO 37120:2018 [4]). Even when municipal budgets are adequate for collection, the safe disposal of collected waste often remains a problem. Diverting recyclable materials from the waste stream is one strategy for addressing this municipal issue. Higher levels of municipal waste contribute to greater environmental problems and therefore levels of collection, and also methods of disposal, of municipal solid waste are an important component of municipal environmental management. Solid waste systems contribute in many ways to public health, the local economy, the environment, and the social understanding and education about the latter. A proper solid waste system can foster recycling practices that maximize the life cycle of landfills and create recycling micro-economies; and it provides alternative sources of energy that help reduce the consumption of electricity and/or petroleum based fuels.
Definition	Percentage of city's solid waste that is recycled.
Calculation	The percentage of city's solid waste that is recycled may be calculated as the total amount of the city's solid waste that is recycled in tonnes (numerator) divided by the total amount of solid waste produced in the city in tonnes (denominator). The result may then be multiplied by 100 and expressed as a percentage (ISO 37120:2018 [4]). Recycled materials may denote those materials diverted from the waste stream, recovered, and processed into new products following local government permits and regulations (International Solid Waste Association, ISWA). Hazardous waste that is produced in the city and is recycled may be reported separately.
Strengths and weaknesses	**Strengths:** Clear unit that is easily understandable and measurable. **Weaknesses:** Not applicable.
Data requirement	
Expected data source	This information should be obtained from municipal bodies, public services and major private contractors dealing with solid waste collection and disposal. Data may be obtained from specific studies carried out on solid waste for specific projects. Information on selected disposal methods should be gathered from municipal facilities and operators, parastatal and private companies dealing with solid waste treatment. Solid waste experts, as well as NGOs working in this area, may be consulted.
Expected availability	Good.
Collection interval	Annually.
Expected reliability	The data might range from highly reliable to somewhat reliable.
Expected accessibility	Good.

A.2.5 Ecosystem

Table A.20

Share of green and blue spaces	
Description incl. justification	Green and water spaces are regarded as an index representing the degree of the nature conservation and improving the public health and quality of life as they are directly related to the natural water circulation, environmental purification and the green network. More green and blue also reduces vulnerability to extreme weather events like urban heat islands and flooding by heavy rainfall. This indicator reflects the ratio of green and water space area from total city land area. Green areas are forest and park areas that are partly or completely covered with grass, trees, shrubs, or other vegetation. Water areas here meaning lakes, ponds, rivers.
Definition	Share of green and water surface area as percentage of total land area
Calculation	$\left(\frac{\mathbf{Water\ area}\ [\mathbf{km^2}] + \mathbf{Green\ space\ area}\ [\mathbf{km^2}]}{\mathbf{Total\ land\ area}\ [\mathbf{km^2}]}\mathbf{x\ 100}\right) = \mathbf{Share\ of\ Green\ and\ blue\ spaces}\ [\%]$
Strengths and weaknesses	**Strengths:** Not applicable. **Weaknesses:** Not applicable.
Data requirements	
Expected data source	Data can be retrieved from the urban planning and environment department of the city. The urban audit database contains information on 'water and wetland', 'green space area (km^2)' and total land area according to cadastral register)'. The surface area can also be estimated using a map of the city.
Expected availability	Good.
Collection interval	Yearly.
Expected reliability	Good.
Expected accessibility	Public information.
References	
European Commission (2012): Methodological Manual on City Statistics [i.6]. European Environment Agency Urban Atlas [i.7].	

Table A.21

Native species	
Description incl. justification	Urbanization affects biodiversity through urban sprawl/habitat fragmentation, loss of fertile agricultural lands, and spread of invasive alien species (ISO 37120:2018 [4]). A loss in biodiversity threatens food supplies, lessens opportunities for recreation and tourism, and impacts a diverse range of medicinal sources, varieties of wood, and energy. It also interferes with essential ecological function, such as carbon sequestration and air filtering. The net change in the number of native species in a municipality is an indication of biological diversity loss or gain.
Definition	Percentage change in number of native species
Calculation	The percentage change in number of native species may be calculated as the total net change in species (numerator) divided by the total number of species from the 5 taxonomic groups from most recent survey (denominator). The result may then be multiplied by 100 and expressed as a percentage (ISO 37120:2018 [4]). The net change in species may be calculated as the number of new species within the city from the three core taxonomic groups and the city's selection of an additional two taxonomic groups (as a result of re-introduction, rediscovery, new species found, etc.) subtracted by the number of species that have become extirpated or locally extinct within the city. The three core taxonomic groups may refer to vascular plants, birds and butterflies. Additional taxonomic groups that cities should select can include the following: mammals, insects, bryophytes, fungi, amphibians, reptiles, freshwater fish, molluscs, dragonflies, carabid beetles, spiders, hard corals, marine fish, seagrasses, sponges, etc.
Strengths and weaknesses	**Strengths:** Not applicable. **Weaknesses:** Not applicable.
Data requirements	
Expected data source	Possible sources of data include government agencies in charge of biodiversity, city municipalities, urban planning agencies, city forestry departments, biodiversity centres, nature groups, universities, etc.
Expected availability	Since data collection is elaborate, availability may be limited.
Collection interval	Yearly.
Expected reliability	If the research is good, so is the indicator.
Expected accessibility	No sensitivities expected.

A.3 Prosperity

A.3.1 Employment

Table A.22

Unemployment rate	
Description incl. justification	The unemployment rate is considered one of the single, most informative labour market indicators reflecting the general performance of the labour market and the health of the economy as a whole. It is used to measure a city's unutilized labour supply and track business cycles. When economic growth is strong, unemployment rates tend to be low and when the economy is stagnating or in recession, unemployment rates tend to be higher (ISO 37120:2018 [4]). Unemployment may refer to individuals without work, actively seeking work in a recent past period (past four weeks), and currently available for work. Persons who did not look for work but have a future labour market stake (arrangements for a future job start) are counted as unemployed (International Labour Organization). Discouraged workers or hidden unemployed may refer to persons who are not actively seeking work because they believe the prospects of finding it are extremely poor or they have restricted labour mobility, face discrimination, and/or structural, social, and cultural barriers - are not counted as unemployed or as part of the labour force. Not actively seeking work may refer to people who have not taken active steps to seek work (i.e. job searches, interviews, informational meetings, etc.) during a specified recent period (usually the past four weeks). (ISO 37120:2018 [4]). Labour Force may refer to the sum of the total persons employed and unemployed who are legally eligible to work.
Definition	Percentage of the labour force unemployed.
Calculation	A city's unemployment rate may be calculated as the number of working-age city residents who during the survey reference period were not in paid employment or self-employment, but available for work, and seeking work (numerator) divided by the total labour force (denominator). The result may be multiplied by 100 and expressed as a percentage (ISO 37120:2018 [4]).
Strengths and weaknesses	**Strengths:** City's unemployment rate can be considered as a sound measure for indicating a city's social and economic performance. **Weaknesses:** Although there exists e.g. a definition for the calculation of the unemployment rate by ISO 37120:2018 [4]), each country/city is to be expected to calculate the unemployment rate based on own policies and rules (e.g. indicating people as unemployed if they are in trainings or not), therefore for the purpose of comparison these exceptional rules have to be taken into account.
Data requirements	
Expected data source	Statistics from local labour bureau, city statistical office.
Expected availability	Statistics are usually frequently (at least yearly) updated by the labour bureaus.
Collection interval	Yearly.
Expected reliability	Various calculation rules regarding the rate within each country/city are to be expected and taken into account regarding comparison between cities.
Expected accessibility	High.

Table A.23

Youth unemployment rate	
Description incl. justification	The youth unemployment rate is a key indicator for quantifying and analysing the current labour market trends for young people (ISO 37120:2018 [4]). Unemployed or underemployed youth are less able to contribute effectively to community and national development and have fewer opportunities to exercise their rights as citizens. They have less to spend as consumers, less to invest as savers and often have no "voice" to bring about change in their lives and communities. Widespread youth unemployment and underemployment also prevents companies and countries from innovating and developing competitive advantages based on human capital investment, thus undermining future prospects. Knowing the costs of non-action, many governments around the world do prioritize the issue of youth employment and attempt to develop pro-active policies and programmes. Unemployed youth may refer to individuals above the legal working age and under 24 years of age who are without work, actively seeking work in a recent past period (past four weeks), and currently available for work. Youth who did not look for work but have a future labour market stake (arrangements for a future job start) are counted as unemployed (International Labour Organization). Discouraged workers or hidden unemployed may not be counted as unemployed or as part of the labour force. Not actively seeking work may refer to people who have not taken active steps to seek work (i.e. job searches, interviews, informational meetings, etc.) during a specified recent period (usually the past four weeks). Youth labour force may refer to all persons above the legal working age and under 24 years of age, who are either employed or unemployed over a specified reference period.(ISO 37120:2018 [4]).
Definition	Percentage of youth labour force unemployed.
Calculation	Youth unemployment rate may be calculated as the total number of unemployed youth (numerator) divided by the youth labour force (denominator). The result may be multiplied by 100 and expressed as a percentage.
Strengths and weaknesses	**Strengths:** City's youth unemployment rate can be considered as a sound measure for indicating a city's social and economic performance. **Weaknesses:** Although there exists e.g. a definition for the calculation of the unemployment rate by ISO 37120:2018 [4], each country/city is to be expected to calculate the unemployment rate based on own policies and rules (e.g. indicating people as unemployed if they are in trainings or not), therefore for the purpose of comparison these exceptional rules have to be taken into account. A large share of people between these ages are outside the labour market (since many youths are studying full time and thus are not available for work).
Data requirements	
Expected data source	Statistics from local labour bureau or city statistical office.
Expected availability	Statistics are usually frequently (monthly or at least yearly) updated by the labour bureaus.
Collection interval	Yearly.
Expected reliability	Various calculation rules and definition of the lower age group within each country/city are to be expected and taken into account regarding comparison between cities.
Expected accessibility	High.

A.3.2 Equity

Table A.24

Fuel poverty	
Description incl. justification	Fuel poverty occurs when a household is unable to afford the most basic levels of energy for adequate heating, cooking, lighting and use of appliances in the home. In absolute sense, when more than 10 % of the income is spent on energy bills this is considered too much. As a large share of the European housing stock consists of buildings in desperate need of refurbishment, particularly in lower income low-energy-efficiency buildings with residents living in fuel poverty, the key to alleviate fuel poverty is to renovate the stock into more energy efficient buildings. Avoiding energy poverty has therefore become an important policy aim in many European countries, for example, in the UK, in Austria and in Germany. It should be noted that there are various definitions and calculation procedures for calculating fuel poverty. Fuel poverty lines are arbitrary in some aspects. Proposed definitions differ strongly in terms of robustness to changes in energy prices, incomes and with regard to data requirements. The CITYkeys city indicator is derived from the UK definition, according to which households are considered as energy poor if their energy bill consumes 10 % or more of the household income.
Definition	The percentage of households unable to afford the most basic levels of energy.
Calculation	For simplicity the 10% variant and not the more complicated Low Income High Costs (LIHC) variant is proposed here. The fuel poverty ratio of a single household under this method is defined as: $Fuel\ Poverty\ Ratio = Modelled\ fuel\ costs\ (i.e. modelled\ consumption \times price)/Income$ Where this ratio has a value greater than 0.1, the household is considered to be fuel poor. In the next calculation step the number of households living in fuel poverty is compared with the total number of households in the city. See note.
Strengths and weaknesses	**Strengths:** Connects policy area energy reduction with poverty alleviation. **Weaknesses:** Due to the high variance in calculation rules the comparability between cities may be poor. Requires census data and quite some calculations.
Data requirements	
Expected data source	The data needed for the calculation are: Household income; Energy consumption (dependent on dwelling characteristics and the lifestyle of householders) and Prices of energy. The cost of energy is modelled rather than based on actual spending. It is calculated by combining the fuel requirements of the household with corresponding fuel prices. Household income data may be available from the city statistical office. Energy prices should be metered prices and should be available from the local energy providers. Energy consumption data per household is usually modelled based on statistics on dwellings, household size, etc.
Expected availability	The information sources needed should be available through the city statistical office and energy service providers.
Collection interval	Annual.
Expected reliability	Depending on the quality of the data needed fitting the calculation rules, the indicator will produce more or less reliable results.
Expected accessibility	Depending on information categories, it is expected that the minimum set of indicator data should be accessible. As the indicator calculation requires individual data, data processing might need to be done by the statistical office or an entity with sufficient protection of private data.
Expected data models	Documented in DECC, 2013 [i.8].
NOTE: The energy costs include all building related energy, i.e. for heating/cooling, warm water and electricity.	

Table A.25

Affordability of housing	
Description incl. justification	Many European cities face spatial segregation of social groups. Gentrification combined with an increase in housing costs, make it more difficult for low-income residents to find affordable housing. Smart cities aim to maintain or increase the diversity within neighbourhoods to ensure that also inhabitants with low incomes can remain in developing neighbourhoods and not being pushed into suburbs or outside the city. As a rule of thumb, no more than 25 % - 40 % of income should be spend on housing in order to be considered affordable. For developed countries the upper limit is between 33 % - 40 %. For this indicator affordable housing is defined as: less than 40 % of the household income is spend on housing expenditures. This includes rents, hereditary tenure, mortgage payments, but excludes expenditures for services or utilities.
Definition	% of population living in affordable housing.
Calculation	The indicator may be calculated as the number of people living in affordable housing (numerator) divided by the city population (denominator). The result may then be multiplied by 100 and expressed as a percentage.
Strengths and weaknesses	**Strengths:** reflecting important processes in cities, such as gentrification; connects with policy goal of poverty reduction. **Weaknesses:** Because of the variability of the definition, a certain amount of subjectivity and uncertainty is given.
Data requirements	
Expected data source	The indicator combines per household data on fixed housing costs, with the gross household income. City statistical department. City social or housing department.
Expected availability	The basic individual data are census data, of which availability depends on the regularity of these censuses in the city/country. Alternatively combining registers might be considered.
Collection interval	With the frequency of censuses (5 to 10 years), or more regularly if based on the combination of registers.
Expected reliability	If based on census data, the indicator will be very reliable.
Expected accessibility	If the indicators has been calculated by the city statistical department, it will be accessible. Individual data underlying the indicator will as a rule not be accessible.

A.3.3 Green economy

Table A.26

Share of certified companies	
Description incl. justification	More and more organizations have systematic attention for the environmental aspects of their business, including products and services. Often this is the consequence of increasing attention of external parties for the environmental performance of the company. These stakeholders have wishes and demands on the environmental aspects of the company, which need to be taken into account by the company to keep its "license to operate" in the longer term. The ISO 14000 series [i.4] of norms for environmental management offers guidance for organizations that want to go further than compliance with rules and regulations. The norms are meant for companies that understand that implementing a systematic approach to the environmental aspects of the company and its products will pay itself back, for example through decrease of waste costs; reductions in energy, resources and materials; improving environmental image; better relationships with government; and new market opportunities. If a city hosts a high share of certified companies, it can be assumed that environmental quality, also locally, benefits.
Definition	Share of companies based in the city holding an ISO 14001 [i.10] certificate.
Calculation	(Number of companies with ISO 140001 [i.10] certificate/total number of companies in the city) × 100 %.
Strengths and weaknesses	**Strengths:** Easy to understand. Possibly related with local environmental quality and the 'image' of the city. **Weakness:** Only a minority of companies is certified, and it is possible for non-certified companies to conduct their business in an environmentally sound manner. Due to various existing certification systems and related definitions, a certain amount of subjectivity cannot be avoided.
Data requirements	
Expected data source	The information can be retrieved from ISO registers or other business registers.
Expected availability	Good.
Collection interval	Annually.
Expected reliability	ISO 14001 [i.10] is international standard, so the reliability and comparability of the data is expected to be high.
Expected accessibility	Good, as companies tend to use this information for the purpose of marketing.

Table A.27

Share of Green Public Procurement	
Description incl. justification	Europe's public authorities are major consumers. By using their purchasing power to choose environmentally friendly goods, services and works, they can make an important contribution to sustainable consumption and production - what is called Green Public Procurement, or GPP. Although GPP is not mandatory, it has a key role to play in the EU's efforts to become a more resource-efficient economy. It can help stimulate a critical mass of demand for more sustainable goods and services which otherwise would be difficult to get onto the market. GPP is therefore a strong stimulus for eco-innovation. A number of European countries already have national environmental purchasing criteria for products and services per sector. Also, green labels may be helpful in identifying the extent to which environmental considerations were taken into account. The indicator leaves the flexibility to define the use of environmental criteria according to local circumstances.
Definition	Percentage annual procurement using environmental criteria as share of total annual procurement of the city administration.
Calculation	(Million EUR annual procurement using environmental criteria/Million EUR total annual procurement of the city administration) × 100.
Strengths and weaknesses	**Strength:** Easy to understand. Common European guidelines for GPP are available. **Weakness:** This indicator is only relevant to government funded procurement; guidelines are extensive; data availability may be limited; green labels do not necessarily tell the full story; definition of GPP is flexible.
Data requirements	
Expected data source	A first entry could be the city's corporate facilities department (but this might be limited to its own sustainable purchasing (i.e. printing paper, catering, etc.). Information on the rest of the organization will likely be scattered over different departments (e.g. the transport department for sustainable procurement of roads; the housing department for sustainable procurement of a large-scale urban development project, etc.).
Expected availability	If the data are available, they are likely to be scattered.
Collection interval	Annually.
Expected reliability	Reliability of the data is limited due to uncertainties in the sources (availability, what is considered and what is not).
Expected accessibility	No sensitivities expected.

Table A.28

Green jobs	
Description incl. justification	'Greening the economy' can boost job creation in areas directly connected to the environment such as conservation, waste, water and air quality. Smart cities are expected to show a significant growth in green jobs. UNEP 2008 [i.11] defines a green job as "work in environmental service activities that contribute substantially to preserving or restoring environmental quality. Specifically, but not exclusively, this includes jobs that help to protect ecosystems and biodiversity; reduce energy, materials, and water consumption through high efficiency strategies; de-carbonize the economy; and minimize or altogether avoid generation of all forms of waste and pollution". So a green job is any job that genuinely contributes to a more sustainable world (i.e. related to measuring, avoiding, reducing, limiting or removing environmental damages as well as the preservation of natural resources). The employing company or organization can either be in a 'green' sector (e.g. solar energy), or in a conventional sector, but making genuine and substantial efforts to green its operations.
Definition	Share of jobs related to environmental service activities that contribute substantially to preserving or restoring environmental quality.
Calculation	(Number of green jobs/Total number of jobs) × 100.
Strengths and weaknesses	**Strengths:** The indicator might show the link between environmental performance and job creation, or boosting the job creation in areas directly connected to the environment. **Weaknesses:** Complex data collection. Often, studies covering/addressing the topics rely heavily on Environmental Protection Expenditures, therefore the assessment of money spent to protect the environment might be overestimated in comparison to the creation of jobs dependent on a good environment. Therefore the risk of high uncertainty is given.
Data requirements	
Expected data source	Usually green jobs are not accounted separately. Statistical data on environmental protection expenditures can be a source to estimate the number of green jobs.
Expected availability	Low: incidental estimates expected.
Collection interval	Yearly.
Expected reliability	Different approaches in calculating the indicator lower reliability and comparability.
Expected accessibility	Low: probably one can find estimates documented in reports.

Table A.29

Freight movement	
Description incl. justification	Freight distribution, pickups and deliveries (sometimes there is a distinction between delivery traffic and goods transport), while essential to ensure the vitality of cities, have an important contribution to high congestion levels, traffic disruptions, and, therefore increased levels of emissions, noise, and other social costs. City centres are often areas with small streets and high population densities. The performance of urban freight systems depends on a variety of factors related to vehicle types, delivery schedules, load optimization, etc. In Europe, 29 % of freight vehicles on the road in 2009 was empty. From an economic as well as environmental perspective, much can be gained by bringing this number down. ICT can be an important enabler to further improve logistics management. Optimizing the system should lead to less vehicle movements.
Definition	Freight movement is defined as the number of freight vehicles moving into an area (e.g. the city).
Calculation	# of freight vehicle movements.
Strengths and weaknesses	**Strengths:** Not applicable. **Weaknesses:** specific indicator that does not take into account a shift between larger and smaller vehicles.
Data requirements	
Expected data source	Roadside counts.
Expected availability	Available if counting systems are constantly in place.
Collection interval	Annually.
Expected reliability	It is expected to be reliable.
Expected accessibility	Likely accessible.

A.3.4 Economic performance

Table A.30

Gross Domestic Product	
Description incl. justification	Gross domestic product, abbreviated as GDP, is a basic measure of a city's overall economic production. As an aggregate measure of production, GDP is equal to the sum of the gross value added of all resident institutional units (i.e. industries) engaged in production, plus any taxes, and minus any subsidies, on products not included in the value of their outputs. Gross value added is the difference between output and intermediate consumption. GDP is also equal to: • the sum of the final uses of goods and services (all uses except intermediate consumption) measured in purchasers' prices, minus the value of imports of goods and services; • the sum of primary incomes distributed by resident producer units.
Definition	City's gross domestic product per capita.
Calculation	
Strengths and weaknesses	**Strengths:** Well-known and accepted method for measuring of economic performance. **Weaknesses:** the indicator does only take into account all 'transactions done over the market' and not e.g. free of charge transactions and services. Furthermore the indicator should be cleaned from actions being good for economic development but bad in the development for human wellbeing.
Data requirements	
Expected data source	Datasets needed: GDP and population. Cities statistics bureau, national statistics bureau if it provides geographical disaggregation or Eurostat NUTS3 level as proxy if no other data is available.
Expected availability	Often GDP figures are only available at a regional level, which may not be appropriate for a small city.
Collection interval	Annually.
Expected reliability	The indicator is well-known, therefore reliability should be expected.
Expected accessibility	No sensitivities expected.

Table A.31

New business registered	
Description incl. justification	The number of businesses can inform a city's level of economic activity and economic performance. It provides one indication of the overall business climate in a jurisdiction, and attitudes towards entrepreneurship. Strong entrepreneurial activity is closely associated with a dynamic and growing economy. The number of businesses is also used to inform competitiveness of a city (ISO 37120:2018 [4]). This indicator assesses the number of new businesses created (including start-ups). An enterprise birth occurs when an enterprise (for example a company) starts from scratch and begins operations, amounting to the creation of a combination of production factors with the restriction that no other enterprises are involved in the event. An enterprise birth occurs when new production factors, in particular new jobs, are created. Enterprise births do not include: • dormant enterprises being reactivated within two years; • new corporate entities being created from mergers, break-ups, spin-offs/split-offs or the restructuring of enterprises or a set of enterprises; • the entry into a sub-population resulting only from a change of activity.
Definition	Number of new businesses per 100 000 population.
Calculation	(Number of new companies registered/Total Population) x 100 000 inhabitants.
Strengths and weaknesses	**Strengths:** Not applicable. **Weaknesses:** Not each new founded enterprise has to have a positive impact on the economy or smart city development. The measurement should e.g. take into account a minimum timeframe the new founded company need to stay on the market or reach a minimum turnaround to be accepted for counting.
Data requirements	
Expected data source	Business demography statistics are available at NUTS2 level at Eurostat. City statistics office and/or economic board and the chamber of commerce might be able to provide the information.
Expected availability	Dependent per city.
Collection interval	Annually.
Expected reliability	Numbers from the statistical offices, chamber of commerce and Eurostat are considered highly reliable.
Expected accessibility	No sensitivities expected.

Table A.32

Median disposable income	
Description incl. justification	While money may not buy happiness, a certain amount is an important means to achieve higher living standards and thus greater well-being. Higher economic wealth may e.g. improve access to quality education, health care and housing. Total disposable household income (according to SILC) is calculated by adding together the personal income received by all of the household members plus income received at household level diminished by regular taxes on wealth, regular inter-household cash transfer paid and tax on income and social insurance contributions. The median is the middle value, i.e. 50 % of all observations are below the median value and 50 % above it. Household disposable income includes income from economic activity (wages and salaries; profits of self-employed business owners), property income (dividends, interests and rents), social benefits in cash (retirement pensions, unemployment benefits, family allowances, basic income support, etc.), and social transfers in kind (goods and services such as health care, education and housing, received either free of charge or at reduced prices) (OECD).
Definition	Median disposable annual household income.
Calculation	In general, individual data are rarely available so income classes are used. Knowing the number of households in each class, the class of the median income is known. The "exact" amount of median income can be approximated by replacing the steps (caused by the classes) in the cumulative frequency curve by a smooth curve of distribution, at least for the class in which the median is situated.
Strengths and weaknesses	**Strengths:** The indicator provides an absolute value for the wealth of the city. **Weaknesses:** Insight in the disposable income does not have a direct relation with wealth and welfare of the population. Different methods to calculate this indicator might make it less reliable for benchmarking.

Data requirement	
Expected data source	The information might be available at the Urban Audit database, the cities statistics bureau.
Expected availability	It is a commonly used indicator, so availability is expected to be high.
Collection interval	Annually.
Expected reliability	Information from the above mentioned sources are regarded as highly reliable. However, due to possible differences in calculations the indicator might not be 100 % reliable for benchmarking.
Expected accessibility	As it is calculated using income classes, no sensitivities are expected.

A.3.5 Innovation

Table A.33

Creative industry	
Description incl. justification	The term refers to the socio-economic potential of activities that trade with creativity, knowledge and information. Governments and creative sectors across the world are increasingly recognizing its importance as a generator of jobs, wealth and cultural engagement. At the heart of the creative economy are the cultural and creative industries that lie at the crossroads of arts, culture, business and technology. What unifies these activities is the fact that they all trade with creative assets in the form of intellectual property (IP); the framework through which creativity translates into economic value. The UK's definition of the creative industries - 'those industries that are based on individual creativity, skill and talent with the potential to create wealth and jobs through developing intellectual property' - includes thirteen sectors: advertising, architecture, the art and antiques market, crafts, design, designer fashion, film, interactive leisure software (i.e. video games), music, the performing arts, publishing, software, and television and radio. Because it was the first definition offered by a government, this original UK definition has been widely adopted by other countries, with sectors adapted based on local commercial and cultural importance.
Definition	Share of people working in creative industries.
Calculation	(people working in creative industries/total workforce) × 100 %.
Strengths and weaknesses	**Strengths:** Not applicable. **Weaknesses:** the interpretation and definition of 'creative industry' may be different. How creative industry is linked to other industry is often unclear. A proxy such as revenues from creative sectors may be necessary to estimate the indicator. The direct contribution of creative industry to innovation is not clear.
Data requirements	
Expected data source	The percentage of employment in the creative class is available at NACE2 and NUTS3 level by Eurostat. Possibly also city statistics office and/or economic board, chamber of commerce, etc.
Expected availability	The availability of employment information per sector will be readily available with the above sources, but defining which ones represent 'creative industry' might require more effort.
Collection interval	Annually.
Expected reliability	Information from the above mentioned sources are regarded as highly reliable. However, due to possible differences in calculations the indicator might not be 100 % reliable for benchmarking.
Expected accessibility	No sensitivities expected.

Table A.34

Innovation hubs in the city	
Description incl. justification	Innovation hubs imply building and increasing intellectual capital and skills. It exposes the interest in creation of value and development of knowledge. It may create links between sectors and fields of development, which previously did not exist and thus positively impact socio-economic development of an urban area. For this indicator, physical co-working spaces for knowledge institutions, business and government should be counted.
Definition	# of innovation hubs in the city, whether private or public, per 100 000 inhabitants.
Calculation	
Strengths and weaknesses	**Strengths:** Not applicable. **Weaknesses:** The number of facilities is not placed in relation to the quality of facilities, which may have impact on the overall performance of such institutions.
Data requirements	
Expected data source	Universities and other research institutes, city government (smart city or economic affairs department).
Expected availability	Data is probably available but might be scattered.
Collection interval	Annually.
Expected reliability	High.
Expected accessibility	No sensitivities expected.

Table A.35

Accessibility of open data sets	
Description incl. justification	Open data, especially open government data, is a tremendous resource that is as yet largely untapped (opendatahandbook.org). In a large number of areas, open city data is already creating value. Examples include participation, self-empowerment, innovation, improved efficiency and effectiveness of government services, etc. While there are numerous instances of the ways in which open data is already creating both social and economic value, new things will become possible that are not already known. New combinations of data can create new knowledge and insights, which can lead to whole new fields of application. The ease of use of open data is an important quality because the main aim of opening data is to make it widely available to the public (City Protocol), e.g. to create new applications. Therefore, evaluating the quality of the open data from this perspective is important to promote the ease of use and the openness of city data.
Definition	The extent to which the open city data are easy to use.
Calculation	Total stars of all datasets/total # datasets. Each dataset has to be rated according to below scheme. All the stars of all the datasets are added up and divided by the total number of datasets. Average stars across all datasets according to the 5 star deployment scheme for Open Data: 1) Making data online available in whatever format under an open license. 2) Making data available as structured data (e.g. Excel® instead of image scan of a table). 3) Making data available in a non-proprietary open format (e.g. CSV). 4) Use URIs to denote things, so that people can point at your data. 5) Link your data to other data to provide context.
Strengths and weaknesses	**Strengths:** The 5 star system makes the qualification of the datasets much more objective and comparable across cities. **Weaknesses:** Quality of the data is only expressed as the openness and ease of use of data. Other aspects like accurate, available, complete, conformant, consistent, credible, processable, relevant, timely have not been taken into account. Although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Data requirements	
Expected data source	The indicator 'Open data' provides a list of open datasets relevant to the city and in which format they are available.
Expected availability	Depends on the local context.
Collection interval	Annually.
Expected reliability	Unknown.
Expected accessibility	Good (data is open).
NOTE: Excel is an example of a suitable product available commercially. This information is given for the convenience of users of the present document and does not constitute an endorsement by ETSI of this product.	

Table A.36

Research intensity	
Description incl. justification	The OECD Frascati Manual 2002 methodology [i.5] defines R&D as "creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications". The main aggregate used for international comparisons of R&D expenditures is gross domestic expenditure on R&D (GERD). GERD is usually broken down among four sectors of performance: business enterprise, higher education, government and private not-for-profit institutions serving households (PNP). GERD is often reported in relative terms as a percentage of GDP, to denote the R&D intensity of an economy. This indicator analyses the total expenditure on R&D by all stakeholders as a percentage of the GDP of the city.
Definition	R&D expenditure as percentage of city's GDP.
Calculation	(total expenditure on R&D/city GDP) × 100.
Strengths and weaknesses	**Strengths:** This is a solid indicator and comparable across cities. **Weaknesses:** Usually measured on the national and regional level, getting data specific to an urban area might be more complicated. Also the funding may come from a different place, i.e. theoretically it is possible that expenditure on R&D exceeds city GDP in university towns.
Data requirements	
Expected data source	For city's GDP, see indicator 'Gross domestic product'. The expenditures on R&D might be available in the municipal Economics department. Eurostat contains the GERD on the NUTS2 level if no city statistics are present.
Expected availability	Low.
Collection interval	Annually.
Expected reliability	High.
Expected accessibility	For a large part, there are no sensitivities expected. However, it is possible that R&D expenditure from companies is not disclosed.

Table A.37

Open datasets	
Description incl. justification	Open data is data that can be freely used, re-used and redistributed by anyone - subject only, at most, to the requirement to attribute and share alike (opendatahandbook.org; opendefinition.org). Open data, especially open government data, is a tremendous resource that is as yet largely untapped. Government is particularly significant in this respect, both because of the quantity and centrality of the data it collects, but also because most of that government data is public data by law, and therefore could be made open and made available for others to use. In a large number of areas, open government data is already creating value. Examples include participation, self-empowerment, innovation, improved efficiency and effectiveness of government services, etc. While there are numerous instances of the ways in which open data is already creating both social and economic value, new things will become possible that are not already known. New combinations of data can create new knowledge and insights, which can lead to whole new fields of application. Since open datasets can stimulate innovation, this indicator analyses the number of open government datasets. In addition, the format of the available datasets is collected as this is important information for the indicator 'quality of open data'.
Definition	number of open government datasets per 100 000 inhabitants.
Calculation	(number of open government datasets/total population) x 100 000. See note.
Strengths and weaknesses	**Strengths:** This is a solid indicator on the actual datasets available and it is comparable across cities. **Weaknesses:** Not applicable.
Data requirements	
Expected data source	The knowledge, planning or economic department should be able to provide an overview. Open data platforms in the city could also provide insight.
Expected availability	The information will be available, but collecting all datasets from various sources might require sufficient effort.
Collection interval	Annually.
Expected reliability	High.
Expected accessibility	Good (data is open).
NOTE: List all open government datasets and the format they are published in.	

A.3.6 Attractiveness and competitiveness

Table A.38

Congestion	
Description incl. justification	Cities and traffic have developed hand-in-hand since the earliest large human settlements (internationaltransportforum.org). The same forces that draw inhabitants to congregate in large urban areas also lead to sometimes intolerable levels of traffic congestion on urban streets and thoroughfares. It is necessary to manage congestion in such a way as to reduce its overall impact on individuals, families, communities and societies. Effective urban governance requires a careful balancing between the benefits of agglomeration and the dis-benefits of excessive congestion. Also, the Strategic Implementation Plan on Smart Cities and Communities defines more efficient urban transport as one goal of Smart City Development.
Definition	Increase in overall travel times when compared to free flow situation (uncongested situation).
Calculation	This indicator can be calculated as indicated by TomTom®: ((travel times in peak hours - travel times during non-congested periods (free flow*))/travel times during non-congested periods) × 100 %. See note 1. **Decide** • Average delay per vehicle kilometre (congestion), with unit: hour delay/vehicle-km. • Vehicle kilometres travelled in congestion, with unit: vehicle-km/time unit Travel time (average per traffic unit), with unit: hour. • Additional travel time caused by incidents, with unit: hour. **EEA** • Average daily km of traffic jams per 1 000 inhabitants in city. **City Protocol** • Average daily traffic jam in hours.
Strengths and weaknesses	**Strengths:** the indicator is very recognizable and relevant to the attractiveness and competitiveness, as it goes to the accessibility of the city. **Weaknesses:** -
Data requirements	
Expected data source	Within the city, the traffic and transportation management department should be able to provide this statistic. Several commercial services also exist based on route navigation.
Expected availability	Measurements on traffic speed and congestion will not always be readily available.
Collection interval	Annually.
Expected reliability	High.
Expected accessibility	No sensitivities expected.
NOTE 1: There are other ways to calculate congestion, see below. That would be interesting to hear from the cities what method they use. For the moment, therefore, the calculation method is flexible, as long as it is specified. NOTE 2: TomTom® is an example of a suitable product available commercially. This information is given for the convenience of users of the present document and does not constitute an endorsement by ETSI of this product.	

Table A.39

Public transport use	
Description incl. justification	Transport usage is a key indicator of how easy it is to travel in the city by modes other than single occupancy vehicles (ISO 37120:2018 [4]). The indicator might also provide insight into transportation policy, traffic congestion, and urban form. Cities with higher transport ridership rates tend to invest more in their transport systems and are more geographically compact. Transport usage also addresses overall travel patterns in the city, and not just the journey to work. In addition, less vehicle use contributes to an accessible, green and healthy city and moreover contributes to European policy goals for sustainable mobility and transport development. While walking and cycling are alternative modes of transport for short distances, public transport connections are needed for longer trips.
Definition	Annual number of public transport trips per capita.
Calculation	This indicator may be calculated as the total annual number of transport trips originating in the city - "ridership of public transport" - (numerator), divided by the total city population (denominator) (ISO 37120:2018 [4]). Transport trips may include trips via heavy rail metro or subway, commuter rail, light rail streetcars and tramways, organized bus, trolleybus, and other public transport services. Cities may only calculate the number of transport trips with origins in the city itself. See note 1.
Strengths and weaknesses	**Strengths:** Not applicable. **Weaknesses:** The quality of the trips is not taken into account. Public transport use does not have a direct relation to the attractiveness and competitiveness of the city. While higher transport ridership rates are generally considered desirable, extremely high ridership rates can also indicate cities with overcrowding problems or with disproportionately large low-income populations.
Data requirements	
Expected data source	Transport data should be gathered from a number of sources, including: official transport surveys, revenue collection systems (e.g. number of fares purchased), and national censuses (ISO 37120:2018 [4]). See note 2 and note 3.
Expected availability	High.
Collection interval	Annually.
Expected reliability	High.
Expected accessibility	No sensitivities expected.
NOTE 1: Transport systems often serve entire metropolitan areas, and not just central cities. The use of number of transport trips with origins in the city itself will still capture many trips whose destination are outside the city, but will generally capture the impact that the city has on the regional transport network. NOTE 2: Farebox records (e.g. transport fares paid) are usually the primary source of data for this indicator. However, the relationship between fares purchased and trips taken is not always exact. For example, many transport systems do not actively check for proof of fare purchase - often, riders are expected to have valid tickets, and are severely fined if a ticket is not presented, but enforcement of such rules is not uniform for every rider on every trip. Other transport systems offer monthly or weekly passes, which do not necessarily allow for accurate counts of each trip. NOTE 3: In many countries, a large number of trips are made via "informal transport" services (e.g. minibuses not operated by the government or municipal transport corporation). These informal trips are not part of the official transport network and may not be counted.	

Table A.40

Net migration	
Description incl. justification	The rate of migration is a direct indicator for the attractiveness of the city to citizens and their willingness to live there. In addition, there is a general movement of people from the countryside towards cities (urbanization).
Definition	Rate of population change due to migration per 1 000 inhabitants.
Calculation	((Move-ins - move-outs) / total population) × 1 000.
Strengths and weaknesses	**Strengths:** Solid indicator and comparable to with other cities. **Weaknesses:** It is not always a choice to live or leave some place.
Data requirements	
Expected data source	City's statistics office. The ESPON database contains information on migration at NUTS3 level, averaged over 5 years.
Expected availability	High.
Collection interval	Annually.
Expected reliability	High.
Expected accessibility	No sensitivities expected.

Table A.41

Population dependency ratio	
Description incl. justification	Dependency ratios indicate the potential effects of changes in population age structures for social and economic development, pointing out broad trends in social support needs (www.un.org). By relating the group of the population most likely to be economically dependent (net consumers) to the group most likely to be economically active (net producers), changes in the dependency ratio provide an indication of the potential social support requirements resulting from changes in population age structures (ibid). In addition, the ratio highlights the potential dependency burden on workers and indicates the shifts in dependency from a situation in which children are dominant to one in which older persons outnumber children as the demographic transition advances (that is, the transition from high mortality and high fertility, to low mortality and low fertility). A healthy dependency ratio contributes to an attractive and competitive city.
Definition	Number of economically dependent persons (net consumers) per 100 economically active persons (net producers).
Calculation	100 x (Population (0 to 14) + Population (65+)) / Population (15 to 64) (www.un.org).
Strengths and weaknesses	**Strengths:** Not applicable. **Weaknesses:** In many populations, people do not stop being economically active at age 65, nor is it true that all persons aged 15 to 64 are economically active. Although older persons often require economic support from others, in many societies they have economic resources of their own and provide support to their adult children. As the period of training for a productive life increases, most adolescents and young adults remain in school and out of the labour force, effectively extending the period of young-age dependency well beyond age 15. The indicator is more relevant at national level than at local level.
Data requirements	
Expected data source	City's statistics office.
Expected availability	High.
Collection interval	Annually.
Expected reliability	High.
Expected accessibility	No sensitivities expected.

Table A.42

International events held	
Description incl. justification	The number of international events held is an indication of the attractiveness and competitiveness of the city. International events are, for example, congresses and fairs.
Definition	The number of international events per 100 000 inhabitants.
Calculation	
Strengths and weaknesses	**Strengths:** Not applicable. **Weaknesses:** Difficult to compare between cities, i.e. cities that are the seat to national governments, international organizations, country representations, have large venues, are easily accessible, etc., will host more events than those who do not.
Data requirements	
Expected data source	City administration and city tourism office.
Expected availability	High.
Collection interval	Annually.
Expected reliability	High.
Expected accessibility	No sensitivities expected.
Expected data models	None.

Table A.43

Tourism intensity	
Description incl. justification	The number of tourists visiting the city is an indication of the attractiveness of the city to foreigners. A study by European Cities Marketing, the European Cities Marketing Benchmarking report 2015 [i.9], shows that city tourism has experienced exponential growth compared to tourism on a national level, making cities the engine of tourism development in Europe. In addition, tourism as an industry adds value to the local economy.
Definition	Number of tourist nights per year per 100 000 inhabitants.
Calculation	
Strengths and weaknesses	**Strengths:** Not applicable. **Weaknesses:** difficult to compare between cities, i.e. cities that are the seat to national governments, international organizations, country representations, have large venues, rich culture, are easily accessible, etc. will host more tourists than those who do not.
Data requirements	
Expected data source	City's tourism office, tourism tax information, European Cities Marketing Benchmarking Report.
Expected availability	High.
Collection interval	Annually.
Expected reliability	High.
Expected accessibility	No sensitivities expected.

A.4 Governance

A.4.1 Organization

Table A.44

Cross-departmental integration	
Description incl. justification	Smart city projects are multi-disciplinary projects. Therefore, they can benefit from an integrated approach and the involvement of many disciplines and departments within the city administration. This is referred to as the "mainstreaming approach": all policy domains are conscious of the fact that smart city initiatives touch their policy domain and they see it as an added value. The level of cross-departmental integration will be estimated by analysing the number of departments involved in smart city initiatives, whether by contributing financial, data sources or human resources.
Definition	The extent to which administrative departments contribute to "Smart City" initiatives and management
Calculation	Likert scale: Only one department involved - 1 - 2 - 3 - 4 - 5 - All departments are actively involved: 1) There is a silo-ed smart city governance structure, only one department actively contributes to smart city initiatives and decides on the strategy. 2) The local authority is poorly oriented towards cross-departmental "smart city" management: officially there is no "mainstreaming approach", some civil servants from a few departments work on this portfolio on the side or provide data for the initiatives, but there is no real strategy and commitment. 3) The local authority is somewhat oriented towards cross-departmental "smart city" management: there is a strategy for a "mainstreaming approach" and several departments contribute in human, data or financial resources. 4) The local authority is clearly oriented towards cross-departmental "smart city" management: there is a strategy for a "mainstreaming approach" and almost all departments provide financial, data and human resources for the smart city themes. 5) The local authority is committed towards cross-departmental "smart city" management: there is a well-anchored "mainstreaming approach" with shared performance targets and all departments are actively contributing to the smart city themes in financial, data and human resources.
Strengths and weaknesses	**Strengths:** The actual involvement of departments in terms of various resources is taken into account. **Weaknesses:** Although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Data requirements	
Expected data source	To be derived from interviews with the smart city coordinator, administration documentation and proposals/reports on smart city project initiatives.
Expected availability	The smart city coordinator should be able to provide all the documentation and information.
Collection interval	Yearly.
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100 % reliable.
Expected accessibility	It is expected that information on the smart city governance structure is public information.

Table A.45

Establishment in the administration	
Description incl. justification	Although many disciplines and municipal departments are ideally involved in the execution of the smart city strategy, a clear primary responsibility lying with one department or a director is an important factor for success. Another element of strong and dedicated establishment is the labour force allocated towards smart city initiatives. This indicator estimates the combined extent to which both elements are established in the city administration.
Definition	The extent to which the smart city strategy has been assigned to one department/director and staff resources have been allocated.
Calculation	Likert scale: Not at all - 1 - 2 - 3 - 4 - 5 - Very much: 1) Not at all: The municipal efforts regarding smart city are not at all reflected by the organizational structure and staff resources. 2) Poor: some civil servants manage this portfolio on the side but there is no real commitment to the subject. 3) Moderate: responsibility has been assigned to a director and a small team is working on the topic. 4) Much: responsibility has been assigned to a director and a large team is working on the topic. 5) Very much: the smart city strategy is a well-anchored in the administration reflected by the assigned responsibility to a large team and the strong commitment to achieve the smart city targets.
Strengths and weaknesses	**Strengths:** Not applicable. **Weaknesses:** although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Data requirements	
Expected data source	To be derived from administration documentation and interviews with the smart city coordinator.
Expected availability	Most successful smart city administrations will have paid specific attention to their structure in relation to the facilitation of projects. If there is no documentation available, involved actors/stakeholders and the project leader itself should be able to provide insight upon which the assessor can base the score.
Collection interval	Yearly.
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100 % reliable.
Expected accessibility	It is expected that this information will be accessible in a general sense.

Table A.46

Monitoring and evaluation	
Description incl. justification	Continued monitoring of performance and compliance with the requirements is an essential stimulating factor for success and allows the presentation of the actual progress made. Continued monitoring and reporting refers to the control processes by which at each stage of development, key personnel report on how the smart city programme progresses with regards to the initial goals, schedule and budget. Adequate monitoring and reporting mechanisms allow for an anticipation on problems, to oversee corrective measures, and warrants that no deficits are overlooked.
Definition	The extent to which the progress towards a smart city and compliance with requirements is being monitored and reported.
Calculation	Likert scale: No continued monitoring - 1 - 2 - 3 - 4 - 5 - Extensive monitoring: 1) No monitoring & reporting: No monitoring and reporting at all was used to verify the progress of policies/strategies/projects. 2) Little monitoring & reporting: there is a basic monitoring scheme in place: a basic set of indicators assessed at irregular time intervals. 3) Some monitoring & reporting: there is a city-wide monitoring scheme in place with an elaborate set of indicators measurement intervals, backed by well-defined (SMARTY) goals of the smart city strategy. 4) Very much monitoring & reporting: there is a city-wide monitoring scheme in place with an elaborate set of indicators and measurement intervals, the findings of which are yearly reported upon. 5) Extensive monitoring & reporting: there is a city-wide monitoring scheme in place addressing all stages of the process, the findings of which are yearly reported upon and published transparently online.
Strengths and weaknesses	**Strengths:** Various aspects of the monitoring and evaluation are combined into one indicator and it allows for comparison among cities. **Weaknesses:** Although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Data requirements	
Expected data source	To be derived from the Smart city strategy document, interviews with the smart city coordinator and monitoring reports.
Expected availability	It is expected that the strategy document of the city is easily available and the smart city coordinator can be contacted easily. The availability of the monitoring reporting depends on the extent of monitoring and reporting.
Collection interval	Yearly.
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100 % reliable.
Expected accessibility	Information on the progress towards a smart city is public information and no problems are expected with regards to the accessibility.

Table A.47

Availability of government data	
Description incl. justification	Open information flows increase transparency and prevent information asymmetry, thereby enhancing participation. This indicator investigates the ratio of unclassified government documents available to citizens, journalist, developer, communities, etc. and whether they are available online in digital form, which is better for share storage (ITU). Unclassified government documents include urban planning, operation, budget, strategy and statistics documents.
Definition	The extent to which government information is published.
Calculation	Likert scale: Not at all - 1 - 2 - 3 - 4 - 5 - Excellent 1) Not at all: most of the information is not available to the public or only upon appointment with an expert. 2) Poorly: most of the information is available to the public, but available in the form of a hard copy which cannot leave city hall. 3) Somewhat: most of the information is available to the public, some in the form of a hard copy, some online. 4) Good: most of the information is available online, but structure is lacking 5) Excellent: all government information is available online and neatly structured.
Strengths and weaknesses	**Strengths:** This indicator combines insight in the accessibility of documents with online availability. The indicator does not require an absolute figure for the percentage of (easily) accessible documents, which would be difficult to measure. **Weaknesses:** Although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Data requirements	
Expected data source	The municipal archivist and website management team can provide information on the accessibility and online availability of government documents. Whether the structure of the website is user-friendly can be assesses with an online web survey that pops-up when surfing the government website.
Expected availability	Information on the correct structure of the website is more difficult to get, but an estimation of the accessibility and online availability should be easy to make by the experts mentioned.
Collection interval	Yearly.
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100 % reliable.
Expected accessibility	In rare cases, governments might be hesitant to reveal how transparent they are, but in general, no issues are expected with accessibility of the information.

A.4.2 Community involvement

Table A.48

Citizen participation	
Description incl. justification	A growing body of literature is exemplifying the importance of civil society/community participation in sustainable urban planning and execution, for example, by means of smart city projects, to bring together information, knowledge and skills from diverse backgrounds to articulate the often ambiguous targets of smart cities and to create a sense of ownership over the outcomes. Moreover, public involvement is identified to have a positive effect on the agreement over solutions and acceptance of policy interventions through the creation of awareness. This indicator analyses the projects that were executed with active citizen participation. Active participation is defined as minimum level 3, 'Advise', based on the scale of Arnstein (1969): 1) Not at all: No community involvement. The project idea came from the municipality and the project was designed and implemented without the community. 2) Inform and consult: The more or less completed project is announced to the community either for information only, or for receiving community views. The consultation, however, is mainly seeking community acceptance of the project. 3) Advise: the project implementation is done by a project team and then presented to community actors, who are invited to ask questions, provide feedback and give advice. Based on this input the planners may alter the project. 4) Partnership: community actors are asked by the project planners to participate in the implementation process. The local community is able to influence the implementation process. 5) Community self-development: the project planners have empowered community actors to outline their needs, to make action plans, to manage the project implementation and evaluate the results.
Definition	The number of projects in which citizens actively participated as a percentage of the total projects executed.
Calculation	
Strengths and weaknesses	**Strengths:** This indicator determines the actual result in citizen participation efforts and allows benchmarking with other cities. **Weaknesses:** Although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Data requirements	
Expected data source	The smart city coordinator and the strategy document should be able to provide the above information.
Expected availability	The information should be known/provided by the above sources.
Collection interval	Yearly.
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100 % reliable.
Expected accessibility	The level of citizen participation is not regarded as sensitive information.

Table A.49

Open public participation	
Description incl. justification	Public participation encompasses varied opportunities for citizens, nongovernmental organizations, businesses, and others outside the federal government to contribute to and comment on proposed rules. The city will widen public exposure to the processes of policy planning and determination and will invite the public to respond to key issues on its agenda. It promotes democratic legitimacy by strengthening the connections between government agencies and the public they serve. This indicator shows the citizens level of commitment to the politics of this city. Higher amount of public participation processes promote an increased sense of belonging to the community and a better adjustment between what the citizens want and what is decided.
Definition	Number of public participation processes per 100 000 per year.
Calculation	Calculation: (Total amount of open public participation processes/City population) × 1 000.
Strengths and weaknesses	**Strengths:** This indicator is an absolute measure of the amount public participation processes and can be compared across cities. **Weaknesses:** Definitions and interpretations of open public participation processes can vary.
Data requirements	
Expected data source	City administration.
Expected availability	It is expected that this information is available with the above sources.
Collection interval	Yearly.
Expected reliability	The calculation can be made reliably.
Expected accessibility	Information on open public participation processes is by definition publicly available.

Table A.50

Voter participation	
Description incl. justification	The percentage of the eligible voting population that voted in the last municipal election is an indicator of the public's level of participation and degree of interest in local government (ISO 37120:2018 [4]). The vast majority of analysts, consider a high voter turnout to be preferable to a low turnout because it means that the government will more likely reflect the interests of a larger share of the population. Low voter turnout implies that the democratic system may not be reflecting the interests of all citizens. However, This indicator will only reveal the level of participation, not the level of satisfaction of the population. In some cases, high rates of participation will mean that the population is not satisfied with its local government's leadership and actions.
Definition	% of people that voted in the last municipal election as share of total population eligible to vote.
Calculation	The voter participation in the last municipal election may be calculated as the number of persons that voted in the last municipal election (numerator) divided by the city population eligible to vote (denominator). The result may then be multiplied by 100 and expressed as a percentage: (people who voted/total voting population) × 100. A result of zero may be indicated if there have been no municipal elections in the last five years and this may be noted in the comments. In countries where voting is mandatory, the per cent of votes (ballots) that are not blank or spoiled may be reported. This will indicate the share of positive voter participation. There is a distinction between eligible to vote and registered to vote. In some countries people have to register (actively) in order to be allowed to vote. In all other countries, eligible and registered voters are one and the same. This should be noted.
Strengths and weaknesses	**Strengths:** This is an absolute indicator reflecting well the level of political participation. **Weaknesses:** Determining the underlying influences of declining voter turnout rates can be difficult. A low turnout may be due to disillusionment or indifference, or even complacent satisfaction with the way the country is being governed. Conversely, a high turnout rate may reflect compulsory voting laws (as in Australia and Belgium) or coercion.
Data requirements	
Expected data source	Information should be obtained from the local authorities, officials or the Ministry responsible for local governments.
Expected availability	It is expected that these numbers are available throughout Europe.
Collection interval	In accordance with the local political cycle (e.g. 4 years).
Expected reliability	The number of voters is expected to be highly reliable.
Expected accessibility	It is expected that these numbers are publicly accessible.

A.4.3 Multi-level governance

Table A.51

Smart city policy	
Description incl. justification	In the past decades, governments have increasingly been "attempting to provide active support for the generation and adoption of environmental innovations". The creation of a supporting framework has been identified as a success factor for shaping responses at the urban level. A framework typically includes a shared vision statement that contains a set of long-term goals. This long-term vision sets out a visualization of where future city development should go, and provides ways to relate responses to urban development aspirations. Integrating goals into a long-term strategic vision for urban development thus is a critical step in support of the transition to smart cities. The existence of such comprehensive smart city visions, alongside with a strong smart city strategy, provides ways in which smart city projects can connect to larger development aims within the city, as well as benefit from supporting measures.
Definition	The extent to which the city has a supportive smart city policy.
Calculation	Likert scale: Not at all - 1 - 2 - 3 - 4 - 5 - Very supportive: 1) Not at all: the complete absence of a long-term smart city vision (including and absence of long-term targets & goals) from the side of the government or an opposing vision create a difficult environment for starting smart city initiatives. 2) Poor: The long-term vision of the government does, to some extent, hamper the environment for smart city initiatives. 3) Neutral: The long-term vision of the government has had no significant, positive or negative, impact on the environment for smart city initiatives. 4) Somewhat supportive: The long-term vision of the government has to some extent benefitted the environment for smart city initiatives. The city has created roadmaps and actions to support vision implementation. 5) Very supportive: The comprehensive long-term vision on the future of the city stimulates the environment for smart city initiatives to a great extent.
Strengths and weaknesses	**Strengths:** This indicator assesses various aspects of the local policy (e.g. vision, targets, roadmaps) and still allows for benchmarking with other cities. **Weaknesses:** Although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present. The interpretation and definition of Smart city may differ between cities.
Data requirements	
Expected data source	To be derived from policy documents and/or an interview with the smart city coordinator.
Expected availability	The required information will be easily available with the above sources.
Collection interval	Yearly.
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100 % reliable.
Expected accessibility	Information on policies is public and problems with regards to accessibility are not expected.

Table A.52

Expenditures by the municipality for a transition towards a Smart City	
Description incl. justification	One of the ways in which the municipality can support the transition towards a smart city, next to a supportive framework, establishment within the administration and cross-departmental integration, is by providing financial resources. Smart city expenditures include process relevant expenditures and funding.
Definition	Annual expenditures by the municipality for a transition towards a Smart City.
Calculation	(Total annual expenditures by the municipality for a transition towards a Smart City/total population.)
Strengths and weaknesses	**Strengths:** This indicator is relevant to the support for smart city initiatives. **Weaknesses:** Further definition on what are smart city expenditures is necessary. Progress towards a smart city is seen as a cooperative and co-creative process in which the city administration does not play a dominant role. This implies that large annual expenditures are not necessarily preferable ('more' does not automatically means 'better').
Data requirements	
Expected data source	City administration.
Expected availability	Information on city budgets should be easy to retrieve from the above source, but allocation of the expenditures to smart city objectives might proof more difficult.
Collection interval	Yearly.
Expected reliability	The reliability is expected to be good.
Expected accessibility	Information on city expenditures is public information.

Table A.53

Multilevel government	
Description incl. justification	Smart city developments benefit from alignment of objectives throughout layers of government, both vertically (regional/national level) and horizontally (other cities). This makes it easier to implement projects in general and in different cities in particular. Moreover, lessons learned can be transferred. The level of cooperation with other municipalities and/or other levels of government will be evaluated by analysing the frequency of consultation or coordination in the planning and decision-making processes and the extent to which partnerships have been established at local, regional level, national level, European and/or international level.
Definition	The extent to which the city cooperates with other authorities from different levels.
Calculation	Likert scale: Not at all - 1 - 2 - 3 - 4 - 5 - Very much: 1) Not at all: there is no cooperation or coordination with other municipalities and/or other levels of government whatsoever. 2) Poorly: there is little cooperation with other authorities, but this is irregular and very dependent of the people involved. 3) Somewhat: there is some cooperation or coordination with other municipalities and/or other levels of government, which is formalized in a partnership policy. 4) Good: there is good cooperation or coordination with other municipalities and/or other levels of government, which is formalized in partnership policies and in process through regular participation in meetings. 5) Excellent: the city is a driving force in the cooperation or coordination with other municipalities and/or other levels of government, which is formalized in policy and in process through regular meetings initiated by the city.
Strengths and weaknesses	**Strengths:** Not applicable. **Weaknesses:** Although it is tried to make scoring the indicator as objectively as possible, a certain amount of subjectivity is present.
Data requirements	
Expected data source	City administration and smart city coordinator.
Expected availability	Information on meetings and policies will be regularly available.
Collection interval	Yearly.
Expected reliability	Because of the subjectivity that cannot be excluded, this indicator is not 100 % reliable.
Expected accessibility	This information is not regarded as sensitive.

Annex B (informative): Change History

Date	Version	Information about changes
April 2019	0.0.1	Working draft
February 2020	0.1.0	Stable draft

History

Document history		
V1.1.1	July 2017	Publication as ETSI TS 103 463
V1.2.1	May 2020	Publication