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SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS, NEXT-GENERATION NETWORKS, INTERNET OF THINGS AND SMART CITIES

Internet of things and smart cities and communities – Evaluation and assessment

Smart sustainable cities maturity model

Recommendation ITU-T Y.4904

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Recommendation ITU-T Y.4904

Smart sustainable cities maturity model

Summary

Recommendation ITU-T Y.4904 provides a maturity model for smart sustainable cities. This maturity model helps to identify the goals, levels and key measures that are recommended for cities to effectively examine their current situation and determine critical capabilities needed to progress toward the long-term goal of becoming smart sustainable cities (SSCs).

The Recommendation includes:

– Smart sustainable city maturity model (SSC-MM),

– Maturity dimensions in smart sustainable cities,

– Maturity levels for smart sustainable cities, and

– Mapping of key performance indicators in smart sustainable cities.

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FOREWORD

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The approval of ITU-T Recommendations is covered by the procedure laid down in WTSA Resolution 1.

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As of the date of approval of this Recommendation, ITU had not received notice of intellectual property, protected by patents, which may be required to implement this Recommendation. However, implementers are cautioned that this may not represent the latest information and are therefore strongly urged to consult the TSB patent database at http://www.itu.int/ITU-T/ipr/.

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Introduction

Maturity model provides a theoretical continuum where maturity increments from one level to the next.

A maturity model can be viewed as a set of structured levels that describe how well the behaviours, practices and processes can reliably and sustainably produce required outcomes. A maturity model can also be used as a tool to understand the current situation and set well-defined goals.

Smart sustainable cities maturity model identifies the levels, key measures, goals, and actions that are recommended for cities to effectively move through the levels and to examine their current situation and determine critical capabilities needed to progress toward the long-term goal of becoming SSCs.

The goal of this Recommendation is to help cities and related stakeholders to develop a common language, improve intra- and inter-city collaboration in defining and executing a city development strategy, and to promote and encourage the use of emerging technologies and solutions.

Recommendation ITU-T Y.4904

Smart sustainable cities maturity model

1 Scope

This Recommendation provides a maturity model for SSCs. A method of assessing and evaluating performance of various dimensions at the current and target maturity levels is necessary to plan and execute a continuous improvement strategy in pursuing a SSC. The goal of the SSC-MM is to help cities and all related stakeholders to use the maturity model to develop a common language, improve intra- and inter-city collaboration in defining and executing a city development strategy, and to promote and encourage the use of emerging technologies and solutions.

The following are some objectives of the SSC-MM:

– To describe general smart sustainable city goals, recognizing that these will vary from city to city.

– To assess the current situation in developing SSCs.

– To assist in formulating a development strategy and outline the necessary milestones.

– To learn the challenges and global best practices in developing SSCs.

– To help cities to do self-evaluation and enable them to share the results with other cities.

A detailed maturity assessment methodology is outside the scope of this Recommendation. Cities are recommended to identify a suitable detailed maturity assessment methodology by themselves.

2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T Y.4901]   Recommendation ITU-T Y.4901/L.1601 (2016), *Key performance indicators related to the use of information and communication technology in smart sustainable cities*.

[ITU-T Y.4902]   Recommendation ITU-T Y.4902/L.1602 (2016), *Key performance indicators related to the sustainability impacts of information and communication technology in smart sustainable cities*.

[ITU-T Y.4903]   Recommendation ITU-T Y.4903/L.1603 (2016), *Key performance indicators for smart sustainable cities to assess the achievement of sustainable development goals*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

3.1.1 **city** [b-ITU-T Y.4900]: A urban geographical area with one (or several) local government and planning authorities.

3.1.2 **smart sustainable city** [b-ITU-T Y.4900]: A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental, as well as cultural aspects.

NOTE – City competitiveness refers to policies, institutions, strategies and processes that determine the city's sustainable productivity.

3.2 Terms defined in this Recommendation

This Recommendation defines the following terms:

3.2.1 **city sustainability**: The sustainability of a smart city based on its economic ability to generate income and employment for the livelihood of its citizens. The guarantee of equitably delivery of social welfare (safety, health, education, etc.) of the citizens despite differences in class, race or gender, the protection of existing environment as well as the future quality and reproducibility of natural resources and the governance of a city, that is, to maintain social conditions of stability, democracy, participation and justice.

3.2.2 **maturity model**: A model derived from one or more specified assessment model(s) that identifies the set of phased development or progress levels showing the assessment categories.

NOTE – Modified from [b-ISO 37153]:2017(en), 3.1

3.2.3 **smart sustainable city maturity model (SSC-MM)**: A model derived to identify the set of phased development or progress levels for a specified city or cities in terms of smart sustainable development.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

EV	Electric Vehicle
ICT	Information and Communication Technology
IoT	Internet of Things
KPI	Key Performance Indicator
SDG	Sustainable Development Goal
SSC	Smart Sustainable City
SSC-MM	Smart Sustainable City Maturity Model

5 Conventions

None.

6 Smart sustainable city maturity model (SSC-MM)

In this Recommendation the smart sustainable city maturity model (SSC-MM) measures the achievement of sustainable development goals (SDGs) in accordance with the information and communication technology (ICT) development of the city. To align with SDGs, the SSC-MM includes the three pillars of sustainability: economic, environmental and social [ITU-T Y.4903].

This Recommendation also features the SSC-MM as a model with five maturity levels and three dimensions as guidelines for cities to progress in order to achieve the SSCs development goals, as shown in Figure 1. A maturity level can be determined for each dimension in a city. The city needs to accomplish all targeted achievements for each selected topic pertaining to a dimension in order to reach a certain maturity level for that topic. Subsequently, the city's SSC maturity level can be determined by combining the maturity levels of the dimensions. The topics used by the city and how they are organised into the three dimensions may be adapted to reflect the approach of each city. The city will incorporate all its ongoing and completed SSC projects and initiatives during its SSC strategy development phase in order to ensure alignment with the existing efforts. Additionally, appropriate safeguards should be put in place for data or information handled in relation to the maturity model. The key performance indicators (KPIs), among others, reflect the city's performance and achievements, thus, they are recommended to be used for assessing maturity levels.
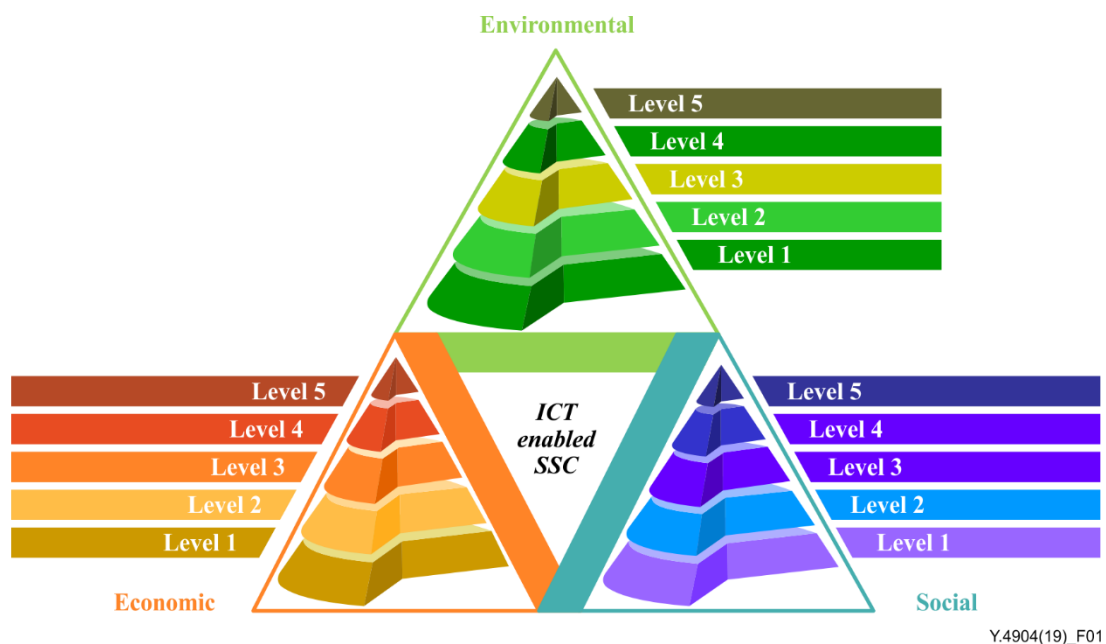
Figure 1 – Smart sustainable city maturity model (SSC-MM)

Based on the definition of SSC and the UN sustainable development goals [b-UN Resolution 288] the following are the maturity dimensions of the SSC-MM:

–   Dimension 1 – Economic: The ability to generate income and employment for the livelihood of the citizens.

–   Dimension 2 – Environmental: The ability to protect the existing as well as the future quality and reproducibility of natural resources.

–   Dimension 3 – Social: The ability to ensure that the welfare (safety, health, education, etc.) of the citizens can be equitably delivered despite differences such as background, race or gender.

The SSC-MM shown in Figure 1 is recommended to

–   describe the general goals of a smart sustainable city;

–   identify development aspects and outline the necessary milestones;

–   help cities to identify KPIs for the purpose of the maturity assessment.

7 Maturity dimensions

7.1 Economic

This dimension is used to evaluate how SSCs help to boost the local economy and improve employment for the livelihood of the citizens.

Economic dimension may include, but are not limited to, the following topics:
– ICT infrastructure;
– Innovation;
– Employment;
– Trade (e-Commerce and export/import);
– Productivity;
– Physical infrastructure (water supply, electricity, health infrastructure, transport, road infrastructure, buildings and urban planning and public space);
– Public sector.

7.2 Environmental

This dimension is applied to evaluate how SSCs help to protect the existing as well as the future quality and reproducibility of natural resources.

Environmental dimension may include, but are not limited to, the following topics:
– Air quality;
– Water and sanitation;
– Noise;
– Environmental quality;
– Biodiversity;
– Energy.

7.3 Social

This dimension is applied to evaluate how SSCs help to ensure the welfare (safety, health, education, etc.) of the citizens and how related services can be equitably delivered despite differences such as background, race or gender.

Social dimension may include, but are not limited to, the following topics:
– Education;
– Health;
– Safety (disaster relief, emergency, public safety and ICT);
– Housing;
– Culture;
– Social inclusion.

8 Maturity levels

This clause describes the five levels of maturity in terms of level goals, common achievements, key practices and KPIs. It uses the topic of 'ICT infrastructure' among others to describe the maturity levels and sample achievements.

NOTE 1 – The maturity level is not aimed for city ranking, but gives the city a long-term roadmap for SSC development and improvements. Cities are encouraged to exchange and share information, knowledge and use cases which are proved to be effective approaches to improve the performance of the city at each level.

NOTE 2 – This Recommendation provides a set of dimensions and maturity levels as a maturity model for SSC. However, the target achievements and their definition levels may be selected according to assessment objects or circumstances.

8.1 Maturity level 1

At this level, the main goal that the city needs to meet is to have a city SSC strategy with an associated plan, once the local decision-makers of the city have developed an overall SSC goal and vision. A clear roadmap or strategic plan is ready to pave the way for ICT enabled SSC developments. An overall city governance is also put in place to manage the SSC development.

The achievements at this level may include, but are not limited, to:
–   The city has developed a detailed strategy to reach out to the relevant stakeholders, including the evaluation of budget, resources and costs related to SSC development;
–   There is a designated senior manager or management team with the responsibility to implement the SSC strategy, coordinate and oversee all smart city initiatives, facilitate co-ordination and identify synergies between them;
–   Common terminologies relating to SSC and common reference model are agreed;
–   Priorities for SSC developments are identified in terms of priority domains, technologies and initiatives;
–   Assessment plan and KPI targets for each maturity level on SSC development are ready;
–   The KPI values of the city current performance are collected and recorded as baseline performance.

8.2 Maturity level 2

The goal the city needs to meet at this level is to align SSC initiatives with the city's SSC strategy, for example, to deploy ICT infrastructures to support operations and activities for SSC development.

The achievements at this level may include, but are not limited to:
–   Development plan for infrastructure that is ready according to the overall SSC roadmap of the city;
–   Key ICT infrastructures are identified to support SSC initiatives;
–   ICT Infrastructures are able to independently operate to provide various SSC services;
–   Records of ICT infrastructures are built and periodically updated;
–   Self-assessment on ICT infrastructure and services that is conducted periodically.
–   Performance improvements are achieved regarding the target KPI values for maturity level 2 as planned in the city SSC strategy.

8.3 Maturity level 3

The goal the city needs to meet at this level is that specific SSC initiatives are deployed, SSC services are provided based on ICT infrastructures via for example, local community service centres, mobile applications and web portals.

The achievements at this level may include, but are not limited to:
–   Departments of the city council or specific authorised organizations, and private-sector companies build separate platforms or systems to systematically manage resources and data;

–	Accessibility of services that are offered via various channels, such as mobile applications, web portals, service platforms, local community terminals;

–	Services are upgraded via functional improvement;

–	Application operation is monitored and analysed to improve service performance and quality;

–	User satisfaction assessments are conducted for targeted communities periodically;

–	Performance improvements are achieved regarding the target KPI values for maturity level 3 as planned in the city SSC strategy.

## 8.4	Maturity level 4

The goal the city needs to meet at this level is to ensure that systems and data are integrated to deliver city services. Technologies such as Internet of things (IoT), cloud computing, artificial intelligence and other advanced technologies may be applied to improve service quality and interoperability.

The achievements at this level may include, but are not limited to:

–	ICT infrastructure interoperability is achieved;

–	Cooperation across infrastructures, systems and/or communities is established;

–	Cross-domain platform and applications are provided;

–	Open data is available to the public from different sources as appropriate;

–	Satisfaction assessments of stakeholders and service providers are conducted periodically.

–	Performance improvements are achieved regarding the target KPI values for maturity level 4 as planned in the city SSC strategy.

## 8.5	Maturity level 5

The goal the city needs to meet at this level is continual improvement of SSC. Each of the city services is investigated to determine ways to increase value to the citizens while reducing operation costs. It is expected that collaboration among systems, data, innovative services and applications will continuously boost city value creation and citizen's happiness. Improved city management effectiveness and efficiency to keep contributing to the long-term SSC vision of the city.

The achievements at this level may include, but are not limited to:

–	Services, applications and cooperation based on collaborative systems are continuously improving;

–	Management and operation based on qualitative and quantitative analyses are effectively established;

–	Continual improvement of services and applications made possible by applying the use of technologies;

–	A systematic assessment process is established to carry out continuous improvement and performance evaluations;

–	Results of assessments and evaluations are analysed, and corresponding action plans are implemented as part of the city SSC strategy.

Table 1 – Recommended achievements for each maturity level

	Strategy	Infrastructure	Data	Services and applications	Assessment	KPIs performance
Maturity Level 1	The overall strategy is developed	Key ICT infrastructures are identified in the strategy	Key aspects on data are identified in the strategy	Strategy and priorities for services and applications on city level are identified	Assessment plan is ready	Long term targets for KPIs are set in city SSC strategy and baseline values for KPIs are collected
Maturity Level 2	SSC initiatives are aligned with the strategy	ICT infrastructures are operated independently	Ontology and methodology to identify, capture, organize and utilise data are agreed	Domain services and applications are operated by particular systems	Self-assessment of ICT infrastructure development and services are carried out	Interim KPI targets for maturity level 2 are achieved
Maturity Level 3	Evaluation of SSC initiatives is carried out	Accessibility of ICT infrastructures is improved	Data is properly stored, processed and managed in systems and platforms	Services and applications are delivered to the public. Application and service operation is monitored and analysed to improve service performance and quality	User satisfaction assessments are carried out	Interim KPI targets for maturity level 3 are achieved
Maturity Level 4	Strategy is developed for improving integration and cooperation	Cross-domain ICT infrastructures are provided with interoperability capabilities	Open data is accessible to the public	Cross-domain services and applications are available to the public	Stakeholders' satisfaction assessments are carried out	Interim KPI targets for maturity level 4 are achieved
Maturity Level 5	Improvement and optimization potential is explored	Continuous development of infrastructure are carried out	Improvements on data sharing, utilization and exchange, etc. are made	Continuous improvements of services and applications are made by applying advanced state of the art technologies	Systematic assessment process is established with corresponding actions	Long term targets for KPIs are achieved

9 Mapping between key performance indicators and maturity levels

One of the requirements to reach the intended maturity level is to achieve the target KPI values set in the performance matrix for the cities. The performance matrix is a combination of KPIs and their target values, which is developed by cities according to their situation and strategy. The city SSC strategy determines the long-term target values and interim target values for KPIs for each maturity level. Cities are recommended to determine their interim target values for KPIs by taking into consideration their priorities, constraints, resources and current situation (baseline) in alignment with their strategy for SSC. The template of performance matrix is provided in Annex A.

For illustration purposes, part of the performance matrix developed by a city with target values for ICT infrastructure KPIs are provided in Table 2.

The example in Table 2 indicates the following measures to gauge performance targets for cities at each maturity level:

1   The city can claim it has reached the performance targets for maturity level 1, if the current value for household Internet access and electricity system outage time are recorded by the SSC strategy, and the performance matrix is developed as shown in Table 2.

2   The city can claim it has reached the performance targets for maturity level 2, if the value of household Internet access reached 30% (i.e., the target for maturity level 2). In this example, no rigid requirement on the value of electricity system outage time needs to be achieved for the city at maturity level 2.

3   The city can claim it has reached the performance targets for maturity level 3, if the value of household Internet access and electricity system outage time reached 40% and 30 minutes, respectively.

4   The city can claim it has reached the performance targets for maturity level 4, if the value of household Internet access and electricity system outage time reached 60% and 25 minutes, respectively.

5   The city can claim it has reached the performance targets for maturity level 5, if the value of household Internet access and electricity system outage time reached 80% and 15 minutes, respectively.

For those cities using the SSC KPIs published by ITU-T, [ITU-T Y.4901], [ITU-T Y.4902], and [ITU-T Y.4903], this Recommendation also provides the mapping of the SSC KPIs for each maturity level based on the maturity level achievements presented in clause 8. The KPIs are listed in two categories:

1   Core indicators: Indicators that all cities are recommended to consider while performing maturity assessment. It is recommended that the target values are achieved for all core indicators listed in a certain level for cities to claim that they have achieved that level.

2   Additional indicators: Indicators cities could consider while developing their own maturity assessment plan and performing maturity assessment.

The ITU-T recommended mapping of core indicators are listed in Annex B, and additional indicators are listed in Appendix I. The SSC KPIs are listed as core indicators if they have been listed as core indicators in one of the ITU-T Y.4901, ITU-T Y.4902, and ITU-T Y.4903 Recommendations. Otherwise, indicators are listed as additional indicators.

Table 2 – Example of performance matrix with target KPI values

Dimension	Topic	KPIs	Current KPI value for maturity level 1	Interim target KPI value for maturity level 2	Interim target KPI value for maturity level 3	Interim target KPI value for maturity level 4	Long-term target KPI value for maturity level 5
Economic	ICT infrastructure	Household Internet access	Baseline collected	Interim target value e.g., 30%	Interim target value e.g., 40%	Interim target value e.g., 60%	Target value e.g., 80%
		Electricity system outage time	Baseline collected	–	Interim target value e.g., 30 mins.	Interim target value e.g., 25 mins.	Target value e.g., 15 mins.

10   Guidance on how to use the maturity model

General steps to perform maturity assessment are indicated below:

1   Map KPIs, such as ITU-T SSC KPIs, into the maturity model;

2   Prepare the maturity assessment related achievements and KPIs as shown in Table 1 (cities can add additional KPIs according to their particular needs and strategy).

3   Develop the performance matrix to show the maturity roadmap by setting target values for KPIs at each maturity level based on cities' situation and strategy.

4   Conduct the maturity assessment at the beginning and also at different stages during the smart city development and determine the performance of the cities.

5   It is recommended to compare the cities' performance with respect to their baseline performance. The results of the comparison are recommended to include the results of the assessment, suggested actions, or any other suitable information required by the maturity model.

Annex A

Sample template for performance matrix to set the target values of KPIs

(This annex forms an integral part of this Recommendation.)

Table A.1 – Sample template for performance matrix of SSC-MM in economic dimension

Dimension	Topic	KPIs	Current KPI value for maturity level 1	Interim target KPI value for maturity level 2	Interim target KPI value for maturity level 3	Interim Target KPI value for maturity level 4	Long-term target KPI value for maturity level 5
Economic	ICT infrastructure	KPI 1	Current value	Interim target value	Interim target value	Interim target value	Target value
		KPI 2					
		…					
	Innovation	KPI 1					
		KPI 2					
		…					
	Employment	KPI 1					
		KPI 2					
		…					
	Trade	KPI 1					
		KPI 2					
		…					
	Productivity	KPI 1					
		KPI 2					
		…					
	Physical infrastructure	KPI 1					
		KPI 2					
		…					
	Public sector	KPI 1					
		KPI 2					
		…					
	…	KPI 1					
		…					

Table A.2 – Sample template for performance matrix of SSC-MM in environmental dimension

Dimension	Topic	KPIs	Current KPI value for maturity level 1	Interim target KPI value for maturity level 2	Interim target KPI value for maturity level 3	Interim target KPI value for maturity level 4	Long-term target KPI value for maturity level 5
Environmental	Air quality	KPI 1	Current value	Interim target value	Interim target value	Interim target value	Target value
		KPI 2					
		…					
	Water and sanitation	KPI 1					
		KPI 2					
		…					
	Noise	KPI 1					
		KPI 2					
		…					
	Environmental quality	KPI 1					
		KPI 2					
		…					
	Biodiversity	KPI 1					
		KPI 2					
		…					
	Energy	KPI 1					
		KPI 2					
		…					
	…	KPI 1					
		…					

Table A.3 – Sample template for performance matrix of SSC-MM in social dimension

Dimension	Topic	KPIs	Current KPI value for maturity level 1	Interim target KPI value for maturity level 2	Interim target KPI value for maturity level 3	Interim target KPI value for maturity level 4	Long-term target KPI value for maturity level 5
Social	Education	KPI 1	Current value	Interim target value	Interim target value	Interim target value	Target value
		KPI 2					
		…					
	Health	KPI 1					
		KPI 2					
		…					
	Safety	KPI 1					
		KPI 2					
		…					
	Housing	KPI 1					
		KPI 2					
		…					
	Culture	KPI 1					
		KPI 2					
		…					
	Social inclusion	KPI 1					
		KPI 2					
		…					
	…	KPI 1					
		…					

Annex B

ITU-T recommended core indicators for each maturity level
(This annex forms an integral part of this Recommendation.)

B.1   Core indicators recommended to be considered at maturity level 1 and onward

Maturity level	Topic	KPI	Referenced ITU-T Recommendations		
			Y.4901	Y.4902	Y.4903
Level 1 and onward	Innovation	R&D expenditure	√		√
Level 1 and onward	Innovation	Patents		√	√
Level 1 and onward	Air quality	Air pollution		√	√
Level 1 and onward	Air quality	GHG emissions		√	√
Level 1 and onward	Environmental quality	Compliance with WHO endorsed exposure guidelines	√		√
Level 1 and onward	Noise	Exposure to noise		√	√
Level 1 and onward	Energy	Renewable energy consumption		√	√
Level 1 and onward	Health	Life expectancy		√	√
Level 1 and onward	Safety – ICT	Information security and privacy protection	√		√
Level 1 and onward	Social inclusion	Gender income equity		√	√
Level 1 and onward	Social inclusion	Public participation		√	√
Level 1 and onward	Physical infrastructure - water supply	Water supply loss		√	
Level 1 and onward	Water and sanitation	Quality of drinking water			√
Level 1 and onward	Safety – ICT	Child online protection (COP)	√		
Level 1 and onward	Social inclusion	Gini coefficient		√	
Level 1 and onward	Public space and nature	Green areas surface		√	
Level 1 and onward	Innovation	Investments in ICT innovation		√	

Maturity level	Topic	KPI	Referenced ITU-T Recommendations		
			Y.4901	Y.4902	Y.4903
Level 1 and onward	Employment	Employment rate			√
Level 1 and onward	Employment	ICT sector employment	√		
Level 1 and onward	Employment	Service industry employment		√	
Level 1 and onward	Productivity	Labour productivity			√
Level 1 and onward	Savings	Saving rate		√	
Level 1 and onward	Household income/consumption	Household ICT expenditures		√	
Level 1 and onward	Capital investment	Improvement of industry productivity through ICT		√	
Level 1 and onward	Capital investment	Investment intensity in ICT projects enabling SSC	√		
Level 1 and onward	Capital investment	Intangible investments as a proportion of GDP	√		
Level 1 and onward	Water and sanitation	Water consumption			√
Level 1 and onward	Water and sanitation	Quality of city water resources		√	
Level 1 and onward	Environmental quality	Green areas and public spaces			√
Level 1 and onward	Environmental quality	Adoption of a consistent planning approval process with respect to EMF			√
Level 1 and onward	Energy	Electricity consumption			√
Level 1 and onward	Education	Adult literacy			√
Level 1 and onward	Education	School enrolment			√
Level 1 and onward	Education	Higher education ratio			√
Level 1 and onward	Health	Maternal mortality			√
Level 1 and onward	Health	Doctors			√
Level 1 and onward	Safety – disaster relief	Resilience plans			√
Level 1 and onward	Housing	Housing expenditure			√

B.2   Core indicators recommended to be considered by maturity level 2 and onward

Maturity level	Topic	KPI	Referenced ITU-T Recommendations		
			Y.4901	Y.4902	Y.4903
Level 2 and onward	ICT infrastructure	Household Internet access	√		√
Level 2 and onward	ICT infrastructure	Household with a computer	√		√
Level 2 and onward	Physical infrastructure - water supply	Availability of smart water meters	√		√
Level 2 and onward	Physical infrastructure- electricity	Availability of smart electricity meters	√		√
Level 2 and onward	Education	Students ICT access		√	√
Level 2 and onward	ICT infrastructure	Wireless broadband subscriptions	√		
Level 2 and onward	ICT infrastructure	Fixed broadband subscriptions	√		
Level 2 and onward	Education	e-learning systems	√		
Level 2 and onward	Physical infrastructure – Health infrastructure	Sporting facilities		√	
Level 2 and onward	Physical infrastructure – building	Public building sustainability	√		
Level 2 and onward	Air quality	Air pollution monitoring system	√		
Level 2 and onward	Education	e-learning systems	√		
Level 2 and onward	Culture	Cultural resources online			√
Level 2 and onward	Physical infrastructure – transport	Public transport network			√
Level 2 and onward	Environmental quality	Solid waste collection			√
Level 2 and onward	Environmental quality	Solid waste treatment			√
Level 2 and onward	Water and sanitation	Wastewater treatment			√
Level 2 and onward	Water and sanitation	Wastewater collection			√
Level 2 and onward	Water and sanitation	Household sanitation			√
Level 2 and onward	Water and sanitation	Recycling of waste		√	

Maturity level	Topic	KPI	Referenced ITU-T Recommendations		
			Y.4901	Y.4902	Y.4903
Level 2 and onward	Water and sanitation	Sewage system coverage		√	
Level 2 and onward	Environmental quality	Solid waste collection			√
Level 2 and onward	Environmental quality	Solid waste treatment			√
Level 2 and onward	Housing	Informal settlements			√
Level 2 and onward	Culture	Cultural infrastructure			√

B.3   Core indicators recommended to be considered by maturity level 3 and onward

Maturity level	Topic	KPI	Referenced ITU-T Recommendations		
			Y.4901	Y.4902	Y.4903
Level 3 and onward	Physical infrastructure-electricity	Electricity system outage time		√	√
Level 3 and onward	Physical infrastructure – transport	Real-time public transport information	√		√
Level 3 and onward	Physical infrastructure – transport	Road traffic efficiency		√	√
Level 3 and onward	Environmental quality	Availability of EMF information	√		√
Level 3 and onward	Health	Electronic health records	√		√
Level 3 and onward	Safety – disaster relief	Disaster and emergency alert	√	√	
Level 3 and onward	Safety – emergency	Emergency service response times	√		√
Level 3 and onward	Physical infrastructure - water supply	Water supply ICT monitoring	√		
Level 3 and onward	Physical infrastructure – transport	Traffic monitoring	√		
Level 3 and onward	Trade	e-commerce purchase ratio	√		
Level 3 and onward	Productivity	Companies providing online services	√		
Level 3 and onward	Water and sanitation	Drainage system management	√		
Level 3 and onward	Noise	ICT noise monitoring	√		
Level 3 and onward	Energy	Energy saving in households		√	
Level 3 and onward	Health	Adoption of telemedicine	√		
Level 3 and onward	Physical infrastructure-electricity	Electricity system outage frequency			√

Maturity level	Topic	KPI	Referenced ITU-T Recommendations		
			Y.4901	Y.4902	Y.4903
Level 3 and onward	Physical infrastructure – transport	Use of public transport		√	
Level 3 and onward	Services and information platforms	Use of social media by the public sector	√		
Level 3 and onward	Services and information platforms	Existence of systems, rules and regulations to ensurethe protection of privacy in public service	√		
Level 3 and onward	Physical infrastructure - water supply	City fresh water sources monitored using ICT	√		
Level 3 and onward	Infrastructure/ connection to services – road infrastructure	Availability of parking guidance systems	√		
Level 3 and onward	Infrastructure/ connection to services – road infrastructure	Street lighting management using ICT	√		
Level 3 and onward	Infrastructure/ connection to services – road infrastructure	Gas system management using ICT	√		
Level 3 and onward	Capital investment	Improvement of industry productivity through ICT		√	
Level 3 and onward	Capital investment	Application of computing platforms	√		
Level 3 and onward	Water and sanitation	Access to improved water source			√
Level 3 and onward	Water and sanitation	Sewage system management using ICT	√		
Level 3 and onward	Energy	Access to electricity			√
Level 3 and onward	Health	Use of electronic medical records	√		
Level 3 and onward	Safety/security public place	Adoption of ICT for disaster management	√		
Level 3 and onward	Safety/security public place	Availability of ICT based safety systems	√		
Level 3 and onward	Culture	Connected libraries			√

Maturity level	Topic	KPI	Referenced ITU-T Recommendations		
			Y.4901	Y.4902	Y.4903
Level 3 and onward	Environmental quality	Soil pollution avoidance		√	
Level 3 and onward	Biodiversity	Native species monitoring			√
Level 3 and onward	Social inclusion	Opportunities for people with special needs			√
Level 3 and onward	Openness and public participation	Use of online city services		√	

B.4 Core indicators recommended to be considered by maturity level 4 and onward

Maturity level	Topic	KPI	Referenced Recommendations		
			Y.4901	Y.4902	Y.4903
Level 4 and onward	Health	Sharing of medical resources	√		√
Level 4 and onward	Environmental quality	Perception on environmental quality		√	
Level 4 and onward	Physical infrastructure – building	Integrated building management systems in public buildings	√		

B.5 Core indicators recommended to be considered by maturity level 5

Maturity level	Topic	KPI	Referenced ITU-T Recommendations		
			Y.4901	Y.4902	Y.4903
Level 5	Trade	Knowledge-intensive export/import		√	

Appendix I

ITU-T recommended additional indicators for each maturity level

(This appendix does not form an integral part of this Recommendation.)

I.1 Additional indicators recommended to be considered at maturity level 1 and onward

Maturity level	Topic	KPI	Referenced ITU-T Recommendations		
			Y.4901	Y.4902	Y.4903
Level 1 and onward	Physical infrastructure – urban planning	Urban development and spatial planning			√
Level 1 and onward	Public space and nature	Protected natural area			√
Level 1 and onward	Innovation	Small and medium-sized enterprises (SMEs)			√
Level 1 and onward	Employment	Tourism industry employment			√
Level 1 and onward	Capital investment	Intangible investments in comparison with total investments	√		
Level 1 and onward	Air quality	GHG emissions per sector per capital		√	
Level 1 and onward	Water and sanitation	Quality of piped water		√	
Level 1 and onward	Energy	Public buildings energy consumption			√
Level 1 and onward	Safety – Disaster relief	Natural disaster-related deaths			√
Level 1 and onward	Safety – Disaster relief	Disaster-related economic losses			√
Level 1 and onward	Social inclusion	Inflation rate		√	
Level 1 and onward	Employment	Creative industry employment		√	√
Level 1 and onward	Health	Health insurance		√	√

## I.2	Additional indicators recommended to be considered by maturity level 2 and onward

Maturity level	Topic	KPI	Referenced ITU-T Recommendations		
			Y.4901	Y.4902	Y.4903
Level 2 and onward	ICT infrastructure	Availability of Wi-Fi in public areas	√		
Level 2 and onward	ICT infrastructure	Availability of mobile-cellular telephones	√		
Level 2 and onward	ICT infrastructure	International Internet bandwidth	√		
Level 2 and onward	ICT infrastructure	Use of Internet by city inhabitants	√		
Level 2 and onward	ICT infrastructure	Coverage rate of digital broadcasting network	√		
Level 2 and onward	ICT infrastructure	Availability of ultra-high speed wireline connection	√		
Level 2 and onward	ICT infrastructure	Availability of high-speed mobile broadband.	√		
Level 2 and onward	ICT infrastructure	Availability of smart phones and tablets	√		
Level 2 and onward	ICT infrastructure	Quality of fixed broadband	√		
Level 2 and onward	ICT infrastructure	Quality of mobile broadband	√		
Level 2 and onward	ICT infrastructure	Household with a mobile device			√
Level 2 and onward and onward	Physical infrastructure – urban planning	Pedestrian infrastructure			√
Level 2 and onward	Health	In-patient hospital beds			√
Level 2 and onward	Culture	Protected cultural heritage sites			√

I.3 Additional indicators recommended to be considered by maturity level 3 and onward

Maturity level	Topic	KPI	Referenced ITU-T Recommendations		
			Y.4901	Y.4902	Y.4903
Level 3 and onward	Physical infrastructure – transport	Share of EVs			√
Level 3 and onward	Infrastructure/ connection to services – road infrastructure	Availability of visualised real-time information regarding gas use	√		
Level 3 and onward	Infrastructure/ connection to services – road infrastructure	Availability of online bike/car sharing system	√		
Level 3 and onward	Infrastructure/ connection to services – road infrastructure	Use of real-time navigation	√		
Level 3 and onward	Knowledge economy	Application of geographic information system (GIS)	√		
Level 3 and onward	Knowledge economy	Application of big data	√		
Level 3 and onward	Public sector	e-Public services adoption			√
Level 3 and onward	Water and sanitation	Water saving in households			√
Level 3 and onward	Energy	Electricity use for street lighting		√	
Level 3 and onward	Education	Application of e-learning in schools	√		
Level 3 and onward	Education	Application of e-learning in academic studies	√		
Level 3 and onward	Culture	Interest in online access to cultural resources		√	
Level-3 and onward	Physical infrastructure-electricity	Electricity supply management using ICT	√		√

I.4 Additional indicators recommended to be considered by maturity level 4 and onward

Maturity level	Topic	KPI	Referenced ITU_T Recommendations		
			Y.4901	**Y.4902**	**Y.4903**
Level 4 and onward	Trade	Electronic and mobile payment			√
Level 4 and onward	Public sector	Open data			√
Level 4 and onward	Trade	Electronic and mobile payment			√

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