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Series Y

Supplement 39
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SERIES Y: GLOBAL INFORMATION INFRASTRUCTURE, INTERNET PROTOCOL ASPECTS AND NEXT-GENERATION NETWORKS, INTERNET OF THINGS AND SMART CITIES

ITU-T Y.4900 Series – Key performance indicators definitions for smart sustainable cities

ITU-T Y-series Recommendations – Supplement 39

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ITU-T Y-SERIES RECOMMENDATIONS

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

GLOBAL INFORMATION INFRASTRUCTURE	
General	Y.100–Y.199
Services, applications and middleware	Y.200–Y.299
Network aspects	Y.300–Y.399
Interfaces and protocols	Y.400–Y.499
Numbering, addressing and naming	Y.500–Y.599
Operation, administration and maintenance	Y.600–Y.699
Security	Y.700–Y.799
Performances	Y.800–Y.899
INTERNET PROTOCOL ASPECTS	
General	Y.1000–Y.1099
Services and applications	Y.1100–Y.1199
Architecture, access, network capabilities and resource management	Y.1200–Y.1299
Transport	Y.1300–Y.1399
Interworking	Y.1400–Y.1499
Quality of service and network performance	Y.1500–Y.1599
Signalling	Y.1600–Y.1699
Operation, administration and maintenance	Y.1700–Y.1799
Charging	Y.1800–Y.1899
IPTV over NGN	Y.1900–Y.1999
NEXT GENERATION NETWORKS	
Frameworks and functional architecture models	Y.2000–Y.2099
Quality of Service and performance	Y.2100–Y.2199
Service aspects: Service capabilities and service architecture	Y.2200–Y.2249
Service aspects: Interoperability of services and networks in NGN	Y.2250–Y.2299
Enhancements to NGN	Y.2300–Y.2399
Network management	Y.2400–Y.2499
Network control architectures and protocols	Y.2500–Y.2599
Packet-based Networks	Y.2600–Y.2699
Security	Y.2700–Y.2799
Generalized mobility	Y.2800–Y.2899
Carrier grade open environment	Y.2900–Y.2999
FUTURE NETWORKS	Y.3000–Y.3499
CLOUD COMPUTING	Y.3500–Y.3999
INTERNET OF THINGS AND SMART CITIES AND COMMUNITIES	
General	Y.4000–Y.4049
Definitions and terminologies	Y.4050–Y.4099
Requirements and use cases	Y.4100–Y.4249
Infrastructure, connectivity and networks	Y.4250–Y.4399
Frameworks, architectures and protocols	Y.4400–Y.4549
Services, applications, computation and data processing	Y.4550–Y.4699
Management, control and performance	Y.4700–Y.4799
Identification and security	Y.4800–Y.4899
Evaluation and assessment	Y.4900–Y.4999

For further details, please refer to the list of ITU-T Recommendations.

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Supplement 39 to ITU-T Y-series Recommendations

ITU-T Y.4900 Series – Key performance indicators definitions for smart sustainable cities

Summary

Supplement 39 to ITU-T L-series Recommendations provides a general overview of a key set of indicators related to the use of information and communication technology (ICT) and corresponding impacts on city sustainability in smart sustainable cities (SSC). It is intended for an audience of SSC decision-makers and strategists, interested in gaining an in-depth understanding of existing knowledge and approaches to indexes and key performance indicators (KPIs) for SSC. This Supplement illustrates the vast body of resources gathered on the evaluation index systems of smart cities and KPIs for sustainable cities, among others, that served as a background for the development of related series of KPIs Recommendations and Supplements. The resources presented in this Supplement were analysed with respect to common elements, and a set of indicators focusing on ICT and its contribution to SSC were developed.

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The World Telecommunication Standardization Assembly (WTSA), which meets every four years, establishes the topics for study by the ITU-T study groups which, in turn, produce Recommendations on these topics.

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

In some areas of information technology which fall within ITU-T's purview, the necessary standards are prepared on a collaborative basis with ISO and IEC.

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Table of Contents

		Page
1	Scope	1
2	Definitions	1
	2.1 Terms defined elsewhere	1
	2.2 Term defined in this Supplement	1
3	Abbreviations and acronyms	2
4	Analysis of key performance indicators systems	3
5	Conclusions	19
Appendix I – ISO: Index system of smart city		20
Appendix II – ITU: ICT development index (IDI)		21
Appendix III – UN-Habitat: City prosperity index		22
Appendix IV – China Institute of Communications: Index system of smart city		24
Appendix V – China, Ministry of Housing and Urban-Rural Development: Index system of national pilot smart city		27
Appendix VI		31
Appendix VII – Italy: Index system of smart city and smart statistics		34
Appendix VIII – Japan: Index system of SSC being discussed in the sub working group for SSC of the Telecommunication Technology Committee		37
Appendix IX – GCIF: Global city indicators facility		40
Appendix X – ICLEI: Global protocol for community-scale GHG emissions		45
Appendix XI – ESCI: Indicators of the emerging and sustainable cities initiative		47
Appendix XII – Vienna University of Technology: European ranking of medium-sized cities		54
Appendix XIII – Leibnitz Institute: European system of social indicators		57
Appendix XIV – Smart cities wheel		66
Appendix XV – Ericsson: Networked society city index		68
Appendix XVI – IBM: Smarter city assessment		72
Appendix XVII – IDC: Index system of SSC		75
	XVII.1 Key components of smartness	75
	XVII.2 Component weighting	75
	XVII.3 Key indicators	77
Appendix XVIII – PwC: Cities of opportunities index		80
Appendix XIX – Siemens: Green city index		86
Bibliography		88

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Introduction

This Supplement defines key performance indicators (KPIs) for smart sustainable cities (SSC). The following documents have been developed with regards to KPIs for SSC:

- Recommendation ITU-T Y.4900/L.1600 on overview of KPIs in smart sustainable cities;
- Recommendation ITU-T Y.4901/L.1601 on KPIs related to the use of information and communication technology (ICT) in smart sustainable cities. This Recommendation lists the KPIs focusing on ICT use in SSCs;
- Recommendation ITU-T Y.4902/L.1602 on KPIs related to the sustainability impacts of ICT in smart sustainable cities. This Recommendation lists the KPIs proposed for ICT impact on sustainability.

This Supplement provides a comparative analysis of 19 different index sets. Supplementary information on each of the approaches reviewed is presented in the appendices, thus providing a comprehensive background of the resources that formed the series of KPI Recommendations and Supplements.

In order to ensure the inclusion of a wide array of perspectives, the indexes reviewed originate from the following sources: international, national/regional, city organization, academic, and company. By doing so, the analysis evidenced the broad set of perspectives and approaches used to measure and assess the performance of SSC, and in particular, the role of ICTs in urban sustainability, thus demonstrating the importance of KPIs development for SSCs.

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Supplement 39 to ITU-T Y-series Recommendations

ITU-T Y.4900 Series – Key performance indicators definitions for smart sustainable cities

1 Scope

This Supplement provides a general overview of a key set of indicators related to the use of information and communication technology (ICT) and corresponding impacts on city sustainability in smart sustainable cities (SSC). It is intended for an audience of SSC decision-makers and strategists, interested in gaining a more in-depth understanding of existing knowledge and approaches to indexes and key performance indicators (KPIs) for SSC. This Supplement illustrates the vast body of resources gathered on the evaluation index systems of smart cities and KPIs for sustainable cities, among others, that served as a background for the development of related series of KPIs Recommendations and Supplements. The resources presented in this Supplement were analysed with respect to common elements, and a set of indicators focusing on ICT and its contribution to smart sustainable cites were developed.

2 Definitions

2.1 Terms defined elsewhere

This Supplement uses the following terms defined elsewhere:

2.1.1 knowledge economy [b-OECD_KE]: An economy whose most important elements are the possession, control, production and utility of knowledge and intelligent resources, while 'knowledge-based economy' is an expression coined to describe trends in advanced economies towards greater dependence on knowledge, information and high-skill levels, and the increasing need for ready access to all of these by the business and public sectors.

2.1.2 smart sustainable cities [b-ITU-T TR SSC Def]: 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 and environmental aspects.

2.2 Term defined in this Supplement

This Supplement defines the following term:

2.2.1 city sustainability: The sustainability of a city is based on four main aspects:

- economic: The ability to generate income and employment for the livelihood of the inhabitants;
- social: The ability to ensure well-being (safety, health, education, etc.) of the citizens to be equally delivered despite differences in class, race or gender;
- environmental: The ability to protect future quality and reproducibility of natural resources;
- governance: The ability to maintain social conditions of stability, democracy, participation and justice.

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3 Abbreviations and acronyms

This Supplement uses the following abbreviations and acronyms:

BB	Broadband
CAGR	Compound Annual Growth Rate
CBD	Central Business District
CIC	China Institute of Communications
EHR	Electronic Health Record
EMF	Electromagnetic Field
ERMC	European Ranking of Middle-sized Cities
ESCI	Emerging and Sustainable Cities Initiative
EUSI	European System of Social Indicators
EV	Electric Vehicle
FDI	Foreign Direct Investment
FG-SSC	Focus Group on Smart Sustainable Cities
FTTx	Fibre to the x (B – building, business; H – Home; C – Cabinet, Curb)
GCIF	Global City Indicators Facility
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIS	Geographic Information System
GP	General Practitioner
GPC	Global Protocol for Community scale GHG emissions
HQ	Headquarter
HSPA+	Evolved High-Speed Packet Access
IBM	International Business Machine
ICLEI	International Council for Local Environmental Initiatives
ICT	Information and Communication Technology
IDC	International Data Corporation
IDI	ICT Development Index
IPPU	Industrial Processes and Product Uses
KPIs	Key Performance Indicators
MOHURD	Ministry Of Housing and Urban-Rural Development, China
OECD	Organization for Economic Co-operation and Development
PM10	Particulate Matter up to 10 micrometres in size
PWC	Price Waterhouse Coopers
R&D	Research and Development
RES	Renewable Energy Sources

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SDR Special Drawing Rights

SSC Smart Sustainable Cities

SWB Subjective Well-Being

TTC Telecommunication Technology Committee

UNFCCC United Nations Framework Convention on Climate Change

UN-Habitat United Nations Human Settlements Programme

WG Working Group

Wi-Fi Wireless Fidelity

4 Analysis of key performance indicators systems

This clause provides an analysis of 19 different sets of index systems and KPIs related to the use of ICTs and sustainability in cities.

The following are highlights of some of the stakeholders and the benefits associated with the development of KPIs for SSC:

- for city dwellers and non-profit citizen organizations, by enabling them to understand the development and progress of SSC with respect to ICT's impact;
- for the development and operation of SSC organizations, including planning units, service providers, operation and maintenance organizations, among others, by helping them to fulfil the tasks of sharing information related to the use of ICTs and their impact on the sustainability of cities;
- for evaluation and ranking agencies, including academia, by supporting them in the selection of relevant KPIs for assessing the contribution from ICT in the development of SSC.

The analysis in this Supplement was conducted through a comparison based on the key dimensions and sub-dimensions that characterize SSC, namely:

SSC dimension	No. of indicators/sub-dimensions
ICT	14 indicators/cover network facilities and information facilities
Environmental sustainability	14 indicators/cover environment and energy and natural resources
Productivity	12 indicators/cover innovation and economic sustainability
Quality of life	22 indicators/cover convenience and comfort, security and safety, health care, and education and training
Equity and social inclusion	11 indicators/cover openness and public participation, social sustainability, and governance sustainability
Physical infrastructure	15 indicators/cover building, transport, sanitation, and municipal pipe networks

These various dimensions and sub-dimensions are developed in further detail in the ITU-T KPI series of Recommendations and Supplements that are part of the ITU-T KPI series.

A comparative analysis of 19 different index sets is summarized in Table 4-1. As per the objectives and the scope of this Supplement, supplementary information on each of the approaches reviewed is presented in the appendices, providing a comprehensive background of the resources that formed the ITU-T KPI series.

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In order to ensure the inclusion of a wide array of perspectives, the indexes reviewed originate from five different sources: international, national/regional, city organization, academic, and company, as follows:

- International:
  a) The International Organization for Standardization (ISO), smart community infrastructures (Appendix I);
  b) The International Telecommunication Union (ITU), ICT development index (IDI) (Appendix II);
  c) United Nations Human Settlements Programme (UN-Habitat), city prosperity index (Appendix III).
- National/regional:
  d) China Institute of Communications, evaluation index system of a smart city (Appendix IV);
  e) China, Ministry of Housing and Urban-Rural Development (MOHURD), index system of a pilot smart city (Appendix V);
  f) European Union, European common indicators (EU research initiative "Towards a local sustainability profile") (Appendix VI);
  g) Italy, smart city and smart statistics (Appendix VII);
  h) Japan, Sub working group for SSC of the Telecommunication Technology Committee (TTC), index system of SSC (Appendix VIII).
- City organization:
  i) Global city indicators facility (GCIF), global city indicators (Appendix IX);
  j) International Council for Local Environmental Initiatives (ICLEI), global protocol for community scale greenhouse gas (GHG) emissions (GPC) (Appendix X);
  k) Inter-American Development Bank, indicators of the emerging and sustainable cities initiative (ESCI) (Appendix XI).
- Academic:
  l) Centre of Regional Science (SRF), Vienna University of Technology, European smart cities, ranking of European medium-sized cities (Appendix XII);
  m) Leibnitz Institute, European system of social indicators (Appendix XIII);
  n) Boyd Cohen, Smart Cities Wheel (Appendix XIV).
- Company:
  o) Ericsson, networked society city index (Appendix XV);
  p) International Business Machine (IBM), smarter city assessment (Appendix XVI);
  q) International Data Corporation (IDC), smart cities index (Appendix XVII);
  r) Price Waterhouse Coopers (PwC), cities of opportunity index (Appendix XVIII);
  s) Siemens, green city index (Appendix XIX).

This body of knowledge was analysed and compiled in two tables:

Table 4-1 compares the different indexes, identifying whether or not they include indicators related to the key SSC dimensions and sub-dimensions identified above.

Table 4-2 contributes further to this analysis, by identifying the number of similar indicators that exist between the set of indicators and the SSC dimensions, as well as the percentage of similar indicators and the distribution of these indicators.

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Table 4-1 – Comparison of KPIs between index systems and sets of KPIs

Dimension	Sub-dimension	Indicators	ISO	IDI	UN-Habitat	CIC	MOHURD	ECI	Italy	TTC	GCIF	GPC	ESCI	ERMC	EUSI	Wheel	Ericsson	IBM	IDC	PwC	Siemens
D1 ICT	D1.1 Network facilities	I1.1.1 Fixed (wired)-broadband (BB) subscriptions per 100 inhabitants		X		X	X		X		X		X				X	X	X		
		I1.1.2 International Internet bandwidth (bit/s) per Internet user	X	X		X			X	X				X			X	X	X	X	
		I1.1.3 Wireless-broadband subscriptions per 100 inhabitants		X		X	X		X		X		X				X	X	X		
		I1.1.4 Percentage of households with Internet access	X	X		X			X		X						X	X	X	X	
		I1.1.5 Coverage rate of next-generation broadcasting network	X				X														
		I1.1.6 Electromagnetic field (EMF) compliance framework in place																			
		I1.1.7 Planning legislation incorporates ICT																			

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		networks and antenna requirements																			
		I1.1.8 ICT EMF information availability to the public																			
	D1.2 Information facilities	I1.2.1 Percentage of enterprises providing network-based services (e-commerce, e-learning, e-entertainment, cloud computing)	X			X			X												
		I1.2.2 Proportion of business based on cloud computing				X	X														
		I1.2.3 Proportion of business based on geographic information system (GIS) (location, navigation, etc.)																			
		I1.2.4 Percentage of households with at least one computer		X		X			X					X			X		X		

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		I1.2.5 Level of cyber-security				X															
		I1.2.6 Ratio of children online protection																			
D2 Environmental sustainability	D2.1 Environment	I2.1.1 Proportion of information published on environmental quality				X													X		
		I2.1.2 Progress degree of ICT in the protection of main city water resources				X				X			X		X			X	X		
		I2.1.3 Effect of flood control monitoring by means of ICT measures											X					X	X		
		I2.1.4 Proportion of water pollution control by means of ICT measures				X				X	X		X		X		X	X	X		X
		I2.1.5 Proportion of air pollution monitoring by means of ICT measures			X	X		X	X				X		X		X		X	X	X

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		I2.1.6 Proportion of toxic substances monitoring by means of ICT measures				X				X											
		I 2.1.7 Proportion of noise monitoring by means of ICT measures				X		X					X								
		I2.1.8 Solid waste disposal management with ICT measures	X		X	X				X	X		X		X		X		X	X	X
	D2.2 Energy and natural resources	I2.2.1 Improvement of civilian electricity usage (per capita) with ICT measures				X			X	X			X	X							X
		I2.2.2 Improvement of industrial electricity usage (per gross domestic product (GDP)) with ICT measures			X	X			X	X			X	X					X		
		I2.2.3 Improvement of civilian water usage (per capita) with ICT measures					X		X	X			X	X							X
		I2.2.4 Improvement					X		X	X				X							

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		of industrial water usage (per GDP) with ICT measures																			
		I2.2.5 Improvement of fossil fuel usage with ICT measures (per GDP)	X		X		X	X	X	X							X				X
		I2.2.6 Improvement of rare metal/noble metal usage (per GDP) with ICT measures								X											
D3 Productivity	D3.1 Innovation	I3.1.1 Percentage of research and development (R&D) expenditure in GDP							X	X				X							
		I3.1.2 Ratio of knowledge-intensive enterprises							X					X						X	
		I3.1.3 Revenue share of knowledge-intensive enterprise											X								
		I3.1.4 Patent number per 100,000 inhabitant							X					X			X				
		I3.1.5 Importance as decision-making												X							

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		centre (headquarter (HQ), etc.)																			
		I3.1.6 SSC new projects opportunities															X			X	
		I3.1.7 Penetration of teleworking system							X										X		
		I3.1.8 Improvement of traditional industry with ICT				X	X														
	D3.2 Economic sustainability	I3.2.1 Percentage of knowledge economy in total investment			X		X		X											X	
		I3.2.2 Percentage of knowledge economy in GDP							X											X	
		I3.2.3 Employment rate in knowledge-intensive sectors			X		X		X	X			X	X	X		X		X	X	
		I3.2.4 Percentage of e-commerce transaction amount				X	X		X	X							X	X	X		
D4 Quality of life	D4.1 Convenience and comfort	I4.1.1 Satisfaction with online commercial and financial services				X	X			X					X	X		X	X		

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		I4.1.2 Satisfaction with environmental safety				X	X								X						
		I4.1.3 Convenience of government services				X	X	X	X					X				X			
		I4.1.4 Convenience of smart traffic information administration and service				X	X						X			X			X		
		I4.1.5 Satisfaction with quality of public transport				X							X	X	X			X	X	X	
		I4.1.6 Satisfaction with crime prevention and security control				X				X			X	X	X					X	
		I4.1.7 Satisfaction with countermeasures against disaster							X				X								
		I4.1.8 Satisfaction with food drug safety monitoring				X															
		I4.1.9 Convenience of urban medical				X									X						

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Table 4-1 – Comparison of KPIs between index systems and sets of KPIs

Dimension	Sub-dimension	Indicators	ISO	IDI	UN-Habitat	CIC	MOHURD	ECI	Italy	TTC	GCIF	GPC	ESCI	ERMC	EUSI	Wheel	Ericsson	IBM	IDC	PwC	Siemens
		care																			
		I4.1.10 Convenience for citizens to access educational resources				X							X	X	X						
		I4.1.11 Perception of proof against risk of poverty											X	X	X	X					
		I4.1.12 Satisfaction with housing conditions											X		X					X	
	D4.2 Security and safety	I4.2.1 Accident prediction ratio			X					X											
		I4.2.2 Penetration of ICT for disaster prevention				X												X	X		
		I4.2.3 Publication rate of disaster alert				X							X					X	X		
		I4.2.4 Penetration of city video surveillance																	X		
	D4.3 Health care	I4.3.1 Percentage of archiving electronic health records (EHRs) for residents				X			X												

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		I4.3.2 Usage rate of electronic medical records				X			X												
		I4.3.3 Sharing rate of resource and information among hospitals				X			X												
		I4.3.4 Coverage rate of household e-health services							X												
	D4.4 Education and training	I4.4.1 Effectiveness of hatching smart tech from knowledge centres (research centres, universities, etc.)				X								X							
		I4.4.2 Penetration of e-learning system				X			X										X		
D5 Equity and social inclusion	D5.1 Openness and public participation	I5.1.1 Immigration-friendly environment contributed by ICT measures												X							
		I5.1.2 Improvement of turnout at city hearings by means of ICT			X	X	X		X				X	X	X				X		

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		I5.1.3 Online civic engagement			X	X	X		X		X			X	X				X		X
	D5.2 Social sustainability	I5.2.1 Feasibility of appealing online			X	X			X						X				X		
		I5.2.2 Atmosphere of free online comment				X	X		X						X				X		
		I5.2.3 Contribution in increasing consciousness of citizenship and social coherence				X			X					X	X						
	D5. 3 Governance sustainability	I5.3.1 Digital access to urban planning and budget document				X	X		X				X			X			X		
		I5.3.2 Appliance of smart community services																	X		
		I5.3.3 Penetration rate of government online services			X	X	X		X							X			X		
		I5.3.4 Percentage of government information open				X	X		X				X			X			X		
		I5.3.5 Penetration of					X						X								

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Dimension	Sub-dimension	Indicators	ISO	IDI	UN-Habitat	CIC	MOHURD	ECI	Italy	TTC	GCIF	GPC	ESCI	ERMC	EUSI	Wheel	Ericsson	IBM	IDC	PwC	Siemens
		smart impediment removal (accessibility) system																			

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Table 4-2 – Proximity statistics of KPIs for SSC

Source	Number of similar indicators	Percentage of similar indicators (%)	Distribution of indicators
ISO	7	7.95	Internet access and bandwidth, broadcasting network, ratio of network enterprises, solid waste, fossil fuel, road sensing, sewage management, water recycling, gas management, electricity supply.
IDI	5	5.68	Internet access and bandwidth, broadband subscription, wireless subscription, home computer.
UN-Habitat	11	12.5	Air pollution, solid waste, industrial electricity, fossil fuel, knowledge economy, employment, accident prediction, political participation, appealing online, government online services, sewage management, water recycling, electricity supply.
China Institute of Communications **(CIC)**	47	53.41	Internet access and bandwidth, broadband subscription, wireless subscriptions, ratio of network enterprises, cloud computing, home computer, cybersecurity, environmental information, water resource protection, pollution (water, air, toxic, noise, solid waste), civilian and industrial electricity, traditional industry improvement, e-commerce, e-finance, environmental safety, government services, smart traffic, public transport, security control, food and drug safety, medical care, education access, disaster alert and prevention, EHRs, smart tech hatching, e-learning, political participation, appealing online, online freedom, social coherence, e-governance openness, government online services, building energy saving, smart building, smart home, road sensing.
MOHURD	22	25	Broadband subscription, wireless subscriptions, broadcasting, cloud computing, civilian and industrial water, fossil fuel, traditional industry improvement, knowledge economy, employment, e-commerce, e-finance, environmental safety, government services, smart traffic, political participation, online freedom, e-governance openness, government online services, smart impediment, sewage management, water recycling, lighting management, gas management, smart meter, electricity supply, underground pipelines, spatial integrated administration.
ESCI	29	4.55	Air and noise pollution, fossil fuel, government services, gas management, electricity supply.

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Table 4-2 – Proximity statistics of KPIs for SSC

Source	Number of similar indicators	Percentage of similar indicators (%)	Distribution of indicators
Italy	36	40.91	Internet access and bandwidth, broadband and wireless subscriptions, ratio of network enterprises, home computer, air pollution, civilian and industrial electricity, civilian and industrial water, fossil fuel, R&D expenditure, knowledge enterprise, patent, teleworking, knowledge economy, employment, e-commerce, government services, counter-disaster satisfaction, EHRs, household e-health, e-learning, political participation, appealing online, online freedom, social coherence, e-governance openness, government online services, smart building, water recycling.
TTC	13	14.77	Internet bandwidth, water resource protection, pollution (water, toxic, solid waste), civilian and industrial electricity, civilian and industrial water, fossil fuel, rare metal, R&D expenditure, employment, e-commerce, e-finance, security control, accident prediction, political participation.
GCIF	6	6.82	Broadband and wireless subscriptions, Internet access, water and solid waste pollution, anti-poverty, political participation.
GPC	0	0	
ESCI	29	32.95	Broadband and wireless subscriptions, water resource protection, flood control, water pollution (water, air, noise, solid waste), civilian and industrial electricity, civilian water, smart tech revenue, employment, smart traffic, public transport, security control, counter-disaster satisfaction, education access, anti-poverty, housing comfort, disaster alert, immigration convenience, political participation, e-governance openness, smart impediment, building energy saving, sewage management, water recycling, electricity supply.
ERMC	21	23.86	Internet bandwidth, civilian and industrial electricity, civilian and industrial water, R&D expenditure, knowledge enterprise, patent, decision-making centre, employment, government services, public transport, security control, education access, anti-poverty, hatching smart tech, political participation, social coherence.

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Table 4-2 – Proximity statistics of KPIs for SSC

Source	Number of similar indicators	Percentage of similar indicators (%)	Distribution of indicators
EUSI	19	21.59	Water resource protection, pollution (water, air, solid waste), employment, e-finance, environmental safety, public transport, security control, medical care, education access, anti-poverty, housing comfort, political participation, appealing online, online freedom, social coherence, building energy saving.
Smart Cities Wheel (Boyd Cohen)	6	6.82	e-finance, smart traffic, anti-poverty, e-governance openness, government online services.
Ericsson	13	14.77	Internet access and bandwidth, broadband and wireless subscriptions, home computer, flood control, pollution (water, air, solid waste), fossil fuel, patent, smart tech opportunities, employment, e-commerce.
IBM	15	17.05	Internet access and bandwidth, broadband and wireless subscriptions, water resource protection, flood control, water pollution, e-commerce, e-finance, government services, public transport, disaster alert and prevention, smart building, smart home, sewage management, water recycling, smart meter, electricity supply.
IDC	36	40.91	Internet access and bandwidth, broadband and wireless subscriptions, home computer, environmental information, water resource protection, pollution (water, air, solid waste), industrial electricity, teleworking, employment, e-commerce, e-finance, smart traffic, public transport, disaster alert and prevention, video surveillance, e-learning, political participation, appealing online, online freedom, e-governance openness, smart community, government online services, building energy saving, smart building, smart home, road sensing, parking guidance, electronic bus bulletin, sewage management, water recycling, lighting management, gas management, smart meter, electricity supply, underground pipelines, spatial integrated administration.
PwC	12	13.64	Internet access and bandwidth, air pollution, solid waste, knowledge enterprise, opportunities, knowledge economy, employment, public transport, security control, housing comfort.
Siemens	7	7.95	Pollution (water, air, solid waste), civilian electricity and water, fossil fuel, sewage management, water recycling, smart meter.

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Legend to Tables 4-1 and 4-2: Sources and indicators

ISO	ISO/TC 268/SC1
IDI	ITU, ICT development index
UN-Habitat	city prosperity index
CIC	China Institute of Communications
MOHURD	China, Ministry of Housing and Urban-Rural Development
ECI	European common indicators
Italy	Italy, smart city and smart statistics
TTC	Sub working group for SSC of TTC in Japan
GCIF	Global city indicators facility
GPC	Global protocol for community scale GHG emissions
ESCI	Emerging and sustainable cities initiative
ERMC	European ranking of medium-sized cities
EUSI	European system of social indicators
Wheel	Boyd Cohen: Index system of SSC, smart cities wheel
Ericsson	Ericsson, networked society city index
IDC	Spain, IDC smart cities index
IBM	IBM, Smarter city assessment
PwC	PwC, Cities of opportunities index
Siemens	Green city index

5 Conclusions

This Supplement collects a number of indicators that have been developed for cities by global, national, regional, academic and company stakeholders. The analysis evidenced the broad set of perspectives and approaches that exist in this field, but most importantly and common to all, it shows the importance attributed to measuring, monitoring, and learning from ICT usage in smart sustainable cities.

The content and supplementary information contained in this Supplement allows the following general reflections:

– Although the specific categorization used is different between indexes, frequently used categories are economy, environment and, to some extent, governance. These are areas that have been recognized to be at the core of SSC strategies.

– The social aspect of sustainability is addressed in various ways by specific sets of indicators. Some have a main category for social aspects and add sub-categories, others do not include the social aspect as an individual category, but instead use several categories that are related to social aspects.

– Despite the specific and sometimes diverging approaches to measuring the role of ICTs in smart city contexts, the sources reviewed confirmed the relevance of the key dimensions and sub-dimensions identified by the focus group on smart sustainable cities (FG-SSC) for the development of SSC KPIs. They also suggest the appropriateness of looking into ICT aspects, environmental sustainability, productivity, quality of life, equity and social inclusion, and non-ICT infrastructure development, as crucial components of smart sustainable cities.

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Appendix I

ISO: Index system of smart city

Source: [b-ISO/TC268/SC1], Smart community infrastructures, with possible directions for the development of metrics, http://www.iso.org/iso/home/standards_development/list_of_iso_technical_committees/iso_technical_committee.htm?commid=656967

Table I.1 – Example of "community infrastructures"

1	Energy	Power grid, gas, fuels (gas station), etc.
2	Water	Water treatment process, water for industrial use, treated water, sewage disposal, etc.
3	Mobility	Road, railroad, airport, port, river, etc.
4	Waste	Waste recovery, recycling, etc.
5	ICT	Information processing, Internet, carrier, broadcasting, etc.

Table I.2 – Examples of "performance (to be technically improved)"

1	Societal	Convenient	Viewpoint of resident
		Comfortable	
		Secure	
		Safe	
2	Economic	Management efficiency	Viewpoint of community managers
		Vitalization of industry	
		Rotation of generation of the residents	
3	Environmental	Global warming	Viewpoint of environmentalists, world opinions
		Natural resources saving	
		Protection of biodiversity	

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Appendix II

ITU: ICT development index (IDI)

Source: ITU Measuring the Information Society, <http://www.itu.int/ITU-D/ict/publications/idi/>

Eleven indicators for measuring the ICT development in countries are divided into three categories: ICT infrastructure and access, ICT use and ICT skills.

1) ICT infrastructure and access indicators

i. fixed-telephone subscriptions per 100 inhabitants
ii. mobile-cellular telephone subscriptions per 100 inhabitants
iii. international Internet bandwidth (bit/s) per Internet user
iv. percentage of households with a computer
v. percentage of households with Internet access

2) ICT use indicators

i. percentage of individuals using the Internet
ii. fixed (wired)-broadband subscriptions per 100 inhabitants
iii. wireless-broadband subscriptions per 100 inhabitants

3) ICT skills indicators

i. adult literacy rate
ii. secondary gross enrolment ratio
iii. tertiary gross enrolment ratio

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Appendix III

UN-Habitat: City prosperity index

Source: [b-UN-Habitat report] (Table 1.1.3, p.18)

In the Wheel of Prosperity as defined by UN-Habitat, the "spokes" are the five dimensions of prosperity: productivity, infrastructure, quality of life, equity and social inclusion, and environmental sustainability. See Figure III.1 below.

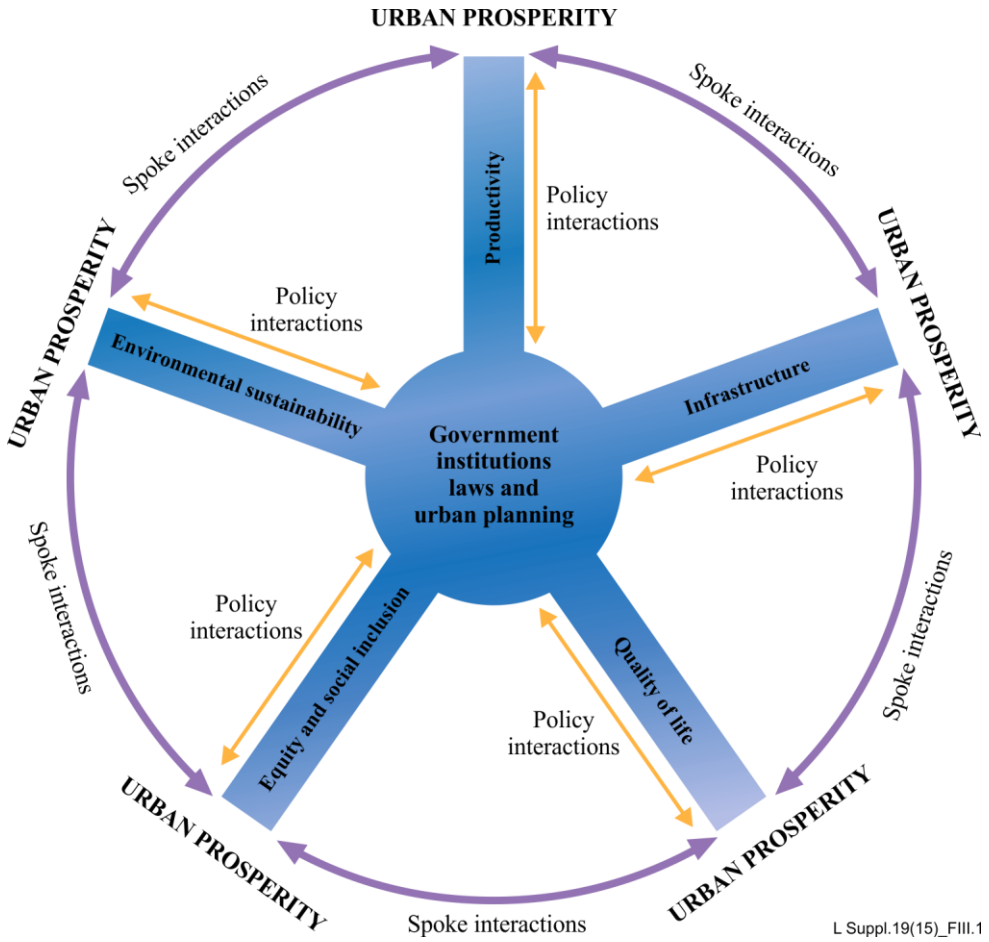

Figure III.1 – Wheel of Prosperity

In the "City Prosperity Index", each dimension has its own index and it might be built up by a number of indices. The basic "City Prosperity Index" consists of the following sub-indices and indicators:

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Table III.1 – City prosperity index

Dimension	Definition/variables
Productivity	The productivity index is measured through the city product, which is composed of the variables capital investment, formal/informal employment, inflation, trade, savings, export/import, and household income/consumption. The city product represents the total output of gods and services (value added) produced by a city's population during a specific year.
Quality of life	The quality of life index is a combination of four sub-indices: education, health, safety/security and public space. The sub-index education includes literacy, primary, secondary and tertiary enrolment. The sub-index health includes life expectancy, under-five mortality rates, human immunodeficiency virus (HIV)/acquired immune deficiency syndrome (AIDS), morbidity and nutrition variables.
Infrastructure	The infrastructure development index combines two sub-indices: one for infrastructure and another for housing. The infrastructure sub-index includes: connection to services (piped water, sewage, electricity and ICT), waste management, knowledge infrastructure, health infrastructure, and transport and road infrastructure. The housing sub-index includes building materials and living space.
Environmental sustainability	The environmental sustainability index is made of four sub-indices: air quality (particulate matter up to 10 micrometres in size (PM10)), CO_2 emissions, energy and indoor pollution.
Equity and social inclusion	The equity and social inclusion index combines statistical measures of inequity of income/consumption (Gini coefficient) and social and gender inequity of access to services and infrastructure.

There is also an extended "City Prosperity Index" with additional indicators and a plan to include governance as a sixth dimension. Furthermore, a specific work has been made on streets as a driver for prosperity, available at: <http://mirror.unhabitat.org/pmss/listItemDetails.aspx?publicationID=3513>

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Appendix IV

China Institute of Communications: Index system of smart city

Source: <http://www.china-cic.org.cn>

The evaluation index system of a smart city includes four major indexes: information infrastructure, smart applications, support system, and value implementation. These four major indexes form the evaluation system of a smart city with the guidance of other elements, such as the network infrastructure, the construction of public support service system, and smart application, reflecting the level of value implementation of a smart city.

The evaluation index system of a smart city can be divided into four dimensions, including 19 second-level indexes and 57 third-level indexes [b-FG-SSC-5]. This index system comprehensively considers various aspects, such as the infrastructure development level of urban information network, comprehensive competitiveness, policies and regulations, green and low-carbon, and culture and technology. It also includes software conditions, such as the intelligent transport administration, the medical education system, the capability of environmental protection network and industrial sustainable development, and the cultural and scientific quality of citizens. This system can embody and index the abstract smart city, forming a distinct guidance, ensuring a more efficient urban administration, a more liveable urban environment, and a continuously increasing happiness index of residents.

Table IV.1 – Evaluation index system of SSC

No.	First-level index	Second-level index	Third-level index
1	**Information infrastructure**	Network infrastructure	Coverage rate of Fibre to the x (FTTx)
			Coverage rate of wireless networks
			Household network bandwidth on average
			Penetration rate of broadband users
			Coverage rate of mobile phones
			Penetration rate of third generation (3G) mobile networks users
		Cloud platform	Percentage of serving enterprises
			Industrial output of cloud computing
		Information security	Physical safety index
			Data safety index

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