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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 city impact assessment

Recommendation ITU-T Y.4905

International Telecommunication Union

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Recommendation ITU-T Y.4905

Smart sustainable city impact assessment

Summary

Recommendation ITU-T Y.4905 is a holistic impact framework for the assessment of smart and sustainable cities to address the effects of digital innovation on social, economic and environmental issues. Smart sustainable city (SSC) initiatives have been proposed as potential solutions to economic, social and environmental challenges and pressures encountered by cities. Advances in information and communication technologies (ICTs) enable significant transformation potential in the way city resources, services and infrastructures are planned and managed. More specifically, ICT can play an enabling role to address the urban challenges of the twenty-first century. Smart sustainable cities harness ICTs (including various subtopics under ICT such as digital transformation, data, Internet of things (IoT), digital services, etc.) and intend to deliver city enhancements through a portfolio of action items. By their very nature, SSC initiatives impact the underlying cities. It is important to identify and asses this impact. The identification and assessment of impact will allow for better planning, the setting expectations with stakeholders, better informed budgeting, more effective public private partnerships and the promotion of alternative financing mechanisms. This will also help in communicating SSC initiatives.

History

Edition	Recommendation	Approval	Study Group	Unique ID*
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Impact assessment, impact management, smart city, smart sustainable city.

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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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1 Scope

This Recommendation formulates a holistic smart sustainable city (SSC) impact assessment framework.

Specifically, it covers the impact of digital innovation on:

- social;
- economic; and
- environmental aspects of SSC initiatives and projects.

Since SSC initiatives impact cities, it is important to take a broad perspective and assess the impact of these initiatives. International Association for Impact Assessment (IAIA) defines impact assessment as "the process of identifying the future consequences of a current or proposed action". Impact assessment can help city administrators as well as their stakeholders understand to what extent their SSC initiatives impact their cities.

It can be utilized by:

- cities and municipal administrations, including the SSC-relevant policy-making organizations, and government sectors, enabling them to understand the direct and indirect impacts of their SSC initiatives;
- city residents and non-profit citizen organizations, enabling them to understand the far-reaching consequences of their SSC initiatives and project;
- city administrators to determine appropriate trade-off between different options and also for decision making;
- private sector organizations to align with SSC initiatives' intended consequences and impacts and to contribute to them in terms of implementation and/or financing where possible.

This impact assessment can be used by city planners as a forward-looking tool to evaluate what might happen in the future with respect to their planned initiative(s). It is essential to consider both positive as well as adverse impacts during such an assessment. By its very definition, it can be seen that this impact assessment can be used to balance current and future sustainability of cities with respect to conceived SSC initiatives. Sustainability is often stated as a goal by various entities including city planners, yet it is not easy to measure or assess. The intention of identifying impact is to be equipped with a well-informed and more holistic perspective of the SSC initiatives and projects. An impact assessment can be used as a high-level tool for city administrators.

Impact can be assessed:

- for an entire city, or alternatively for a geographically well-defined subset of it;
- either for the entire set of SSC initiatives (consisting of a large portfolio of city projects) or alternatively it can also be conducted for one or more city projects;
- for all impact types, namely: social, economic and environmental, or a subset of them.

Finally, impact mitigation measures are included to evaluate impacts for cities.

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 L.1400] Recommendation ITU-T L.1400 (2011), *Overview and general principles of methodologies for assessing the environmental impact of information and communication technologies*.

[ITU-T L.1450] Recommendation ITU-T L.1450 (2018), *Methodologies for the assessment of the environmental impact of the information and communication technology sector*.

[ITU-T Y.4900] Recommendation ITU-T Y.4900/L.1600 (2016), *Overview of key performance indicators in smart sustainable cities*.

[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*.

[ISO 14064-1] ISO 14064-1:2018, *Greenhouse gases – Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals*.

[ISO 14064-2] ISO 14064-2:2019, *Greenhouse gases – Part 2: Specification with guidance at the project level for quantification, monitoring and reporting of greenhouse gas emission reductions or removal enhancements*.

[ISO 14064-3] ISO 14064-3:2019, *Greenhouse gases – Part 3: Specification with guidance for the verification and validation of greenhouse gas statements*.

3 Definitions

3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

The following terms are defined in [ISO 14064-1]:

3.1.1 GHG project

3.1.2 greenhouse gas (GHG)

3.1.3 greenhouse gas emission

3.1.4 greenhouse gas removal

3.1.5 organization

The following terms are defined in [ITU-T L.1400]:

3.1.6 ICT goods

3.1.7 ICT networks

3.1.8 ICT services

3.1.9 ICT sector

The following term is defined in [ITU-T Y.4901]:

3.1.10 ICT companies

The following terms are defined in [ITU Y.4900]:

3.1.11 city

3.1.12 smart sustainable city

3.2 Terms defined in this Recommendation

This Recommendation defines the following term:

3.2.1 scoping boundaries: Definition of what is to be assessed in terms of impact, taking into consideration the geography, types of impact and smart sustainable city initiative.

4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

EIA	Environmental Impact Assessment
EMF	Electromagnetic Field
GDP	Gross Domestic Product
GHG	Greenhouse Gas
ICT	Information and Communication Technology
IOM	Input Output Model
IoT	Internet of things
LCA	Life Cycle Assessment
NGO	Non-governmental Organization
OECD	Organisation for Economic Co-operation and Development
SCADA	Supervisory Control and Data Acquisition
SSC	Smart Sustainable City
SIA	Social Impact Assessment

5 Conventions

None.

6 General principles and impact types for SSC impact assessment

This clause defines the general principles and the impact types that should be taken into consideration when applying the SSC impact assessment.

6.1 General principles for impact assessment

SSC impact assessment should be in alignment with the following principles:

- **comprehensive**: all, or nearly all important, elements or aspects of impact which are of interest should be included during the assessment process;
- **transparent**: the impact assessment process and its outcomes should be explicit, unambiguous and easily perceivable;

- **participatory**: the impact assessment should involve stakeholders to ensure their participation;
- **evidence based**: the results of impact assessment should be derived from or informed by actual evidence;
- **data driven**: the results of impact assessment should be determined by or dependent on the collection or analysis of data;
- **inclusive**: all or representative subset of stakeholders should be engaged during the impact assessment process;
- **digital technology-focused**: projected impacts should be identified for digital innovation related SSC initiatives.

6.2 Impact types

In this Recommendation, an SSC impact is assessed along social, economic and environmental dimensions (see Figure 1). This impact assessment can be used to understand the changes foreseen by SSC digital innovation initiatives. It can also be used to identify and circumvent negative and unintended impacts while capitalizing on, and further enhancing, positive and sustainable impacts.

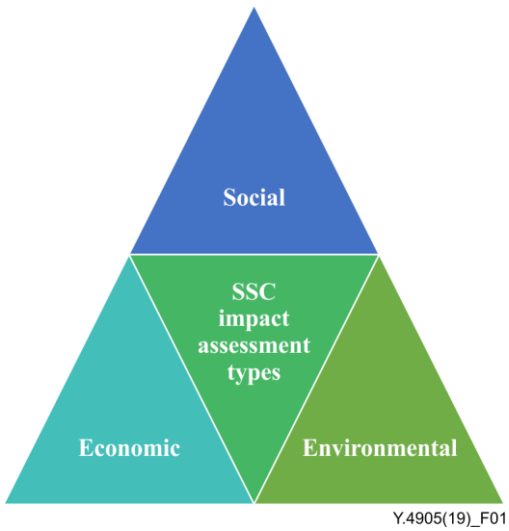

Figure 1 – Smart sustainable city impact assessment types

7 Description of SSC impact assessment types

Clauses 7.1, 7.2 and 7.3 describe SSC social, economic, and environmental impact assessments, respectively.

7.1 SSC social impact assessment

Social impact assessment (SIA) identifies and analyzes the digital innovation related issues which impact people and their lives in cities related to SSC initiatives. Social impact captures issues related to how people live, their communities, their well-being and concerns and aspirations among others [b-Vanclay].

It is important to indicate that social impacts can be experienced in both perceived or real senses, or both (unlike environmental impacts which are experienced only in a real sense). Hence, it also captures subjective opinions and perceptions of individuals and communities.

As SSC strategic action items transform a city, these social impacts can be assessed through an inclusive process by involving and engaging stakeholders. SSC initiatives purposely and also

inadvertently introduce changes in people's lives by utilizing information and communication technology (ICT) and digital transformation.

Social impact refers to consequences of SSC initiatives to human populations that alter the ways in which people live, work and relate to one another, organize to meet their needs, and generally cope as members of society. It also includes cultural impacts of SSC initiatives involving changes to the norms, values and beliefs that guide and rationalize their cognition of themselves and their society.

Social impact tends to affect one or more of the following areas categorized as societal (communal) and personal (individual) aspects (see Figure 2):

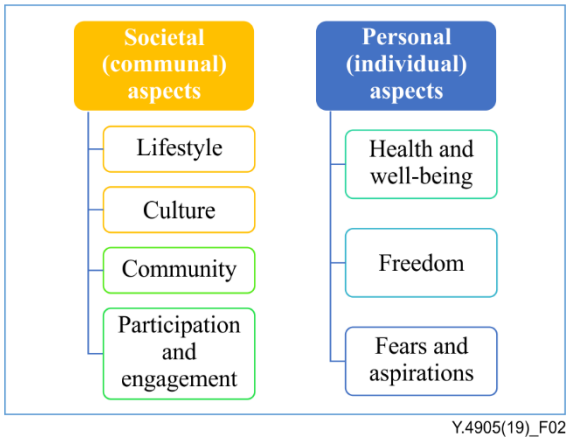

Figure 2 – Potential social impact areas

7.1.1 Societal (communal) aspects

Some SIA aspects pertaining to societal (communal) aspects include, among others:

- people's lifestyle – how people live in their daily lives together and interact with one another on a day-to-day basis;
- their culture – the shared beliefs of people, their customs and values;
- their community – the collective cohesion, stability, character, services and facilities of communities and cohorts of people in cities;
- their participation and engagement – the extent to which people are able to engage and participate in SSC initiatives collectively that affect their lives and communities.

7.1.2 Personal (individual) aspects

Some SIA aspects pertaining to personal (individual) aspects include, among others:

- health and wellbeing – social aspects also include the health and well-being of people; this includes physical and mental well-being and not merely the absence of disease;
- personal freedom – includes cases where people experience personal disadvantage;
- fears and aspirations – peoples' perceptions about their safety, their concerns as individuals about the future of their community and identity, and their aspirations for their community and family.

Therefore, cities are recommended to conduct an SIA if they want to identify the societal (communal) and personal (individual) impacts of their SSC initiatives.

7.1.3 Social impact assessment general issues

An SIA incorporates assessing intended and unintended social consequences, both positive and adverse, of SSC strategic action items. An SIA is intended to assess issues, among others, related to community development and empowerment, building and developing social capital in the form of

social networks and trust. An SIA can help enhance equity, strengthen social inclusion and cohesion, promote transparency and empower different segments of the society for SSC interventions. It helps identify the opportunities, constraints and potential social impacts associated with SSC initiatives in advance.

An SIA can utilize both quantitative and also qualitative data. Quantitative data is usually obtained from existing reports and structured surveys. Primary data sources may include, among others, local households and residents, city administration officials, land administrators and resource owners, community leaders, local businesses, and local development non-governmental organizations (NGOs). Secondary data sources may include, among others, census data, government statistics, various city and community plans, government reports, academic and research institutions' reports, and NGO reports.

Qualitative data includes perceptions and attitudes identified by various stakeholders in the city to changes stemming from SSC initiatives. Qualitative data can be obtained through interviews, focus groups and workshops from relevant city stakeholders. A simple tool is shown in Appendix I; this tool can be used to identify issues raised by city stakeholders during the SIA qualitative data collection process.

Issues raised by city stakeholders can include, among others, various perception related ones pertinent to their freedom, fears, aspirations, etc. In some cases, these issues might be stated qualitatively in the form of subjective opinions and perceptions rather than actual facts supported by real evidence.

An SIA aims to maximize the benefits of ICT and digital transformation in SSC initiatives while, at the same time, minimizing their potential adverse implications – that is, more specifically of the ones borne by people and communities. An SIA helps in mitigating these through targeted action items and helps pave the way for their smooth implementation.

7.1.4 Social impact examples

Digital public services may introduce skills barriers for their users (e.g., digital literacy); they may also encounter cultural barriers whereby people may prefer physical face-to-face interactions. Similarly, new disruptive and emerging technologies in the city economy may pressure existing businesses to reduce employment opportunities leading to social resistance. Leading-edge ICT skills may be scarce in the city and may pose a skills-divide in the labor force for employment; this may create a certain level of anxiety. Digital city services, whether in the public or private sector, may cause security and privacy concerns and may adversely impact trust and confidence in them if not addressed properly. Economic development projects, especially if large scale in certain sectors, may cause anxiety and concerns in people due to potential adverse environmental impacts; they may also cause concerns in terms of rising living expenditures and reduced well-being. However, economic prosperity and new job opportunities may have positive impacts on people and communities in the city. Rising living standards and disposable income may render city residents more confident about themselves and about their future. People can empower themselves and enhance their well-being through various means in their city lives. These are some non-exhaustive examples to illustrate the concepts.

An SIA ensures that SSC initiatives:

- are well-informed and take into consideration key relevant social issues;
- incorporate a participation strategy for involving a wide range of stakeholders;
- follow a systematic methodology and process for conducting impact assessment.

The actual SIA for a given city would be an exhaustive list of the specific SSC strategic action items for that city. The SIA may utilize qualitative and quantitative methods. The Organisation for Economic Co-operation and Development (OECD) framework for measuring well-being and progress [b-OECD] and The World Happiness Report [b-World] include examples of quantifying people aspects which can be used by cities in their SIA processes.

7.2 SSC economic impact assessment

The cconomic impact assessment is a commonly used approach for understanding the economic consequences of ICT and digital innovations (see [b-Katz], [b-Fornefeld], [b-Katz1]). In this Recommendation, an economic impact assessment identifies and analyzes the economic effects and contributions of SSC digital innovation initiatives in cities. SSC initiatives are likely to generate significant economic benefits for cities and communities which in some cases may not be obvious for their stakeholders, or are not necessarily quantified from an economic perspective.

An economic impact assessment incorporates a quantitative method to estimate the economic benefits that SSC initiatives bring to their cities and communities.

Cities are recommended to use financial and economic data as part of the economic impact assessment to estimate one or more of the following potential economic impact measures:

– business or economic output;
– value added or city gross domestic product (GDP);
– wages and salaries;
– jobs and labor force; and
– tax revenues among others.

Cities can qualitatively and quantitatively analyze economic impacts incurred by SSC strategic action items. As SSC strategic action items transform a city, economic impacts can be assessed concomitantly. Clauses 7.2.1 and 7.2.2 explain two commonly used quantitative approaches for economic impact assessment.

7.2.1 Leontief input output model

In this approach, cities are recommended to estimate economic impacts at direct, indirect, and induced levels:

– direct impacts arise from direct expenditures associated with SSC initiatives (e.g., ICT goods and services procurement and implementation, additional human resources need in city administrations);
– indirect impacts arise from the suppliers of SSC initiatives procuring goods and services and recruiting new employees (i.e., creating new employment) to meet the SSC initiatives demand;
– induced impacts capture expenditures stemming from the additional income in SSC initiatives involved households (i.e., households that earned extra income due to SSC initiatives and spend it on various other items). Induced impacts are spill-over impacts to various sectors of the economy.

The indirect and induced impacts are, in general, called secondary impacts.

In this approach, cities are recommended to use the Leontief input output model (IOM) [b-Leontief], which describes a simplified view of the economy if the Leontief IOM is available to them.

The main objective of the IOM is to estimate the level of production for each of several types of goods or services in an economy. More specifically, it is used to estimate how a change in demand for one sector effects the entire economy. Input-output tables in the IOM organize the business sector of an economy in terms of which sectors produce what outputs and which ones uses what inputs. In essence, it is a matrix of inputs and outputs in an economy. IOMs help in estimating how an increase in demand for a product of one sector could impact other sectors and the economy as a whole.

IOMs are used to construct input-output multipliers which can be used to estimate the economic impacts of incremental spending in an economy [b-Miller]. Hence, direct multipliers measure direct impacts which are changes that occur in businesses that would initially receive expenditures and

revenue as a direct consequence of the SSC initiatives. However, indirect multipliers measure indirect impacts stemming from changes in activity for suppliers of businesses related to SSC initiatives. Induced multipliers measure induced impacts stemming from shifts in spending on goods and services as a consequence of changes to the payroll of the directly and indirectly affected SSC initiatives related businesses (i.e., they constitute additional household income, sometimes also referred to as consumer surplus).

7.2.2 Top down econometric model

If the Leontief IOM is not available to cities, a macro-economic level assessment could be conducted, using a so called 'top-down approach' to assess the economic impact. This approach looks at overall changes in the city economy and key economic impact measures, such as city GDP, or output, or city employment, etc., and seeks to understand the extent to which these economy-level changes can be attributed to SSC initiatives. This can be done through econometric modelling with a measure of the SSC initiative as one explanatory variable, alongside a range of other variables that could also explain the changes being observed in the key economic impact measure. For example, if city administrators were to use this approach to estimate the impact of SSC initiatives on economy-wide city GDP, an econometric model might be developed with city GDP as the dependent variable (the factor that we are seeking to understand the change in) and explanatory variables (the factors that might drive a change in city GDP) including a measure of SSC initiative plus potentially numerous other factors that might drive changes in city GDP such as changes in employment or capital investment in an economy, etc.

Note for Implementers of the top-down econometric model: To use this approach, there is a need to have sufficient data points in the city for each of the variables in the econometric model. Therefore, it is often best suited to evaluating impacts of an SSC initiative a number of years post-implementation. Furthermore, and perhaps most importantly, it is often difficult to establish a cause-and-effect relationship between the SSC initiative and changes observed in the key economic impact measure such as city GDP. Further, this approach does not allow any insight into what inputs, activities, outputs and outcomes of the SSC initiative is specifically driving the end impacts observed. These factors may limit the usefulness of this top-down econometric approach for cities.

7.2.3 Economic impact examples

Digital adoption of public services and data saves time of businesses as well as public sector entities; which in turn can be translated into financial savings (i.e., cost savings). This is an example of direct economic impact. Some quantification estimates are given below for smart city transformation items.

Total time savings for public sector entities can be calculated by the formula:

> Total public sector time saved = Public servant time saved per public service transaction × Number of public service transactions conducted

City public sector entities cumulatively conduct a significant number of transactions annually. Hence, the time savings amount to significant values when summed up over a long period of time (e.g., annually).

The cost savings can be estimated with the following formulas:

> Projected total public sector cost savings = Total public sector time saved × Average compensation per public sector employee per unit of time

NOTE – In this formula, a public-sector employee is assumed to be the one dealing directly with businesses on behalf of the public sector.

Additionally, public sector shared services also create financial efficiencies by circumventing the need for individual public sector entities to implement those services on their own. Substantial cost savings can be achieved through economies of scale and economies of scope through implementation of shared services (i.e., direct economic impact). Hence, cost savings can be projected by estimating

how much it would cost public sector entities to implement those services on their own versus implementing a shared service and using it (avoids replication of investments by public sector entities while simultaneously expediting implementation). Cost savings (i.e., operational efficiencies) clearly enhance the fiscal sustainability of cities. Digital transformation of public services creates surplus demand for various ICT sectors which is an example of indirect economic impact. Hence it can contribute in boosting their competitiveness by supplying services and solutions to meet public sector demands. The impact will be felt positively by both public and private sectors if and when ICT based solutions are implemented correctly. It will increase the productivity of the public sector through achieved cost savings; it will also in tandem increase supply of ICT products and services by the private sector. Consequently, it is expected to boost the GDP contribution of the ICT sector and help create new sub-sectors. It will benefit innovation as well and boost entrepreneurial activity in the economy.

Economic policies and regulations supporting innovation and entrepreneurship will be conducive to economic growth, resulting in added economic value. Their successful implementation will enable new products and processes, new companies and business models, new industries and sectors, which in turn will enhance the economic competitiveness of smart cities. They will enable cities to become more productive, economically resilient and agile. Successful innovation will also create new job opportunities and help reduce the unemployment rate in an economy. Furthermore, innovations in a city will also uplift labor force skills for future sustainability. Economic impacts of innovation can also be quantified based on specifics of SSC strategic action items selected by a city.

Additionally, transformations in city resources and infrastructures may also yield significant economic impacts. For example, losses due to unaccounted for water may be reduced through Internet of things (IoT) deployments. These reductions will be direct savings in terms of actual water supplied to the city (i.e., direct economic impact). The total water savings can be quantified in monetary terms by multiplying using appropriate tariff rates (the same argument also applies for energy savings due to reductions in energy losses in the supply network). Similarly, total reductions in water and energy consumptions (demand-side reductions) can be quantified in monetary terms by multiplying using appropriate tariff rates and converted into savings.

Savings mentioned under economic impact correspond to financial efficiencies created by a city. These efficiencies create economic benefits which may be diverted or reallocated for other uses in both public and private sectors, resulting in induced economic impacts.

Economic impact assessment will also be beneficial in estimating return on investments for SSC initiatives and projects (and other related financial measures, e.g., internal rate of return, net present value). This may also help facilitate various smart financing mechanisms (e.g., public private partnerships, green funds and bonds) for SSCs by demonstrating financial feasibility for their city initiatives and projects.

7.3 SSC environmental impact assessment

An environmental impact assessment (EIA) [ITU-T L.1400] identifies and analyzes issues which impact urban environments in cities related to SSC digital innovation initiatives in order to promote sustainable development. Environmental impact captures anticipated effects and consequences on water, energy, air, land, waste and in general on urban natural environment and resources in a city.

[b-ITU-T L.1440] gives general guidance on city-level environmental assessments related to ICT and provides a description of the methodologies to be used for the assessment of the environmental impact of ICT in cities. [ITU-T L.1450] defines the methodologies needed to calculate the footprint of the ICT sector with respect to life cycle greenhouse gas (GHG) emissions considering, for example, the volume of activity; energy consumption and embodied emissions related to product life cycle, among others; and to define a GHG emissions budget for the ICT sector.

[b-ISO 14040] describes the principles and framework for life cycle assessment (LCA), and [b-ISO 14044] specifies requirements and provides guidelines for LCA, including: definition of the goal and scope of the LCA, the life cycle inventory analysis phase, the life cycle impact assessment phase, the life cycle interpretation phase, reporting and critical review of the LCA, limitations of the LCA, and the relationship between the LCA phases.

[ISO 14064-1] provides specification with guidance at the organization level for the quantification and reporting of GHG emissions and removals. [ISO 14064-2] specifies principles, concepts, requirements and methods with guidance for quantifying, monitoring and reporting GHG emission reductions or removal enhancements from GHG projects; it focuses on GHG projects or project-based activities specifically designed to reduce GHG emissions or increase GHG removals. [ISO 14064-3] provides specification for the validation and verification of GHG assertions.

As SSC strategic action items transform a city, environmental impacts can be assessed through a well-structured process by addressing potential impacts on city flora and fauna, soil, water, energy, air, climate, landscape, and city architectural, archaeological and cultural heritage.

Clauses 7.3.1 to 7.3.5 deliberate potential environmental impact areas resulting from SSC strategic action items. Five main potential environmental impact areas have been identified in this Recommendation; namely:

1) water;
2) energy;
3) waste;
4) GHG emissions; and
5) others.

Hence, cities are recommended to conduct EIA if they want to identify the environmental impacts of their SSC initiatives. More specifically, cities should identify which of the potential environmental impact areas are going to be included in their EIA for detailed assessment. Cities can use both quantitative and qualitative methods during EIA.

7.3.1 City water impact

Water plays a key role in a city's functioning and development. It is not only consumed by a city's inhabitants as drinking water, but it is also closely related to urban green space management, crop cultivation, biodiversity and certain industrial activities. Furthermore, water is increasingly becoming a scarce resource for most cities, a trend that is expected to continue in the foreseeable future. Hence efficiencies in water, i.e., water conservation, is an important factor for its sustainability.

SSC initiatives may have, among others, the following impacts on the city water supply and demand management:

– smart water meters can be deployed to more effectively measure and manage water consumption (e.g., realtime consumption measurement), detect leaks, and provide better consumption information; which in turn may allow employing different schemes to reduce consumption;
– water distribution systems can be monitored through ICT systems (e.g., supervisory control and data acquisition (SCADA) systems). These systems create water supply efficiencies through IoT implementations which can measure the actual delivered water through flowmeters, adjust the pressure of water through pressure sensitive valves, track water levels for stored water through transducers, and determine areas of water loss. It can help reduce the water supply loss by bridging the gap between water supplied to the distribution system versus the volume of water actually billed by water supply utilities;
– drainage and storm water monitoring by ICT can allow better planning of urban drainage systems and can also alleviate or eliminate urban flooding;

– IoT-enabled irrigation systems can optimize use of water based on temperature, humidity and weather conditions among others, leading to reduced consumption of water;
– access to safely managed drinking water services is important for cities. Hence, it is quite essential to ensure the quality of drinking water supplied by the urban water system. IoT implementations can help measure and enhance quality of water in the water supply and distribution networks;
– SSC initiatives also enhance wastewater collection and treatment in urban areas. They improve water quality by reducing pollution and elimination of hazardous materials to increase recycling and reuse in cities;
– cities should plan water demand and the sources for their water supply. It is important to determine freshwater sources, their usage and depletion over time to ensure their sustainability. ICT can play an enabler role in such planning.

7.3.2 City energy impact

Globally, cities consume a large majority of energy. Given the increased pace of urbanisation, energy demand is projected to increase, rendering it a highly critical resource. Hence finding sources and creating efficiencies in energy are important for its sustainability.

SSC initiatives may have, among others, the following impacts on the city energy supply and demand management:

– smart electricity meters can be deployed to more effectively measure and manage energy consumption (e.g., realtime consumption measurement), help detect energy losses and provide better consumption information;
– energy distribution systems can be monitored through ICT (e.g., SCADA). ICT systems allow for maintenance of desired voltages, currents and power factors, alarms generation, perform automatic monitoring, etc. They can also help in reducing energy supply outages and ensuring cost-efficient operations through enhanced substation, feeder and end user load control. It is important to minimize electricity outage time as well as the outage frequency;
– demand adjustment (response) programs can be implemented through adjusting tariffs (e.g., time-based peak demand tariffs or other financial incentives). These programs help shape energy demand and allow better planning. Similarly, sustainable building solutions (e.g., net zero buildings, building information systems, buildings certification programs for energy consumption) aim to reduce energy consumption in both public and private sector buildings;
– it is important to provide authorized access to electricity services in cities. It is a fundamental enabler in cities to provide affordable and reliable energy services to ensure sustainable, economic and social development.

7.3.3 City waste impact

Urban waste collection, management and disposal are important issues for a clean city environment, impacting the health of individuals.

SSC initiatives may have, among others, the following impacts on city waste management:

– smart waste collection systems can utilize IoT-based systems to sense the fill-rate of waste bins, utilize compacting bins through solar powered systems, and provide efficient fleet management to collect urban waste. They will help in enhancing the utilization of waste bins as well as the utilization of associated waste collection fleet in urban areas;
– waste management techniques such as waste reduction, separation, processing, recycling and reuse are feasible and low-cost alternatives to incineration of solid waste. They also contribute to circularity in cities and transform waste into a resource;

– it is important to provide waste collection services in cities since it affects city health, cleanliness and quality of life. SSC initiatives can reduce disposing of waste to sanitary landfills and incineration by opting for circular techniques.

7.3.4 City GHG emissions impact

SSC initiatives have a multitude of impacts on GHG emissions. Cities account for a major portion of GHG emissions worldwide. Main GHG emissions sources in urban areas include energy consumption, industrial processes, waste, transportation, building materials, etc. GHG emissions have adverse impacts on climate change. Hence, many cities undertake initiatives to reduce GHG emissions stemming from water and energy production (e.g., smart meters, smart grid, renewable energy alternatives) and consumption activities (demand response policies, smart meters, integrated building management systems), transportation activities (e.g., electric vehicles, shared mobility, bicycle usage, autonomous vehicles) and waste management activities (e.g., waste recycling and processing).

SSC initiatives may have, among others, the following impacts on the city GHG emissions:

– digitizing services and processes in public and private sector organizations may circumvent the need for physical commute and face-to-face transactions, which in turn will also reduce GHG emissions;

– diversifying energy sources and providing renewable energy as an alternative source is another important impact area for cities. Renewable energy sources enhance sustainability, potentially provide independence in energy sources and also reduce GHG emissions. However, as cities grow their energy needs also increase, resulting in increased energy consumption. This in turn also increases GHG emissions unless the energy is produced through renewable sources;

– efficiencies in water and energy production and consumption in most cases will also reduce GHG emissions. Hence, SSC initiatives such as demand shaping programs (e.g., tariff adjustments), smart building management and information systems, ICT-based supply monitoring systems reducing leakage and losses during transmission will also reduce GHG emissions. However, as cities grow and their populations increase demand for water and energy also increase concomitantly leading to increased GHG emissions;

– earlier mentioned waste management techniques such as waste reduction, separation, processing, recycling and reuse help reduce GHG emissions, potential toxic gases and materials in urban areas contributing to urban sustainability. However, in the absence of such waste management techniques cities rely on landfills and incineration of waste which increase GHG emissions;

– efficiencies in transportation and logistics (e.g., achieved through IoT and ICT-based systems) diminish travel times and total distances travelled leading to reduced GHG emissions;

– there are several other industry-specific IoT and ICT-based SSC initiative examples which create efficiencies and reduce resulting GHG emissions (it would be cumbersome to enumerate all these examples in here);

– some of the above GHG emissions reduction examples are implemented through SSC initiatives utilizing ICT-based digital technologies (e.g., IoT, artificial intelligence (AI)). Hence, a portion of GHG emissions reduction may be offset by the GHG emissions due to ICT-based digital technology implementations.

7.3.5 City other environmental impacts

Air quality, noise, electromagnetic field (EMF) radiation, green spaces and landscapes, pedestrian and bicycle infrastructure, urban resilience, etc., are among other factors that impact the environment in cities.

SSC initiatives may have, among others, the following impacts on the city environment:

– pedestrian and bicycle infrastructure and zones in a city provide alternative modes of mobility in urban environments. These zones tend to improve pollution, noise, liveability and safety;

– air pollution from households, commercial and industrial activities, transportation, and power generation can pose problems in cities. Exposure to ambient air pollution in urban environments can have adverse effects in humans and biodiversity as well. IoT-based air quality systems detect particulate matters, and other potentially hazardous gases. They can help identify hotspots for degraded air quality, assess exposure to air pollution, monitor levels of compliance with air quality standards, and help determine outcomes of air quality policies;

– the availability of wireless infrastructure (e.g., mobile networks, antennae, base stations) in cities generates EMF radiation. IoT systems can detect and identify locations with unacceptable levels of EMF radiation and can assist in reducing it through appropriate planning and mitigation measures;

– another concern for environmental quality in cities is exposure to noise. IoT systems can help detect unacceptable noise levels by location / source in a city and help reduce it;

– green areas are important in cities as they capture pollutants, reduce the "urban heat island" effect, and provide recreational spaces. Digital urban planning systems and tools aid in designing and incorporating acceptable, accessible and sufficient amount of green spaces in urban environments;

– protected natural areas help in preserving biodiversity in cities. They are important in conservation of nature and their associated ecosystems. IoT systems can help in assessing and enhancing biodiversity in urban environments;

– urban resilience helps maintain a city's overall environment in the face of threats and vulnerabilities such as: natural disasters, man-made disasters, etc. Hence, it can have a significant impact in upholding a city's environment through targeted planning and risk mitigation.

7.3.6 City adverse environmental impacts

The increase in urban population, new industrial / economic and social development projects, and continued urban sprawl increase the pressure on cities and their resources. Some examples of potential resultant adverse urban environmental impacts include:

– increases in demands for water and energy resources. Planning for their availability and distribution to the entire city becomes challenging. Additionally, expansion of cities and related economic activities may threaten the quality of water and air due to contamination, unless carefully planned and mitigated;

– urban waste also increases putting even more pressure for proper waste management;

– GHG emissions also increase (in the absence of targeted GHG emissions reduction action items), potentially leading to poorer air quality and air pollution, and an adverse effect on climate change;

– SSC initiatives relying on ICT-based systems may increase EMF radiation if not treated or planned for carefully;

– green spaces may diminish due to increased levels of urbanization leading to increased pollution and less recreational space for city inhabitants. Biodiversity may also decline as a result of increased urbanization;

– climate change, GHG emissions and global temperature increases may increase sea levels, potentially threatening some cities and their residents;

– city landscape may change resulting in undesirable impact on architectural, archaeological and cultural heritage of the city.

7.3.7 Environmental impact examples

Digital adoption of public services has multi-fold indisputable positive impacts on certain city resources and infrastructure. Digital adoption of public sector interactions (e.g., public services and data related interactions) will avoid physical travel by vehicles to public sector entities, which in turn will also circumvent related GHG emissions.

GHG emissions savings can be estimated with the following formula:

> Projected GHG emissions savings = Total public sector trips avoided through digital interactions × Average GHG emissions per public sector trip

Similarly, number of trips avoided can be estimated with the following formula:

> Projected city trips avoided = Total public sector digital transactions (interactions)

Circumvented GHG emissions contribute to cleaner air whereas avoided city trips also reduce the stress on city transportation infrastructure and also potentially enhance quality of life perception by city inhabitants.

Additionally, ICT deployment across smart and sustainable cities (e.g., IoT devices in the form of sensors and actuators) will enable monitoring and controlling through timely identification and intervention (e.g., air pollution, noise, water cleanliness) to protect the environment.

Similarly, ICT deployments in city resources and in their related infrastructures (e.g., smart grids) aid in monitoring resources distribution and consumption; and taking actions to enhance their efficiencies (e.g., reduction of unaccounted water losses, electricity line losses, excessive user consumption). Such efficiency enhancements are critical for scarce resources such as water and energy.

Clean and renewable energy projects reduce GHG emissions in the city resulting in cleaner air and will slow down climate change. However, certain economic development projects may cause adverse impacts on the environment by increasing GHG emissions.

Tourism and culture related SSC strategic action items may positively impact architectural, archaeological and cultural assets of a city. Public parks and landscaping projects enhance overall urban experience of city inhabitants and will lead to an improved quality of life perception. These non-exhaustive examples illustrate the concept. The actual EIA for a given city would depend on the specific SSC strategic action items selected by that city.

8 Guidance on using SSC impact assessment

This clause provides general guidance on how impacts can be assessed for SSC initiatives. Cities implement a number of SSC initiatives with different scopes (e.g., water, energy, mobility, economy, social, cultural related smart sustainable city initiatives). It is important to ensure that impact assessment boundaries are delineated and a well-defined process is applied.

Initially, cities should determine the time horizon for impact assessments prior to conducting them. More specifically, the impact assessment should clearly indicate which time range is considered with a well-defined starting and ending time. Impacts should be determined (projected) for this well-defined time range during the assessment.

8.1 Scoping boundaries for SSC impact assessment

Boundaries in this Recommendation consist of three types:

1) geographical;
2) initiative; and
3) impact.

Boundaries determine what is "in" and "out" of scope of the impact assessment as defined in this Recommendation. See Figure 3.

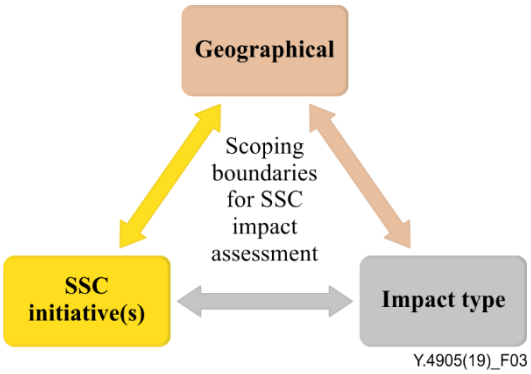

Figure 3 – Scoping boundary types for SSC impact assessment

Cities should identify data availability and gaps during the scoping. Spatial and temporal scopes determine requisite data needs which in turn influence appropriate survey and research methods to be utilized for data collection.

8.1.1 Geographical boundary

Cities should determine the geographical boundary (i.e., actual physical or territorial boundary) for which the impact assessment will be conducted. Cities can decide to use entire city boundaries or may opt to specify a different geographical boundary (e.g., a subset of city boundaries).

SSC initiatives may impact beyond their immediate implementation location. Hence, cities are advised to consider appropriate spatial boundary for capturing SSC initiatives impact.

8.1.2 Smart sustainable city initiative(s) boundary

Cities should determine the scope of initiative(s) for which the impact assessment will be conducted.

Cities can decide to include one or more of their SSC initiative(s) as part of the impact assessment, or may opt to include a portion of an initiative as well (e.g., a city might have an umbrella initiative consisting of several projects and it may decide to include one or more projects within the umbrella initiative as part of the impact assessment).

Cities may use, among others, scale, complexity, location, and duration as potential factors to consider in selecting which SSC initiative(s) to include in the impact assessment.

8.1.3 Impact type boundary

Cities should determine which of the three main impact types will be included in the impact assessment, namely: social, economic and environmental.

Cities are, in general, recommended to take a comprehensive approach and include all three impact types in their impact assessment. This will allow incorporation of social, economic and environmental perspectives making the impact assessment more holistic and comprehensive.

Cities should consult various stakeholders to preliminarily assess potential impacts for their SSC initiatives. Consultation with government officials, various organizations and also local community might help determine which impact type(s) to include for assessment.

8.2 Baselining for SSC impact assessment

Cities should determine their baselines prior to conducting an impact assessment.

Baselining refers to determination of reference points by the city against which future impacts will be assessed. Impact assessment builds on top of the baseline and projects additional (incremental) impacts which will potentially occur as a result of implementing scoped SSC initiative(s).

Hence, the scoped SSC initiative(s) will alter (perturb) the baseline (or the "business as usual") scenario and will give rise to changes. Cities' impact assessment should try to objectively and accurately predict these changes within the scoped boundaries.

8.3 Field research and analyses for SSC impact assessment

Cities should determine and conduct the required research and analyses required for assessing impact. This may entail both qualitative and quantitative research.

Research tools and techniques such as surveys, interviews, focus groups, and quantitative modelling can be used during the impact assessment. Survey responses should be aggregated in a data set, cleansed and tabulated for further analysis. Regarding qualitative research (such as interviews and focus groups), raw responses should be collected and analysed resulting in general trends and well-defined issues identification and conclusions. Quantitative modelling techniques should be utilized where feasible and applicable (e.g., economic impact assessment).

Appropriate stakeholders should be identified for conducting field research and analyses.

In some cases, a third-party such as a research or consulting organization can conduct the impact assessment in terms of in-depth data collection and analyses.

Data sources for field research and analyses should be clearly identified in advance and may include primary and secondary data sources where applicable. Government and public sector organizations, private sector organizations, NGOs, members of the society and various individuals may act as sources of data depending on the field research and analysis required.

The selection of data used to perform impact assessments should be documented and available for verification. Data of the best available quality should be selected. The practitioner shall describe and document the data collection approach adopted as well as the data sources selected.

Cities should plan their budgets in terms of human and financial resources required for conducting the requisite field research and analyses.

8.4 Impact evaluation and mitigation

After conducting their field research and analyses, cities should determine the potential impacts arising from their SSC initiative(s). Once the potential impacts are known, cities should then evaluate the relative importance of each potential impact and take mitigation measures for adverse potential impacts as they see fit.

The purpose of mitigation measures is to avoid, accept, reduce or minimize adverse and unwanted potential impacts while maintaining and enhancing positive and beneficial potential impacts. Cities should determine one of the following mitigation measures:

1) ***accept potential impacts:*** Cities can accept and assume the potential impacts identified during the assessment process and implement the SSC initiative(s) identified during the SSC initiative(s) boundary step;

2) ***reduce adverse impacts where feasible***: Alternatively, cities can in some cases reduce the adverse potential impacts identified during the assessment process. For example, concerns of people or society in particular cases may be addressed through better communication and explanation of benefits. Similarly, policy and regulatory tools can be used to address certain concerns. Particular elements of the SSC initiative(s) may be eliminated, rectified, redesigned, relocated, etc., to address adverse potential impacts and to develop enhanced alternatives, if deemed feasible and applicable;

3) ***monitor impacts:*** Cities can accept but also monitor potential impacts during the implementation of SSC initiative(s) to ensure they materialize as predicted during the assessment process. Unforeseen impacts might require interventions and corrective actions to ensure adverse impacts remain within acceptable levels;

4) ***avoid impacts:*** Cities can in rare circumstances decide not to implement the SSC initiative(s) as a result of the potential impacts. Adverse impacts identified during the impact assessment may impede cities to undertake the SSC initiative(s) as defined part of SSC initiative(s) boundary.

In addition, positive impacts can be used to emphasize and communicate the benefits of SSC initiatives to their stakeholders. They can also help in obtaining funding or financing for them. Especially, positive economic impacts may increase the likelihood of obtaining funding or financing for SSC initiatives.

Appendix I

A simple tool to identify issues raised by city stakeholders during SIA

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

This appendix includes a simple table (Table I.1) to depict the issues raised by city stakeholders during an SIA, their importance, their causes and who is impacted by them.

Table I.1 – Social impact issues raised by stakeholders

Issues raised by stakeholders	Importance of issues for stakeholders				What aspects of SSC initiative cause the issue?	Who is impacted by the issue?
	SH1	SH2	...	SHN		
Issue 1						
Issue 2						
...						
NOTE – SH denotes stakeholder.						

Appendix II

A simple tool to scope boundaries for SSC impact assessment

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

This appendix includes simple tables to describe scoping boundaries of SSC impact assessment.

Table II.1 – Brief explanation of geographical boundary

Geographical boundary		Brief explanation
Entire city	□	Entire city is included in the impact assessment
Subset of city	□	Please specify which geographical boundaries are included in the impact assessment (e.g., communities, boroughs, councils, cantons, districts, etc.)

Table II.2 – Brief explanation of SSC initiative(s) boundary

SSC initiative(s) boundary		Brief explanation
SSC initiative 1	□	Indicate which SSC initiative(s) are included within the scope of impact assessment
SSC initiative 2	□	Please note that more than one SSC initiative may be included within the scope of impact assessment
...		

Table II.3 – Brief explanation of impact type boundary

Impact type boundary		Brief explanation
Social impact assessment	□	If not included then briefly indicate reasons
Economic impact assessment	□	If not included then briefly indicate reasons
Environmental impact assessment	□	If not included then briefly indicate reasons

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