Evaluating sustainability of using ICT solutions in smart cities – methodology requirements

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ABSTRACT

There is a need for verification of the sustainability potential of an increasing number of smart city initiatives. This paper discuss a set of requirements necessary to consider when developing a methodology intended to evaluate the environmental and socio-economic sustainability impact of Information and Communication Technology (ICT) solutions at a city level. A smart city definition is chosen and a model of the city is proposed, dividing the city into service sectors where ICT solutions are expected to be implemented. Requirements on a quantitative methodology for assessing the sustainability potential of ICT solutions in cities are listed, including transparency in selection of city boundary and results, and the importance of setting realistic scenarios and using publicly available data. The methodology activities presented include defining system boundaries, building scenarios and assessing the solution at a city level, and scaling the solution between cities.

Keywords

Assessment, city, Information and Communication Technology (ICT), methodology, sustainability.

1. INTRODUCTION

The ongoing urbanization in the world has lead to an increased focus on cities [1]. Cities and their citizens cause a significant, and increasing, share of greenhouse gas emissions and there is a need to find solutions for sustainable city development. The application of Information and Communication Technology (ICT) is often mentioned as part of the solution [2] and the term 'smart city' is increasingly being used in this context.

Verification of the sustainability potential of smart city initiatives would be useful, both for the ICT industry and stakeholders in the city. For this, a methodology is needed for scaling ICT solutions and assessment results to cities and between cities. This paper presents a methodology for quantitative impact assessments of ICT solutions at a city level, not to evaluate the total impact of ICT in a city, neither to assess the city as such, nor to compare cities.

There are many initiatives by cities, companies, research groups, and authorities to create methodologies or frameworks for assessment of the sustainability or the environmental impact of a city. As an illustration of the great number of initiatives could be mentioned that a compendium of 'sustainability indicator initiatives' [3], kept by the International Institute of Sustainable Development, includes over 600 initiatives at global, national, regional and local level. Further, in [4] the authors have reviewed over 675 tools applicable to the assessment of urban sustainability as a baseline before proposing their own methodology. In contrast, there are only a low number of initiatives that focus specifically on the role of ICT in the city context.

In the latest years, more generally, several standards have been developed using life cycle thinking to determine the environmental impact of ICT products, networks and services, for instance in European Telecommunications Standards Institute (ETSI) and International Telecommunication Union (ITU) [5]-[8]. Lately ITU has started to develop a recommendation for city assessment related to global warming. There are also a number of initiatives where cities are to report their green house gas emissions and energy usage, for instance [9]-[11].

2. METHOD

The work is based on an extensive literature study which covered almost two hundred papers and reports on assessments, indicators, methodologies and evaluation tools related to sustainability, ICT and cities. The literature study aimed to define the term smart city and to make an overview of city related sustainability evaluation frameworks. The first order references were found through a search on scientific databases at the library on Royal School of Technology (KTH) in Stockholm Sweden, on Google scholar, and by searching web sites of large organization like United Nations (UN) and European Union (EU). Through the first order references, second and third order references were found. Over 60 frameworks, methodologies, set of indicators, or similar were studied in order to find approaches to fit the purpose of evaluating ICT solutions at a city level. Hereinafter, they are referred to as frameworks. A comparison of the reviewed frameworks is not included in this paper, but the main findings related to the development of a methodology for ICT solutions are included in Section 3.2. Examples of these initiatives are:

- methods like life cycle assessment (LCA) and social LCA [12]-[14];
- different environmental accounting systems described in [15];
- economical evaluations like Genuine Savings which measures the net investment in produced, natural and human capital [16];
- indices like Environmental Performance Index, Human Development Index [17]-[18];
- indicator sets like European Common Indicators, European System of Social Indicators, Sustainable Development Indicators, UN Millennium Development Goals [19]-[22];

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- city related indicator sets like Global City Indicators, UN Habitat Urban Indicators, Urban Audit, and Sustainable Seattle [23]-[26];
- more building specific frameworks, like CASBEE which is a framework for assessing the environmental performance of a built environment. [27];
- different city rankings like Cities of Opportunity, European smart city assessment, Green City Index [28]-[30];
- city reporting standards such as the Global Protocol for Community scale green house gas emissions (GPC), Carbon Disclosure Project (CDP) for cities [9], [11].

Based on the literature study and internal workshops with life cycle assessment experts, a high-level model of the city was developed for the purpose of assessing the use of ICT solutions within different sectors and activities of the city. The most commonly used indicators in different sectors of the city were identified. The main idea was that the most commonly used indicators are either well-established, easy to measure, easy to get data from, or a good measure of some sustainability aspect. A problem with this approach is that the most commonly used indicators may not be the most relevant for assessing impacts of ICT solutions in a city. In this paper these indicators have influenced the way the city is modeled and how sectors of relevance for ICT solutions are categorized. Furthermore, they are used to determine applicable requirements on a methodology for evaluation of the sustainability impact of ICT solutions in the city.

The paper is divided into two parts. The first part deals with the city, and starts with a discussion regarding the definition of the smart city concept and how that concept relates to sustainable development of a city. The city is then described based on different city services where ICT solutions can be applied. The second part specifies requirements for development of a methodology to evaluate the sustainability impact of ICT solutions on a city level. The section also includes methodology steps and proposes system boundary and functional unit.

3. DEFINITION AND MODELING OF A SMART CITY

This section provides a discussion on the term 'smart city' in relation to other expressions, especially in relation to sustainability perspectives. Furthermore, the main findings of the studied frameworks and initiatives, mentioned in Section 2, are provided and used as input to the requirements proposed later in this paper. Finally, a city model is presented which is based on services within the society.

3.1 Smart City = Sustainable City?

The term '*smart city'* is increasingly used, and many cities want to be labeled as 'smart' [31]. The word *smart* often implies a usage of ICT solutions in the city. Other terms used for the wanted development of cities are 'intelligent', 'innovative', 'wired', 'digital', 'creative', and 'cultural' [31]. The smart city is framed by three dimensions: technology, people and community in [32]. Some papers use *intelligent cities* and *smart cities* as synonymous terms [33] while others make a distinction [31]. In [34] *intelligent city* refers to a city that has an information technology infrastructure. The *smart city* includes various smart functions like smart transport and smart education according to [35]. Before a city can be developed into a smart city with an undefined number of ICT services in use, it is necessary to have the basic ICT infrastructure and knowledge of ICT usage. Based on [36] this paper will use the following definition for the smart city concept: *A smart city is a city that meets its challenges through the strategic application of ICT goods, network and services to provide services to citizens or to manage its infrastructure*.

Though it seems that the *smart city* somewhat implicitly leads to a *sustainable city*, there could be smart cities proving not to be sustainable [31]. 'Sustainable growth' is dealt with worldwide, for instance in EU [37] and sustainable development is in the so called Brundtland Commission Report [38] described as a "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". Others talk about sustainable development in connection with quality of life, either as a process of continually improving the way we live [26][39], or as cultural, economic, environmental and social aspects that lead to an improvement in quality of life [40].

Sustainability is often defined by three pillars: environmental, economic and social aspects. The International Union for Conservation of Nature [41] describes a sustainable development as a development that combines economic growth, social progress and environmental protection. In this paper, a sustainable development of a city is considered as the balance between minimizing the environmental impact, while at the same time maximizing the positive social and economical impact. Depending on the current sustainability level of a city, the track of future development to achieve a more sustainable society could look very different.

With the above definitions, a smart city could, but does not have to be a city which develops in a sustainable way. To judge the sustainability development of a smart city, it is necessary to evaluate the ICT solutions in the city in terms of economic, social and environmental sustainability.

3.2 Evaluation of Frameworks

Some of the many sustainability assessment framework initiatives previously mentioned in Section 2 have been developed to support policy decisions, while others are ranking systems of cities, for instance Cities of Opportunity and other examples in the point list above. Furthermore, some of the frameworks focus on individual factors, such as quality of living, while other frameworks focus on the sustainable development of the city or the city performance. The main findings were:

- No framework was found to assess the impact from ICT usage at a city level though some included ICT aspects.
- No framework was found to fully include life-cycle thinking or to use widely adopted environmental LCA impact categories[1] e.g. those listed in [42].
- A production perspective was much more common than a consumption perspective when setting the system boundaries.

[1] Impact categories [42]: abiotic resource depletion, global warming, acidification, eutrophication, photochemical ozone creation potential, ozone depletion potential, human toxicity potential, primary energy and electricity requirements, and ecotoxicity potential to freshwater, land and seawater.

- In general, the use of natural resources was not considered in the city evaluations, which may be due to a production perspective focus.
- Carbon dioxide (CO_2) or green house gas (GHG) emissions and energy usage were included in almost all investigated indicator sets.
- There was a large variation in categories in the socio-economic indicator sets reviewed and many unique indicators were found.
- An environment category is often used also in socio-economic evaluations as that is a large part of a citizen's well-being.

In environmental indicator sets, transport, water and waste are often included as categories together with energy, GHG emissions and air quality. Hence, there is a mix of basic environmental impact categories[1] and industry-related categories. Also living environment aspects like available green area and noise levels in the city are often included in the environmental assessment frameworks. For the non-environmental frameworks reviewed, the indicator categories are less aligned, however, the scopes also differ to a larger extent - from sustainable development to increased quality of life. Education, health, safety, finance and jobs are common categories together with buildings (shelters) and travel facilities. However, equity and civic engagement are also important categories, especially when measuring the quality of life.

Examples of commonly used indicators in the reviewed material are: gross domestic product per capita, unemployment rate, life expectancy, adult literacy, rate of crime, average living area, voter participation, water quality, waste treatment, GHG emissions, air quality and energy consumption.

3.3 A City Model

A city can be illustrated in many different ways. In this paper the city has been divided into service sectors that are considered to be applicable for introduction of ICT solutions. Figure 2 represents a model of the city based on the city services divided into three different groups: infrastructure services, community services and non-community services.

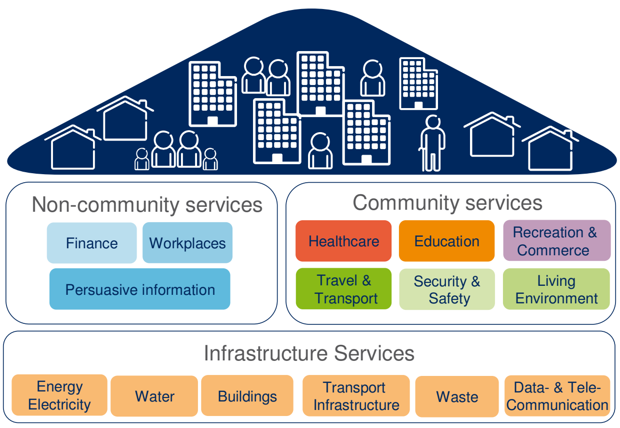

Figure 2. Services applicable for ICT solutions.

The *infrastructure services* consist of services related to buildings, transport infrastructure and infrastructure for water, energy, electricity, waste, and data- and telecommunication. In this paper the *community services* include services that are provided directly to citizens and visitors of the city. These are services like education and healthcare, but the community service layer also includes things like proximity to commerce, culture, sports and parks. Furthermore, the *non-community services* consist of other services where ICT could be used and which will have an impact on sustainability of the city. The finance services include for instance creation of an attractive business environment, while a workplace service relates to improve work efficiency, and persuasive information services to influence people's choices.

The city needs to attract both people and business. Many people move to cities aiming for a better life, where "better" stands for different things depending on your situation. Employment and the household budget are important factors for groups of various ages, while health becomes more and more important with age [43]. For visitors the availability of culture, architecture, restaurants, commerce, sports, parks and nature are of special interest. The growth state of a city, expressed as mature, transitional, and emerging, is related to what kind of challenges the city needs to tackle [44]. For instance a city which grows fast will have major challenges providing people with basic needs such as access to food, water and safety. For transitional and mature cities the challenges are more related to choice and convenience, and lifestyle and independence [44].

The city illustration in Figure 2 has been compared to the United States (US) federal enterprise architecture reference model that lists the US government's services to citizens [45]. A high correlation between the different models was shown, despite the fact that the models are developed for different purposes.

4. A METHODOLOGY TO ASSESS THE SUSTIANABILITY POTENTIAL OF ICT SOLUTIONS AT A CITY LEVEL

This section aims to provide requirements and steps for a quantitative methodology to assess the environmental and socio-economic impacts of ICT solutions at a city level.

4.1 General Requirements

A methodology for assessing the sustainability impact of various ICT solutions used in a city needs to address both evaluation of already introduced ICT solutions and scenarios for future use of ICT solutions. The methodology needs to be applicable to assess ICT solutions for a variety of situations. The methodology also has to handle dynamics between several different ICT solutions.

For the ICT industry to be credible, impact assessments of ICT solutions should be based on as much real data as possible. For the methodology development, the following aspects are necessary to take into account:

- **Selection of indicators**: to have a manageable, yet sufficient amount of indicators both on a city level and for specific ICT solutions used in the city.
- **Data:** to handle case specific as well as general publicly available data, considering both city-related data and evaluation indicators, with the possibility to define baseline, reference year, etc.
- **Transparency in city boundary:** to have transparency in the definition of the city boundaries, both geographically and around what impacts are included in the assessment e.g. impacts occurring within the defined city boundaries, in the

surrounding region, on a national level or on a global level, e.g. whether import/export is included.
- **Transparency in results:** avoid merging impacts into too few categories and avoid translating different impacts into one unit (e.g. money).
- **Life cycle thinking:** use a life cycle perspective when possible and especially for the ICT solutions.
- **Realistic scenario for ICT implementation**: the scale of the ICT solution and its impacts should be based on relevant data for the specific city.

4.2 Assessment Procedure

The direct impacts of the ICT solution, as well as the impacts that are the result of changed activities in the city, for instance less travelling or increased safety, are addressed. The focus of the methodology is high level assessments of the use of multiple ICT solutions in a city, based on a quantitative data collection from existing and potential ICT initiatives across cities.

The following methodology activities are considered:

- Identify ICT solutions (section 4.2.1)
- Define the system boundary for the city and a functional unit for the assessment (section 4.2.2)
- Build scenarios and assess ICT solutions at a city level (section 4.2.3)
- Select indicators to connect solution specific impact results to overall city level sustainability (section 4.2.4)
- Scale ICT solution scenarios between cities (section 4.2.5)

4.2.1 Identify ICT solutions

The first step is to identify ICT solutions to apply to a city. The ICT solutions could be existing or future large-scale commercial implementations, minor proof of concept applications, case studies and trials. These are hereafter referred to as *reference cases*.

4.2.2 System Boundary and Functional Unit

The methodology should be applicable for different kinds of cities. A geographical system boundary needs to be defined for all specific cities. If a too small area like a city center is chosen, there will be a large difference between the daytime and the nighttime population. To avoid some uncertainties in this allocation the geographical system boundary can be extended to incorporate a greater region of the city e.g. greater Stockholm or greater London. Another way is to use adjusted population numbers defined as the mean value of the nighttime population and the daytime population [27].

Availability of city area data for different geographical areas also needs to be considered. It is likely that the methodology will have to include ways of scaling national or regional data to different city levels.

Furthermore, the methodology needs to address import to and export from the city. For an assessment which captures the whole impact on a per capita level, it is necessary to define whether a consumption or a production perspective should be used. Consumption perspective takes all consumption related to the city into account, including impacts from production taking place elsewhere. A production perspective on the other hand relates to impacts from activities and production within the city boundaries. Even though a consumption perspective may be preferred, it is often difficult to cover and the scope might have to be limited to impacts caused within the city boundary. Allocation of travel outside the city boundary including international travelling also needs to be addressed. Hence, as stated in the list above transparency in city boundary definition is of high importance.

We propose the functional unit of the city as such to be the *city's total yearly impact provided per individual in the city,* i.e. impact per capita and year. The temporal boundary does not have to be yearly, but that is the most common time frame. With this functional unit it will be possible to summarize the total impacts from several ICT solutions in the city. On a solution level though, when assessing the impacts from a specific solution, a more appropriate functional unit might be the impact per user of the solution or the impact per a defined amount of service delivered by the solution. For example, an ICT solution that reduces the amount of CO_2 emissions which is only used by a small percentage of the total city population will not influence the city's total CO_2 emissions per individual substantially, but may be significant for the impact of the individuals using it.

4.2.3 Build Scenarios and Assess ICT Solutions at a City Level

To assess ICT solutions at a city level, a scenario will have to be created. The scenario includes the number of people expected to use the solution and expected changes on activities influencing environmental and socio-economic impacts. Scenarios define the potential use of an ICT solution in the city today, but can also be constructed for different future developments.

A number of parameters related to the city and its citizens need to be gathered to get a sufficiently comprehensive basis for setting a realistic scenario. In cases when measurement data before and after the implementation of an ICT solution is available, the scenario is already given.

The main parameters needed to build a scenario can be divided into parameters influencing the number of users, and parameters influencing the induced changes of activities. Which parameters to use, will differ between the ICT solutions that are to be assessed. Table 1 shows parameters that should be considered to estimate the number of users and also gives examples for a specific ICT solution which provides remote monitoring for hospitals and their patients with chronic heart failure (CHF). It is believed that more city factors are likely to be identified as useful to decide upon the number of users of a specific ICT solution in a city. A solution will have several user groups. In Table 1 two user groups are exemplified. User I is the end-user of the ICT solution, hence the patients, and User II is the implementer of the ICT solution, being the doctors or hospital personnel in the example.

The experience of using ICT within the different user groups will influence how widely the solution will be used. In most cases, there is no data available for the ICT user experience within the expected user group. However at country level, ITU publishes the *ICT development index* for countries [46].

Drivers and barriers on individual and societal levels will influence the actual use of the ICT solution, time to full utilization and thereby what impacts the solution will have on environmental and socio-economic activities. Examples of drivers and barriers that are useful when making the ICT solution usage scenario are given in Table 2.

Table 1. Parameters for defining number of users in the ICT solution scenario including the chronic heart failure (CHF) case as an example

Data type	Example of parameters
User I End-user *Example: Patients*	Maximum users in the city *CHF case: Disease prevalence in the city population e.g. maximum number of patients*
	ICT user experience for User I *CHF case: ICT user experience within different age groups of the patients with chronic heart disease*
	Expected growth of maximum number of users (over time) *CHF case: Expected growth of prevalence*
	Growth of ICT development in the country (over time)
User II Solution implementer *Example: Doctors and hospital personnel*	Number of service provider facilities or nodes *CHF case: Number of hospitals implementing the ICT solution for its patients*
	ICT user experience for User II *CHF case: ICT infrastructure and services used within the hospitals*
City factors	Availability of required ICT infrastructure and services: in general and in the specific sector Availability of voice/data network, smart devices, sensors, etc. *CHF case: Fixed/mobile broadband connection availability in different parts of the city (required for the data transfer in remote monitoring)*
	Expected growth/change of availability of required ICT infrastructure and services (over time)

Table 2. Examples of drivers and barriers related to the implementation and use of an ICT solution

Type of data	Example of parameters
Drivers and barriers	Incentive for User I and II to use the ICT solution (cost reduction, time saving, etc.) *Example: Reduced travel to and time spend in hospital for patient and decreased costs spend per patient for hospital*
	Influence from corporations or city council on the use of the ICT solution and hereby the impacts, e.g. programs that support the implementation or policies promoting use of ICT services in the specific sector *Example: Change in demographic distribution e.g. people getting older increasing the target market, demanding an action in the city strategy*
	Previous/other programs in the same or other sector of the city influencing the stakeholders' motivation in a positive or negative way *Example: A successful implementation of digital patient records influencing the willingness to implement the remote monitoring solution*

Assessing the sustainability impacts of the ICT solution scenario includes calculating the life cycle impacts of the ICT system introduced by considering all hardware, software and services required, and identifying and assessing changes in activities in the city.

The interaction between the different ICT solutions in a city, and the dynamics in the resulting impacts should both be considered in the methodology.

4.2.4 Selecting Indicators

For the methodology to work, both at a solution level and at a city level, indicators on both levels will have to be defined. The identification of suitable indicators on a city level should start with identification of indicators that are publicly available for most cities such as GDP, life expectancy, global warming impact, etc. In addition, solution and use case specific indicators need to be identified. The socio-economic indicators will most likely not be the same for these levels of evaluations since socio-economic impacts vary widely with the target group for the evaluation. Socio-economic impacts measured on a solution level will probably include changed activities for the individual users, while high level evaluations of cities will include changed activities for the society. The environmental indicators are more correlated between the solution and city level, as the same impact categories can be evaluated for small scale solutions and individual use as well as for whole city implementations.

To select solution and use case specific indicators for a socio-economic assessment the service sectors in Figure 2 can work as a framework as they indirectly relate to different socio-economic aspects. For environmental impact indicators, however, these sectors are less applicable for direct use, and the city service sectors have to be translated into activities related to environmental impacts. ICT's mitigation potential in other sectors can be categorized into for example dematerialization, demobilization, mass-customization, intelligent operation and soft transformation [47]. For proposed methodology, activities that influence the environmental performance have been categorized into consumption of goods, travel and transport, use of infrastructure and energy use, exemplified in Table 3.

Table 3. Examples of environmental activity categories

Environmental activity category	Activity	Example of data required for environmental assessments
Consumed goods	Increase/decrease of consumables or dematerialization	Paper use per person (kg), server space per user (GB), cars per person (no)
Travel and transports	Increase/decrease distances traveled	Travel in car (km), travel in other transportation (km)
Use of infrastructure	Increased/decreased building stock, public spaces and transportation infrastructure	Building area (m^2), roads and rail ways (km)
Use of energy, water, and other resources	Increased/decreased use of electric power, water, fuel	Energy use (kWh/m^2 or operation), water consumption (m^3)

4.2.5 Scaling ICT solutions between Cities

To be able to use a previous ICT city assessment scenario and results to create a scenario for ICT use in another city - without roll-out details on a use case being available - it is necessary to understand similarities and differences between the cities on a high level. City profile data must be gathered in order to compare cities. In addition, data related to the use of ICT solutions in different infrastructure and service sectors of the city, as well as associated drivers and barriers for the implementation of the ICT solutions in the city, need to be considered. Examples of parameters that need to be taken into account to enable comparisons between cities are provided in Table 4. Note that these types of data could also be included when calculating users and resulting impacts from the ICT solution, according to Table 1 and 2.

Table 4. Examples of data needed for comparison between cities for the purpose of scaling ICT solutions

Type of data	Example of data categories
City profile	Population
	Geographical boundary: city district, city, extended city, municipal, cluster of cities, region, etc.
	Functions: commercial/city center, commercial/ industrial, suburb/houses, suburb/apartment, all functions
	Population growth connected to different kinds of needs: mature, transitional, emerging [44]
	Level of development: is the city located in a developed or developing area?
	ICT development level: low, medium, high [46]
Drivers and barriers	Current/previous programs or policies focusing on the sector where the solution is implemented, focusing on sustainability or promoting use of ICT in the specific sector or in the city in general
Sector specific data	Data related to the sector where the ICT solution is implemented and influenced activities If a transportation solution is assessed number of cars, available public transportation, average time spend/distance to work, etc should be compared.

5. DISCUSSION

For the continued work we have identified the following aspects to need further considerations: data availability, usage of city models, and causality.

Data availability and quality is a major issue in this type of high-level quantitative city assessments. Data is often only available at a national level and/or for aggregated groups of people and activities. It is important to transparently discuss how the data availability, related system boundary selection and data gaps influence the assessment results. Related to life cycle assessments there are three levels of uncertainty; parameter uncertainty (related to input data), scenario uncertainty (related to choices) and model uncertainty (related to set relations) [48]. How parameter and scenario uncertainties influence the city assessment results can be evaluated through simulations and sensitivity analysis. Different users of the methodology have access to different data, for example an ICT manufacturer might have access to full life cycle assessment data for the ICT solution, while less accurate data for the city, and vice versa for a city administrator.

As a city is a complex system it needs to be modeled and structured into sub-units to be understood. Based on the literature study, the city could be structured into as a set of citizen's activities or divided into sectors. The division into sectors proposed in this paper was chosen as it is useful to map needs of future ICT solutions and in impact assessments as a framework to identify changed activities. One disadvantage with this approach is the risk of overlooking horizontal activities, such as freedom of speech, gender of equity that cannot be categorized into a specific sector, and this will be further addressed in our continued research.

Another methodological difficulty in city assessment is related to causality - it is difficult to show that a change of the total sustainability in the city is related to a specific ICT initiative. Aggregated impacts from a number of solutions and adjustments in the city could reach a level that influences the overall impacts, but it will be very difficult to connect the change to individual solutions. As an example an ICT solution within the education sector can be evaluated in terms of indicators at different levels, *access to computers*, or *more graduates from the school*. However, the city probably uses indicators such as *percentage of citizens with higher education* and *adult literacy*. Both of these indicators are likely to be affected, but – due to their high level and time perspective - it will take time and scale before any improvements in the statistics are shown.

Further methodology development includes to test the methodology on a number of reference cases and to scale the results between different cities, to understand how data availability impact the results.

6. CONCLUSION

This paper deals with important aspects of a methodology for assessing the sustainability potential of ICT solutions in cities. Though there are many initiatives related to the assessment of cities with respect to sustainability, quality of life, environmental impacts, or similar, no methodology has been found which can be used to assess the sustainability potential of ICT solutions in a city.

General requirements for the methodology presented include transparency in selection of city boundary and results, and the importance of setting realistic scenarios and using publicly available data.

It is recommended that the listed requirements are considered by those who work with methodology development or assessment of sustainability impacts of current or future ICT solutions in a city. Furthermore, the requirements are also of interest for city administrators and others who currently use available indices and indicators to track the sustainable development of the city. Especially, transparency in selection of city boundaries and impacts included are of high importance to understand the real sustainability impact.

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