Smart City and ICT. Shaping Urban Space for Better Quality of Life

Renata Paola Dameri

Abstract Smart City is a recent topic, but it is spreading very fast, as it is perceived as a winning strategy to cope with some severe urban problems such as traffic, pollution, energy consumption, waste treatment. Smart city ideas are the merge of some other more ancient urban policies such as digital city, green city, knowledge city. A smart city is therefore a complex, long-term vision of a better urban area, aiming at reducing its environmental footprint and at creating better quality of life for citizens. Mobility is one of the most difficult topic to face in metropolitan large areas. It involves both environmental and economic aspects, and needs both high technologies and virtuous people behaviours. Smart mobility is largely permeated by ICT, used in both backward and forward applications, to support the optimization of traffic fluxes, but also to collect citizens' opinions about likeability in cities or quality of local public transport services. The aim of this paper is to analyse the Smart Mobility initiatives as part of a larger smart city initiative portfolio, and to investigate about the role of ICT in supporting smart mobility actions, influencing their impact on the citizens' quality of life and on the public value created for the city as a whole.

Keywords Smart city · Digital city · Quality of life · Smart city performance

1 Smart City: A Strategy for Better Quality of Life in Urban Areas

Smart city is a topic that increased its importance all over the world during the latest ten years [1]. The main reasons are to be found in the urbanization interesting all the countries and continents, and the continuous increasing of the number of people living in urban areas. The urban population in 2014 accounted for 54 % of the total global population, up from 34 % in 1960, and continues to grow. It is estimated that

R.P. Dameri (✉)
Department of Economics and Business Studies, University of Genova, Genoa, Italy
e-mail: dameri@economia.unige.it

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by 2017, even in less developed countries, a majority of people will be living in urban areas (Global Health Observatory). Projections show that urbanization combined with the overall growth of the world's population could add another 2.5 billion people to urban populations by 2050, with close to 90 % of the increase concentrated in Asia and Africa (UN World Urbanization prospects).

Managing urban areas has become one of the most important development challenges of the 21st century. Success or failure in building sustainable cities will be a major factor in the well being of people all over the world. If well managed, cities offer important opportunities for economic development and for expanding access to basic services, including health care and education, for large numbers of people. Providing public transportation, as well as housing, electricity, water and sanitation for a densely settled urban population is a need to be accomplished, but taking concurrently into account the impact of human activities on the environment [2].

Figure 1 shows the present distribution of people living in cities and the larger cities in the five continents.

Cities are therefore places where economic development and cultural richness, but also traffic, congestion, difficulty to access to public services and pollution coexist, impacting both positively and negatively on the quality daily life of citizens.

Smart city is considered as a crucial urban strategy to face these problems, preventing pollution and congestion and supporting innovation, economic development and inclusion in the meantime [3]. Even if till now a shared and consolidated definition of smart city doesn't exist, we can describe a smart city using its components, which are: urban area, environment, technology, and people. Indeed, a

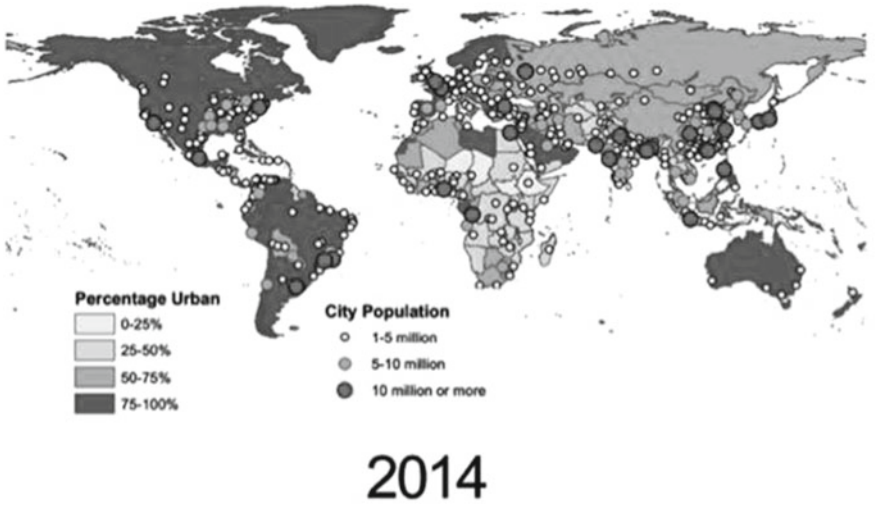

Fig. 1 % People living in cities and the larger cities in the five continents

smart city is a city that uses innovative technologies and especially ICT to prevent and reduce pollution, preserving the environment, and to enhance the quality of life of all its citizens, aiming at economic development and social inclusion. City is the subject, high technologies are the instruments and people and the environment are the addressers of strategy acting with a very large scope, including mobility, urban infrastructure, social policies, culture, economic development and so on [4].

Even if the roots of smart city are faraway in the time, only from 2010 the topic had a boom [5]. We can find the reason of this explosion of interest in several causes, such as: the increasing urbanization, the diffusion of smart phones and other smart devices that support a wired city, the EU funding for research and pilot projects aiming at using the most innovative technologies to reduce the urban footprint on the environment and the CO_2 gases emission.

This high interest regards both the theoretical studies and the real implementation of smart cities all over the world. A survey about scientific papers indexed on Scopus shows that:

- papers with the words "smart city/ies" in the title in 2014 accounted for 280, up from 1 in 1994 when we found the first paper about this topic, but also up from 15 in 2010: it means that the number about this topic has been increasing of 18 times in only five years;
- papers with the words "smart city/ies" in the abstract in 2014 accounted for 464, up from 33 in 2010.

The survey shows also that papers about smart cities are published in academic and scientific journals of all the human field of knowledge [6]: Life sciences, Health sciences, Physical sciences, Social sciences (as classified by Scopus); it is because smart city is a cross topic regarding not only one subject, but almost all the aspects of the human life.

Also the number of implemented smart cities is continuously increasing. Even if we haven't a complete survey about the smart cities all over the world, we can find some figures supporting this fact. For example, the ICF—Intelligent Community Forum names each year the Intelligent Community of the Year, selected amongst 21 nominated cities or metropolitan areas. The ICF nomination is awarded to communities or regions with a documented strategy for creating a local prosperity and inclusion using broadband and information technology to attract leading-edge businesses, stimulate job creation, build skills, generate economic growth, and improve the delivery of government services. The ICF web site lists all the cities nominated from 2006 till now. Figure 2 shows the world map with these cities: it clearly appears that are spread all over the world, with a higher density in Europe, North America and Far East.

The EU Parliament has recently published a detailed report studying the smart city phenomenon in Europe [7]. The researchers examined all the 468 EU cities with population over 100,000 inhabitants within the EU28. Applying the EU definition of the smart city, they found 240 smart cities, that is, 51 % of the sample. It means that more than half cities in Europe are somewhat smart. Even if the report outlines that often these cities are simply implementing one or more smart

Fig. 2 Awarded intelligent cities. *Source* ICF

initiatives, lacking of a veritable strategic plan for becoming smart in all the aspects of the urban life, this percentage reveals that smart cities are a pervasive trend regarding all Europe. EU funding are certainly strongly supporting the implementation of smart initiatives, especially during the economic crisis that prevent local bodies to invest high amount of money in smart projects from their poor budgets. But the EU support has not only a financial role: supporting smart initiatives, EU Commission is also spreading all over the European countries, regions and cities the awareness of better metropolitan areas, based on the three pillars of inclusion, economic development and environment preservation.

Even if the technology is the core component of a smart city, a strategic vision of the city of future including environment preservation, social inclusion, citizens' democratic participation is the critical success factor for improving the quality of life in ever larger and complex cities [8]. Smart cities are therefore not only a technological project, but also a cultural program for livable cities all over the world.

2 Smart City and Digital City: Two Faces of the Same Coin

As already said, even if smart cities are spreading all over the world, a shared smart city definition has not been written till now [9]. However, it is possible to look at the most cited scientific paper about smart city to investigate about this concept and its constitutive components. This survey permits also to investigate about the role

Table 1 Most cited smart city definitions

Smart city definition	Author	Year
A city that monitors and integrates conditions of all of its critical infrastructures, including roads, bridges, tunnels, rails, subways, airports, seaports, communications, water, power, even major buildings, can better optimize its resources, plan its preventive maintenance activities, and monitor security aspects while maximizing services to its citizens	Hall	2000
A city to be smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance	Caragliu	2009
Smart City is a city in which it can combine technologies as diverse as water recycling, advanced energy grids and mobile communications in order to reduce environmental impact and to offer its citizens better lives	EU-SETIS	2012
A smart city is a well-defined geographical area, in which high technologies such as ICT, logistic, energy production, and so on, cooperate to create benefits for citizens in terms of well-being, inclusion and participation, environmental quality, intelligent development; it is governed by a well-defined pool of subjects, able to state the rules and policy for the city government and development	Dameri	2013

and influence of ICT in building a smarter city. Table 1 shows the most cited smart city definitions used by the author to build a present vision of the smart city concept.

As previously noted, smart city is a recent topic with ancient roots. In 2000 Hall [10] studied the smart city especially focusing on two aspects: city infrastructures and services for citizens. In this work by Hall, the city is seen like a body that should monitor all the physical and environmental resources to improve and preserve them, aiming at satisfying the citizens supplying them the best services, both in quality and in quantity. At that time, Hall already settled the basis of the smart city phenomenon: a crossing of material conditions and citizenship. Differently think other cited authors, such as Hollands [11] focusing more on cultural aspects of a smart city such as entrepreneurship, innovation and intelligence; or Bowerman et al. [12] focusing on the green aspect of a smart city, careful towards the environment and its preservation.

In 2009 Caragliu et al. [4] wrote a very interesting paper analysing smart cities in Europe. Their aim was not to individuate all the smart cities, nor to rank them, but to understand their roots and their characteristics. Also in this work the authors focus on the two core components of a smart city, infrastructures and people. But in this definition several aspects are clearer and better defined. Infrastructures explicitly refer to both traditional, physical artefacts and innovative technology, and the authors recalls ICT like one of the fundamental components of a smart city. People are not simply citizens, but their knowledge potential, that if well managed could create a veritable human and social capital. Smart city aims are multidimensional and

include economic development, social inclusion, environment preservation and democratic government. Similarly think also other most cited authors: Nam and Pardo [13] outline the crucial components of a smart city, that are technology, people and institutions; also Giffinger et al. [14] describe a smart city like the interrelationship between multidimensional factors such as economy, people, mobility, government; Paskaleva [15] links the smart city effectiveness to the progress of e-government best practices; Chourabi et al. [16] evidence that the smart city is the synergy between various disciplinary areas and identify eight critical factors of smart city initiatives: management and organization, technology, governance, policy context, people and communities, economy, built infrastructure, and natural environment; Lombardo et al. [17] offer a profound analysis of the interrelations between smart city components connecting the cornerstones of the triple helix, involving firms, public administration and universities or research bodies.

Along with the deep and extensive academic research about the topic, also several international political institutions have been studying this phenomenon. Especially the EU Commission concentrates its funding on the smart city program: EU sees a smart city like an instrument to reduce the environment footprint of large industrialised cities in Europe, through very specific initiatives regarding green mobility, building efficiency, renewable energy sources and low emission cooling and heating. In supporting this vision of a smart city, EU Commission has also contributed to shape a different idea of a smart city, most focused on technology than on people.

However, a smart city is something more than a sum of innovative technologies: it is a large urban strategy interesting a well defined territory, all the infrastructures lying on this territory, citizens and the government and governance of all the city components [18]. A strong strategic vision should support a long term smart program, aiming not only at preserving the environment or at increasing technological innovation, but concretely aiming at improving the citizens' quality of daily life.

In this comprehensive vision of a smarter city, ICT plays a central role. Not only the smart city has its root in the digital city, but also the digital city has becoming the core part of the smart city; ICT is somewhat innerving a smart city in all its aspects. Table 2 shows the most cited definitions of Digital city.

Three are the aspects to be considered.

For the first, several aspects of the Digital city are the same in the Smart city: the territory to be linked, the role of people and government, the aim to improve the quality of life offering public and private services to citizens, as it emerges from the definitions listed in Table 2 [19–23]. Second, the number of studies regarding the digital city has not being increasing from 2010, as it appears absorbed in the smart city field of studies [5]. Third, a deep analysis of most cited papers about smart city reveals that the ICT component is often at the centre of smart projects or of the comprehensive smart strategy for the urban area. For example, Nam and Pardo [13] referring to technology implicitly recalls ICT; Karnouskos and De Hollanda [24] focus their idea of smart city on software components; Su et al. [25] refer to a smart city based on the digital city; Schaffers et al. [26] link the smart city success to the Internet; and the list could continue.

Table 2 Most cited digital city definitions

Digital city definition	Author	Year
A digital city is substantively an open, complex and adaptive system based on computer network and urban information resources, which forms a virtual digital space for a city. It creates an information service marketplace and information resource deployment center	Oi and Shaofu	2001
The concept of Digital City is to build an arena in which people in regional communities can interact and share knowledge, experiences, and mutual interests. Digital City integrates urban information (both achievable and real time) and create public spaces in the Internet for people living/visiting the city	Ishida	2002
A Digital City has at least two plausible meanings: (1) a city that is being transformed or re-oriented through digital technology and (2) a digital representation or reflection of some aspects of an actual or imagined city	Schuler	2007
Digital city denotes an area that combines broadband communication infrastructure with flexible, service-oriented computing systems. These new digital infrastructures seek to ensure better services for citizens, consumers and business in a specific area	Komninos	2008

Therefore, a smart city is strongly based on ICT and the aim to improve the citizens' quality of life is mainly pursued by using ICT in all the multidimensional aspects of a smarter city.

Figure 3 explains how ICT is not a separated dimension of a smart city, but a pervasive element of all the smart city dimensions, regarding transport and mobility, energy, buildings. New research questions therefore emerge from this framework: how and how much ICT contributes to improve the citizens' quality of life in smart city programs? How is it possible to assess and measure this contribution?

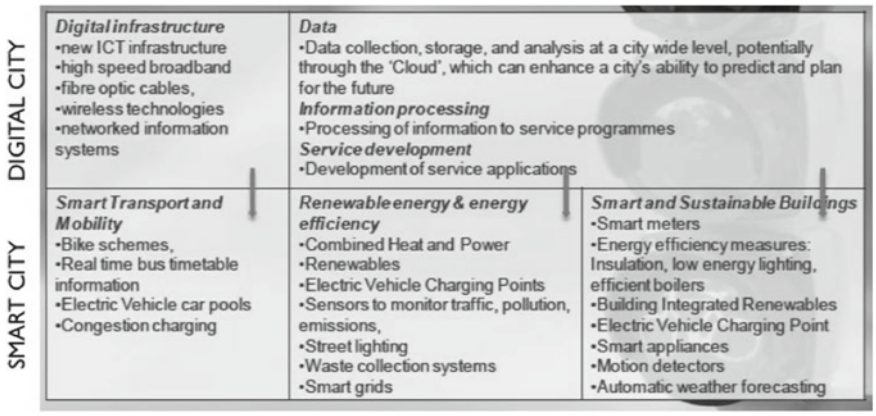

Fig. 3 Digital city pervades smart city

ICT impact evaluation and measurement of ICT contribution in smart projects are central not only to understand the relationship between smart aims and digital components, but also to support political and business decisions in choosing, prioritizing and better planning smart initiatives [27].

3 Evaluating ICT Role and Impact in Smart City Initiatives

Given the pivotal role of ICT in realizing smart city projects and initiatives, a deeper analysis should understand how and how much ICT contributes in differently shaping citizens' daily life in cities, improving their well being. These arguments need to be studied separately. Indeed, one thing is to speak about the role of ICT in defining a smarter city, and how and how much ICT is the leading technology in smart projects rather then the pervasive and supporting technology in projects regarding different aspects of a smart city: such as a smart mobility program using ICT to govern public transport networks, or a smart energy projects using ICT to govern energy smart grid.

Another thing is to speak about how and how much ICT plays its role in generating public and private instruments, artefacts or services able to change the daily life of people living in cities, generating benefits and finally a higher well being.

3.1 Understanding and Assessing the ICT Role and Pervasiveness in Smart City Initiatives

The most of authors studying smart city agree in involving several aspects of the urban life in this large topic [4, 13, 14]. Smart city is a cross urban strategy, regarding both physical components of a city and human and political aspects [15, 16, 28]. Till now, almost all the European smart cities have been implementing their own smart initiatives without a comprehensive strategic plan, but simply putting in their agenda some projects with a smart content especially responding to EU requirements and obtaining EU funding. Also solutions vendors and consultants have been supporting the smart city wave, driving urban innovation especially focused on some topics such and e-government, public administration digitalization, green energy. The result is a strong bottom-up movement producing a plethora of projects often incoherent each other and collected in non-formalised project portfolio. The analysis of these smart city portfolios, when realised and available, is very useful to understand what a smart city includes into its scope and how many projects are pervaded by ICT.

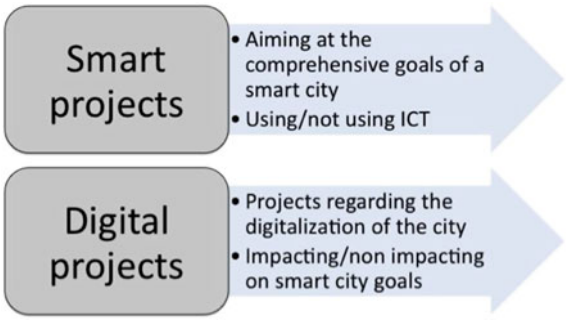

Fig. 4 Smart and digital projects taxonomy

To analyse smart city portfolios, a framework has been defined; it supports the analysis aiming at discovering the role and weight of ICT in smart city. Figure 4 explains the criteria adopted for this survey.

All the projects have been classified as:

- smart projects, when aim that at some typical smart goals such as reducing greenhouse gases, improving building energy efficiency, improving the use of renewal energy sources; smart projects are further classified in using or not using ICT: for example, a solar energy smart grid can use ICT to govern the best energy production and delivery, planning a new park in the city centre positively impact on the environment without using ICT;
- digital projects, aiming at the digitalization of the city; digital projects are further classified in projects impacting or not impacting on smart goals: for example, an app on smart phone informing trucks about the traffic around the city centre impacts on smart goals, the digitalizazion of internal processes of the Municipality doesn't impact on the smart goals of the city.

This framework has been applied on the smart city project portfolio on two amongst the most relevant smart cities in Europe: Amsterdam and Genova. Amsterdam is universally recognised as the first smart and digital city in the world. Genova is the city winning the highest number of EU calls about smart city programs.

In Fig. 5 we can see the results of our portfolio analysis.

It emerges that ICT is an important technology embedded in smart projects or at the core of smart projects, but also that cities are implementing smart projects based on other technologies or without technology at all, only based on changing the behaviour of people [29] or acting on the environmental aspects of the city [30].

The same facts emerge also from the analysis of the international ranking, evaluating the smartness of a city in an international benchmark, applying several smart indicators counting the city equipment in terms of smart artefacts or intangible resources. Three are the main ranking to be considered:

1. the Giffinger ranking of European medium cities [14];
2. the Smart City Wheel [31];
3. The EU Parliament survey on smart cities in EU28 [7].

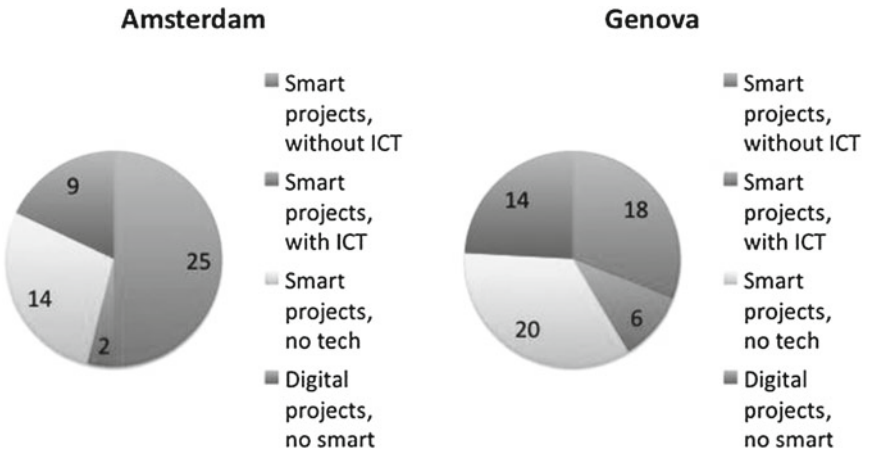

Fig. 5 The portfolio composition of Smart city Amsterdam and Smart city Genova

Each of these rankings considers a different set of indicators; therefore the obtained results are relative, as they depend on the selected indicators, but also the affordability of collected data or their updating. But it is interesting to outline that ICT indicators count only for a partial part of the ranking. For example, Fig. 6 shows the Smart City Wheel model. The red circles evidence the indicators measuring digital equipments in a smart city. It is evident that they are only a small part about all the measured aspects.

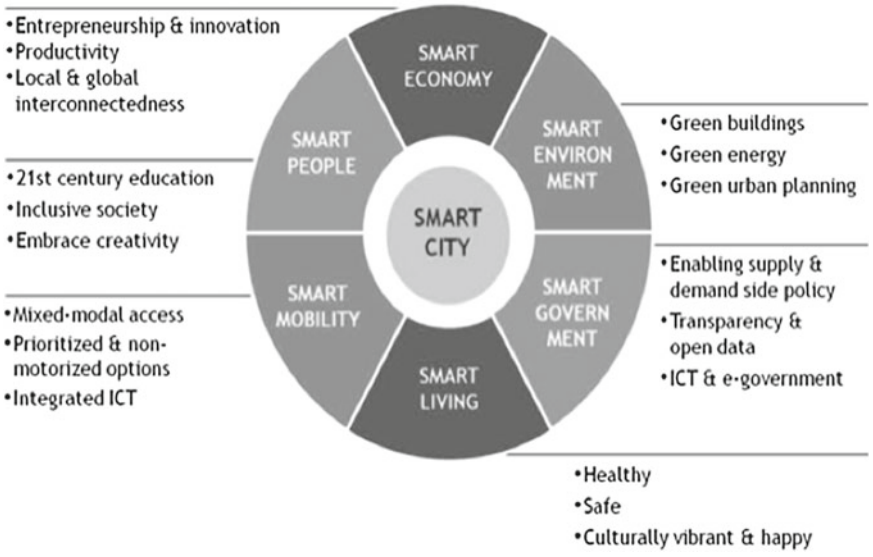

Fig. 6 The smart city wheel model

Therefore we can conclude that:

- the role of ICT in smart cities is important, but not exclusive;
- ICT is assessed both for itself and as a technology supporting smart aspects such as mobility, government and so on;
- ICT weight in smart city depends on the ranking system selected,;
- ICT role in a smart city implementation depend on specific choices of each city and its strategic vision about which type of smart city it wants to implement: digital, green, cultural, or a mix of all of them, and which mix exactly.

3.2 Evaluating the ICT Role and Weight in Improving the Citizens' Quality of Life in Smart Cities

The final aim of a smart city strategy is to pursue the citizens well being and to improve their quality of daily life. But what is well being? And is it possible to measure it?

Several models have been studied to measure people well-being all over the world. A lot of them are specific of one country or geographical area and are therefore not suitable to measure the quality of life in smart city in different countries.

In 2014 OECD designed a framework called Better Life Index, aiming at measuring the citizens' well-being in all OECD countries. This model considers both material and immaterial life conditions, both short term horizon and the future long term horizon of time.

This model could be used to find cause-effect relationships between smart city projects—and also their ICT content—and the impact they exercise on the material and immaterial life conditions. For example, an app informing users of waiting time for a train could improve the quality of life, saving time not wasted in wait but used for doing somewhat else (also having a coffee). The value is then influenced by some dimensions such as:

- readiness of the city, depending on the infrastructure supporting the service and the areas in which the service is available;
- intensity, that is, the number of users capable to access at the service (for example the number of users having a smart phone);
- impact, that is, how much the service is able to influence the daily life of the citizens.

This evaluation is very useful especially a priori. Indeed, when choosing if or what project to implement in a complex smart city program, to be able to estimate the public value it creates is crucial to choice the best projects for the citizens, and not the most innovative but not really impacting on people daily life. For example, to implement bike sharing could be a smart ideas if available bikes are numerous

(readiness), people in city are especially students and tourists (intensity of use) and the city is flat, permitting an easy use of bikes for going to work or school (impact on the daily life).

4 Conclusions

Smart city and digital city are not the same thing, even if smart city has its roots in digital city and digital city is finally a core component of a smart city. However, to simply consider ICT an essential facility of smart strategies is not enough for understanding the role and weight of ICT in shaping a better life for citizens in urban areas. On the contrary, the real capacity of ICT to produce public value when implemented in a large smart initiative depends on a well conceived strategic plan connecting the ICT implementation with a smart vision that links each project with the citizens' well being.

To estimate the awaited value from ICT-based smart projects, it is necessary to take into consideration the city readiness, the intensity of IT use by citizens, and the impact of ICT on citizens' daily life. Without this a priori evaluation, it may be impossible to implement smart projects that will really produce better quality of life in urban spaces, as smart city strategies are expected to.

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