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Smart Cities and Urban Sustainability: two complementary and inter-related concepts

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Abstract

The concept of smart cities constitutes a central issue in the field of spatial planning. Numerous studies have been recorded in the relevant literature concerning the comprehension of the concept as well as the strategies connected to the development of smart cities. In an effort to understand and record the way that smart city strategies influence the objectives of urban sustainability, this paper explores the basic components of their interrelations and underlying connections. Initially, the main concepts of this research, smart cities and urban sustainability, are being clarified and their individual components are analyzed in order to better understand the way they influence urban environment. In this process it is of particular interest to record the way these two concepts could connect and complement each other to create more efficient spatial planning policies and the role of planners in relevance to the challenges that come with the implementation of a smart city approach. The paper concludes that these two concepts have essentially common goals since smart cities approach is about achieving sustainability, efficiency and high quality of life while technology does not play a prominent but a mediatory role in improving and streamlining processes. Therefore, what makes a city both "smart" and "sustainable" is the creation of processes that with the help of ICTs have the potentiality to make the city operate more effectively in all its areas and at the same time to protect the environment, enhance economic growth and improve quality of life. Other qualitative factors such as changing the citizens' behavior towards more sustainable patterns are essential to the making of smart-sustainable cities.

Keywords: Smart cities; Urban sustainability; Urban planning; Smartainability

1. Introduction

Current data on the world population indicate an increasing and migratory trend of the population towards urban centers, a phenomenon that is particularly intense in recent years (Data.worldbank.org, 2018). The consequences of overcrowding in urban centers are the increase of energy consumption, the need for larger population services, the housing shortage and many others. In order to address these issues, future cities will have to act more effectively and intelligently. The concept of "smart cities" represents that kind of future cities having as purpose to create more efficient urban environments (Girardi and Temporelli, 2017). The smart city approach is heavily based on the use of available information and in consequence on the systems of Information and Communication Technologies (ICTs). Its main goal is to improve the quality of life of residents and eventually provide the appropriate conditions for the development of sustainable cities, which will be able to better and more effectively manage urban issues.

In the recent planning literature there is a plethora of references on the concepts of urban sustainability and smart cities whereas there are few references on the way these two concepts could connect and complement

each other to create more efficient planning policies. In an effort to understand how smart city strategies can affect the overall sustainability of urban areas this paper presents a conceptual framework that depicts the interrelations between these two concepts where human behavior and spatial planning plays a significant role in defining the underlying connections.

In this context, this paper starts with the clarification of the concepts of urban sustainability and smart cities in order to understand and record the relations created between the smart city model and the various aspects of urban sustainability. In particular, the first section of the paper presents the concept of smart cities and its components, trends and challenges as well as the role of urban planners. Then there is a presentation of the concept of urban sustainability based on its four basic dimensions: environment, economy, society and urban governance. The relationship between these two concepts is then established by introducing the factors of human behavior and the role of spatial planning.

2. Smart cities

The world's population is expected to increase by a little over a billion people in the next 13 years, reaching 8.6 billion in 2030 and rising further to 9.8 billion in 2050 and 11.2 billion by 2100 (United Nations, Department of Economic and Social Affairs, 2017). Therefore, the phenomenon of population growth becomes one of the, if not the first, dominant issues listed as main global threats. Furthermore, according to the United Nations' Department of Economic and Social Affairs it is estimated that until 2050 the 70% of the world's population will reside in urban areas and therefore maintaining and producing urban sustainability in cities becomes one of the critical global issues to be addressed immediately (United Nations, Department of Economic and Social Affairs, 2017).

As long as the world we live in is becoming more urbanized, cities should become smarter and new innovative methods of managing and operating city life are needed (Eremia, Toma and Sanduleac, 2017). Currently many urban development strategies are using ICTs as a way to increase environmental efficiency and to introduce smart and innovative systems. These strategies reflect the smart cities concept that aims to achieve environmental sustainability, resilience and balanced social and economic development (ITU-T, 2016).

According to Komninos (2009), smart cities are areas of high learning and innovation capacity that are founded on the creativity of the population, their knowledge-based institutions, and their digital infrastructures and services for communication and knowledge management. However, technological systems only concern one of the aspects of the concept of smart cities (Manitiu and Pedrini, 2015). A more comprehensive definition is provided by Giffinger (2007) where a smart city can be perceived as «*a city well performing in a forward-looking way in economy, people, governance, mobility, environment, and living, built on the smart combination of endowments and activities of self-decisive, independent and aware citizens. Smart city generally refers to the search and identification of intelligent solutions which allow modern cities to enhance the quality of the services provided to citizens*».

Being a complex concept, smart cities approach comes to serve six urban dimensions: government, economy, mobility, environment, people and life (Giffinger, 2007; Komninos, 2009). In specific, table 1 presents each one of the six dimensions and the corresponding challenges in a smart city context. The technology, which is directly related to smart cities is not a dimension or an aspect of smart cities but the mean for improving and making them more effective (Monzon, 2015).

Table 1. Challenges of smart cities (ITU-T, 2016; Monzon, 2015; ETRealty.com, 2018)

GOVERNMENT	ECONOMY	MOBILITY	ENVIRONMENT	PEOPLE	LIFE
Flexible government	Unemployment	Sustainable mobility	Climate change	Unemployed	Economic habitation
Low levels of engagement and citizen participation	Single-sector economy	Exclusive mobility	Storage of energy	Social cohesion	Social cohesion
Spatial cohesion	Spatial cohesion	Multimodal transport systems	Holistic approach to environmental and energy issues	Poverty	Health problems
Good vertical and horizontal cooperation of all levels of government	Sustainable local economies	Urban ecosystems under pressure	Urban ecosystems under pressure	Division due to technology	Emergency management
	Disruption of ICT facilities	Traffic congestion	Urban sprawl	Cyber security	Urban sprawl
		No use of cars	Lack of natural resources		Safety and security
		Disruption of ICT facilities			Cyber security

From a planner's perspective the challenges that come with the implementation of a smart city approach concerns mainly the decision-making processes in issues of public interest. More specifically, in a smart city approach where data and information are becoming widely available, it is the planner's responsibility to filter and process these data in favor of society and the common good. In addition, traditional city planning principles and practices that concern basic urban issues such as mobility (means and modes of transport, promotion of public transportation etc.), environment (green spaces, management of natural resources, practices of reduced and efficient energy consumption, etc.) and land management (development of economic activities, development of social housing, etc.) demand effective horizontal and vertical intergovernmental cooperation and spatial integration.

3. Urban sustainability

Sustainable development is one of the most common concepts we currently encounter in the political, economic and urban fields, with the main purpose of meeting contemporary needs (economic, social, environmental), while maintaining the right conditions for the future generations to prosper (Ibrahim, Omar and Mohamad, 2015). According to Finco & Nijkamp, (2001) after recording various definitions of urban sustainability a more comprehensive and conceivable definition is that of urban sustainability *« as the process in which measurable improvement in short and long-term human well-being can be achieved through actions on the*

dimensions of the environment (consumption of resources with environmental impact), the economy (resource efficiency and economic return) and the society (social well-being and health)».

Since sustainability is a multifaced concept and applies to various policy fields depending on the priorities of each city or country, it is imperative to define its key components. According to Li-Ke (2016) and Abdullahi & Pradhan (2017), the three basic dimensions of sustainability are environment, economy and society accompanied by a forth equally critical dimension this of urban governance. Historically urban governance did not constitute an urban sustainability component but its significance in the formation and implementation of sustainability strategies made critical its incorporation in the urban sustainability concept (United Nations - Department of Economic and Social Affairs, 2013). Table 2 presents the various aspects of urban sustainability as part of the four basic sustainability dimensions.

In order to achieve urban sustainability, several strategies focus on resource management such as reducing energy consumption and air pollution. Sustainability as a concept attributes equality and harmony to the future and can be perceived as an effort to harmoniously co-develop environmental, economic and social goals (Mega and Pedersen, 1998). From a spatial planning perspective this is achieved through strategies that are focused on developing high-density mixed-used urban environments, connecting existing and new green spaces, promoting multi-tropical transport systems, regenerating underutilized areas etc. (Kropp and Lein, 2013; Asla.org, 2018). At the same time spatial planning as a form of urban governance is considered to be the field of integration of all dimensions and aspects of urban sustainability.

Table 2. Dimensions and aspects of urban sustainability (United Nations - Department of Economic and Social Affairs, 2013; Li-Ke, 2016; Abdullahi and Pradhan, 2017)

Urban sustainability's dimensions	Aspects
Environment	Air quality Water Waste management Ecological footprint Greenhouse's gases emissions Green spaces Vulnerability to natural disasters Urban productivity
Economy	Economic growth Business investment Cost of public services Transportation Security
Society	Education Public health Equity (accessibility) Social services Active citizen participation
Urban governance	Planning and decentralization Government Distribution of public services Civil and political rights Connection of local, regional, national and global authorities

4. The relationship between smart cities and urban sustainability

The concepts of smart and sustainable cities have been given a number of different definitions, but many researchers refer to these two concepts as one, i.e. "smart sustainable cities". Analysis of their definition indicated that the strategy of smart cities is about achieving goals of sustainability, efficiency and high quality of life while technology does not play a prominent but a mediatory role in improving and streamlining processes (Monzon, 2015). Therefore, a city might be sustainable without being smart and vice versa. In addition, according to Höjer and Wangel (2015) due to the complexity of urban environments it happens that application of smart technologies might not be as efficient in large cities as in smaller ones. Therefore what makes a city both "smart" and "sustainable" is the creation of processes that with the help of ICTs, have the potentiality to make the city operate more effectively in all its areas and at the same time to protect the environment, revitalize local economic growth and improve people's quality of life (Universit *et al.*, 2018).

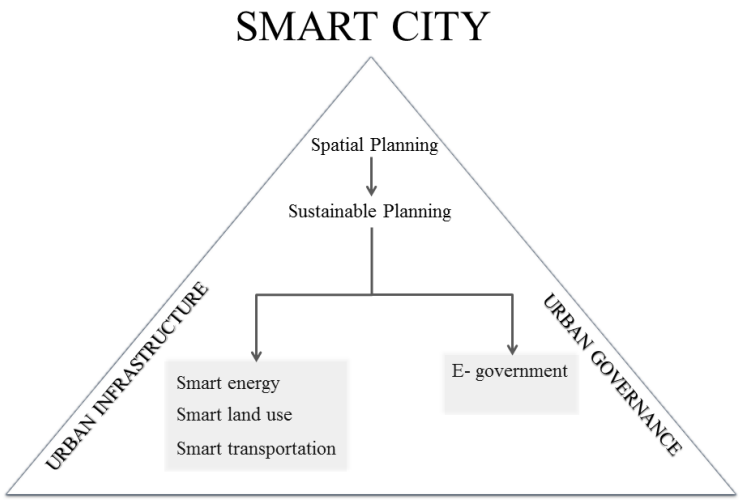

Figure1. Impact of smart city on sustainable planning, (Khansari, Mostashari and Mansouri, 2014)

If we focus on urban sustainability as expressed through land use planning strategies, compact urban development, land use mix and good public transport are proposed as essential components in order to reduce the consumption of natural resources. In this context, smart city strategies enhance urban sustainability by introducing better infrastructure and facility management as well as transparency in planning decisions and urban governance (see Figure 1), (Khansari, Mostashari and Mansouri, 2014).

It is indicative that Girardi & Temporelli (2017) proposed the unification of the terms and context of smart cities and urban sustainability into the term Smartainability, which refers to the coexistence and complementarity of the two concepts. Their idea resulted from the fact that the primary goals of both strategies are common and the need to capture the relationships and interconnections created between the opportunities provided by the smart city (ICTs, smart solutions) and the various dimensions of urban sustainability.

4.1. The process of achieving smart-urban sustainability

Urban sustainability is a multidimensional concept and its application through smart city policies involves the consideration of many critical factors. Figure 2 portrays the process and intricate relations of how to achieve urban sustainability though a smart city approach. According to Khansari et al. (2014) in this process there are two basic pillars; sustainable behavior and sustainable planning.

The first pillar, sustainable behavior, concerns the inhabitants and the way they perceive things and act in their everyday life. Changes in daily activities related to energy consumption practices, travel patterns and waste management can have a direct and positive impact on economic and environmental sustainability. Furthermore, changes in citizens' political behavior are critical in order to empower the process of participatory governance which is the fourth dimension of sustainability. The second pillar, sustainable planning, deals with the typical spatial planning issues such as transportation, energy, and land use allocation that have a direct effect on the environmental performance of the city. The smartness factor embedded in these components can greatly affect the sustainable behavior and daily activities of citizens. For instance, it is well known that land use allocation affects urban form which in turn affects travel behavior, therefore alterations in urban form and primarily in land uses have the capacity to alter mobility behavior and vice versa (Jabareen, 2006; Williams, Burton and Jenks, 2013; Reid, 2015). According to Mühlhans et al. (2004) smart technology along with economic and political measures can affect the traditional relation between land uses and transport (see Figure 3) while energy consumption enters the above mentioned perpetual cycle to achieve low energy consumption and environmental sustainability.

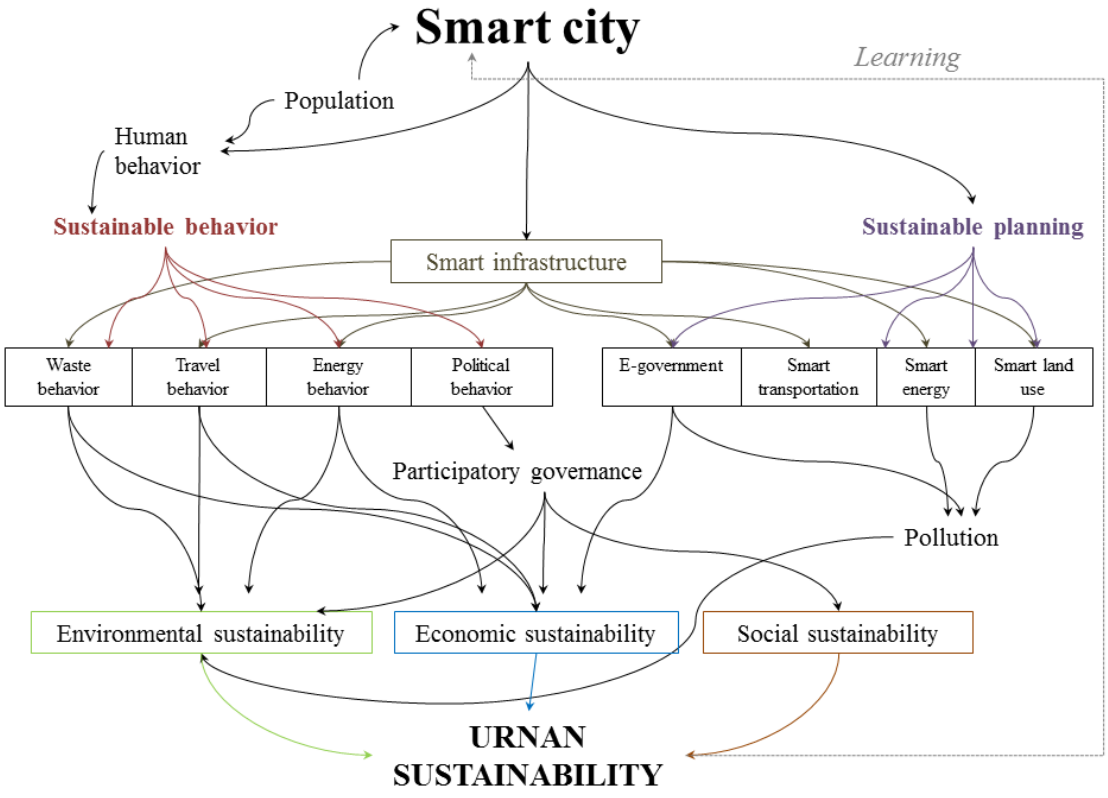

Figure 2. The process of achieving urban sustainability (Khansari et al., 2014)

Last but not least, another basic component of sustainable planning is governance. Smart governance has the ability to improve the distribution of governmental services and at the same time create conditions for participatory actions for citizens in the decision-making processes. Participatory practices in urban commons create a sense of inclusiveness and transparency which in turn could change citizens' political behavior achieving in that way the goal of social sustainability.

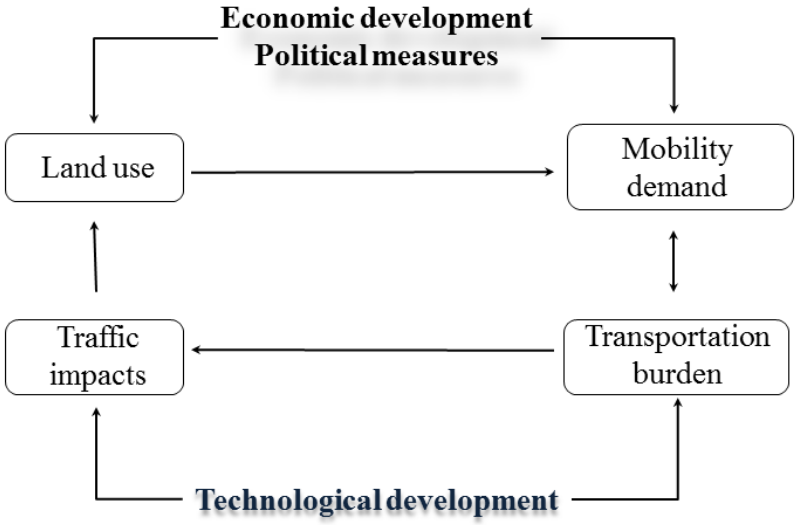

Figure 3. Relationships between technological and economic development, land use and transport (Mühlhans *et al.*, 2004)

Thus, the process presented in Figure 2 indicates that urban sustainability is achieved when the basic principles for economic, social and environmental sustainability are respected. In a smart city, the process of achieving these basic principles is assisted by ICTs with smart solutions on typical spatial planning issues (smart transport, smart land use, smart energy) and by enhancing governance practices and citizens' sustainable behavior. Finally, it is important to note that the knowledge (the dotted grey line in figure 2) acquired during the process is emended back into the process in order to invent new smart ways of achieving the sustainability goals.

5. Conclusions

Urbanization is certainly one of the most significant trends in the last 150 years and cities have now the opportunity to be the force for addressing sustainable growth. Focused on wise resource management, urban sustainability has been the core concept of sectoral interventions, strategic urban planning and comprehensive urban policies. In addition, there is a growing consensus that good and effective urban governance is crucial in achieving urban sustainability, therefore a fourth dimension has been added to the classic urban sustainability triangle of economy, society and environment. While urban sustainability is reinventing itself through the practice of urban governance, the revolution of ICTs in cities are bringing forward new challenges in city management. This trend is driving the smart cities phenomenon worldwide where ICTs and other means are used to improve quality of life and efficiency of urban functions.

A shift in changing human behavior and promoting effective spatial planning seems to be the two critical factors in achieving the goals of sustainable development. ICTs as part of a smart city approach gives the opportunity to create innovative solutions that improve quality of life and efficiency in urban operations and services while ensuring that the needs of present and future generations are met. Furthermore, having the right infrastructure and technical platforms will enable ICTs to improve accessibility of new information systems (e.g. mobility information or energy consumption) to a wider range of city dwellers while at the same time will offer new opportunities for participatory governance models. Therefore, it seems that the concepts of urban sustainability and smart city are interconnected in various ways and complement each other in many aspects, hence one cannot be achieved without the other.

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