

Smartness of Smart Sustainable Cities: a Multidimensional Dynamic Process Fostering Sustainable Development

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Abstract — Smart Sustainable Cities are gaining global attention rapidly. They are becoming a reality and hundreds of related initiatives around the world are taking place. Accordingly, cities are claiming to be smart and even smarter than others. However, smartness, as a concept, still has no standardized definition noting that it does not exist until it is defined and measured. For selected researchers and practitioners, it is assessed through the city's participatory governance, economy, mobility, environmental strategy and management of natural resources, and the presence of aware citizens. Others focus on the advancement of technologies and the infrastructure needed to introduce smart solutions. For smartness to be properly assessed, its boundaries should be clearly set. By setting these boundaries through a comprehensive definition, it becomes possible to build an assessment model that methodologically monitors smartness of cities. In this research, a literature review on existing interpretations of smartness is presented and followed by an analysis of the goals of a Smart Sustainable City with lights shed on the quest of sustainable development. Through an analytical discussion, smartness is proved to be a dynamic process enabling change. It uses technologies to infuse innovation thereby achieving multidimensional urban efficiency. Also, a mutually reinforcing relationship between smartness and sustainable development is shown. The research paper concludes with introducing a holistic definition of smartness which contributes to clarifying the concept and constitutes a cornerstone in assessing the performance of Smart Sustainable Cities. It also provides the grounds for supporting or defying self proclamation of a city for being smart and/ or smarter than others.

Keywords- *Smart Sustainable City; Smartness; Development; Information and communication Technology; Innovation.*

I. INTRODUCTION

With the transition from the 20th to the 21st century, overpopulation became one of the core concerns in relation to urban growth and sustainability of cities. Today, 54% of the world's population lives in urban areas, a proportion that is estimated to reach 66% by 2050 [1]. Urban growth is expected to continue and this requires a major change in the approaches of urban planners. Cities should be turned into safe, healthy, efficient and attractive places for people to live in. Attention should be attributed to different variables constituting the base for a Smart Sustainable City (SSC) [2]. Though advanced, SSCs are becoming a reality and hundreds

of related initiatives around the world are taking place [3]. Currently, there exists a competition on how to interpret the concept of a SSC. It has become a notion with a relatively positive connotation [4]. Many cities around the world embarked on the SSCs bandwagon labeling themselves as "smart" believing that it is a sign of development [5] whereas smartness does not exist until it is properly defined and measured [6].

Smartness, used to assess the performance of a SSC, is still not a well rooted concept in the literature. It is regarded differently by different researchers and practitioners. One group of countries claims to be smart by associating smartness to the development of the technical infrastructure needed for a SSC. Another group refers to smartness as the improvement of e-government services considered to be a prerequisite for the development of a SSC [7]. The variance in the interpretation of the concept makes it difficult to set the boundaries for assessing and reviewing the performance of a SSC and to overcome self proclamations of cities for being smart and sustainable. Therefore, this research aims at filling this gap in knowledge.

The main driving question to identify smartness is "What could be the main elements that make a city smartly sustainable"? Is it governance, technology, communication, transport, infrastructure, people, economy, culture, environment, natural resources, innovation, quality of living or something else? By answering this question, we would be identifying the main elements and potential cross cutting issues in a SSC that city planners and decision makers should consider when assessing the performance of a selected city. Therefore, identifying, through a critical analysis, the boundaries of smartness either by adopting an existing definition or by putting forward a new one that captures the elements needed to be present for a city to be smart and sustainable is needed. By bridging this gap in knowledge, this paper aims at providing guidance on the main issues to look at when assessing smartness and explaining what it really means for a city to be smarter than another in the urban sphere. In addition to framing the core elements constituting smartness of SSCs, the introduced definition is anticipated to provide basis for building a comprehensive model to monitor smartness on one hand and to assist policy and decision makers in urban planning for the betterment of their cities on another hand [8]. Also, this paper links smartness to the quest of sustainable development, a concept that is widespread at the global level.

Section 2 of this paper explores the concept of smartness and its exiting definitions. Section 3 critically analyzes the definitions of smartness and sheds light on its alignment to the principles of sustainable development. Section 4 highlights enablers and cross cutting issues affecting smartness and proves it to be a dynamic process. Section 5 overviews the expected outcomes of the research. The paper concludes with Section 6.

II. SMARTNESS: CONCEPT AND DEFINITION

This section sheds light on the definitions of a SSC and smartness as available in the litterature and touches on different related concepts.

A. Definition of a SSC

The definitions of a SSC are numerous and so is the interpretation of smartness. The concept is getting popular around the world but it is being referred to in different names and in varied contexts which makes it fuzzy. There is neither a single template for framing this concept nor a unique definition [9]. In order to address this gap in knowledge, the International Telecommunication Union - Telecommunication Standardization Sector (ITU-T), responsible for standardizing telecommunications related issues at the global level, formed a technical focus group named the ITU-T Focus Group on Smart Sustainable Cities (FG-SSC). The latter, after an extensive participatory effort, standardized the definition of a SSC as follows: "A smart sustainable city is an innovative city that uses Information and Communication Technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects" [10].

Variance in relation to the dimensions of a SSC also exists in the literature [11], but the majority of the approaches agree on six dimensions, namely smart economy, smart environment, smart governance, smart living, smart mobility and smart people [12] as depicted in Fig. 1. The ITU through its ITU-T/FG-SSC referred to these dimensions as the primary indicators for a SSC. Given the adoption of these six dimensions by the international community and their strong academic foundation, they are used in this research to represent the dimensions of a SSC. The integration of these dimensions among others will constitute the main blocks of smartness.

B. Definition of Smartness

Tracing the roots of the term "smartness" in the context of cities can contribute to a better understanding of what this term denotes and connotes in the urban sphere. In the marketing language, smartness is centered on a user perspective [13]. In the urban planning field, it refers to the intelligent use of ICTs to improve the productivity and efficiency of a city's infrastructure and services [14]. In the technology context, smartness implies the automatic

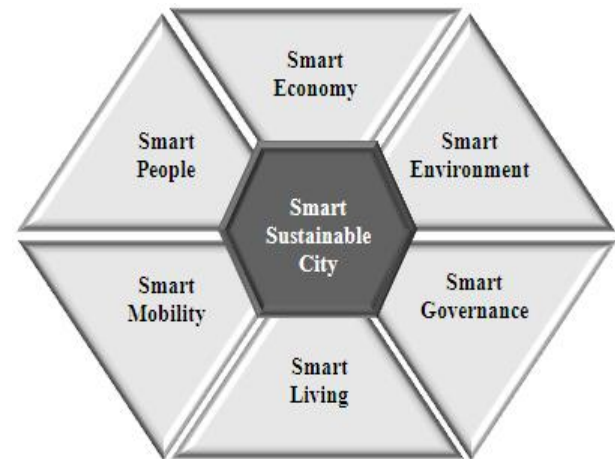


Figure 1. Dimensions of a Smart Sustainable City

computing principle such as self-configuration, self-healing, self-protection, and self-optimization [15]. In the urban growth context, smartness is treated as a normative claim and ideological dimension. Being smarter entails strategic directions and adaptation to user needs [16]. Nowadays, governments and public agencies at all levels are embracing the notion of smartness to distinguish their new policies, strategies, and programs for targeting development, economic growth, and better quality of life for their citizens [17].

Academics, professionals, private sector and governments, despite few commonalities, refer to smartness differently. "Smartness" of a city describes its ability to bring together all its resources to effectively and seamlessly achieve the goals and the targets it has set to itself [18]. Thus, smartness is mainly linked to seamless integration and interoperability. In some instances, smartness is interpreted as being strictly linked to urban efficiency at the level of economic development, environment, human capital, culture and leisure, and e-governance [19]. It is also regarded as urban efficiency along the six dimensions previously mentioned and considered intelligence as the use of ICTs infrastructure as the "glue" which integrates all the other elements of the smartness of the city [20]. Another approach groups the core factors leading to smartness into three categories, namely technology, people and institution and refers to smartness, in this case, as the urban efficiency reached via the intersection of these three groups [21]. Also, literature research shows that core smartness factors are also focused on sustainability and livability [22]. The latter lists internal and external factors grouped into eight clusters, namely management and organization, technology, governance, policy, people and communities, economy, built infrastructure and the natural environment. Therefore, smartness is the result of the achievement of these factors all together aiming at achieving urban efficiency. According to the European Union, smartness is a concept associated with the model of a

technologically advanced, green and economically attractive city [23]. The ITU-T/FG-SSC considers smartness as an attribute of the SSC along the six different dimensions shown in Fig. 1. It also looks at smartness in terms of finding smart solutions instead of conventional ones to address the needs of citizens. Therefore, smartness refers to addressing the needs of citizens via innovative technologically oriented solutions. In-line with this focus on innovation, selected researchers and practitioners interpret smartness as innovativeness [24].

Different approaches highlighted the role of technology and mainly ICTs as crucial to smartness since it transforms life and work within a city in significant and fundamental ways [25]. However, researchers argue that without the real engagement and willingness to collaborate and cooperate between public institutions, private sector, voluntary organizations, schools and citizens, smartness will not be reached [26]. Therefore, ICTs are essential for smartness but collaboration and partnerships amongst the different elements of the city is a must.

The list of definitions is long which clearly shows that the concept is still vague. No effort was so far conducted to come up with a synthesized definition capturing the main elements of smartness in the context of SSCs. In what follows, a discussion of the aforementioned definitions is presented and a holistic definition of smartness framing its related elements is introduced.

III. SMARTNESS OF A SSC: TOWARDS A HOLISTIC DEFINITION

This section discusses the above mentioned definitions of smartness and shows that smartness is a multidimensional dynamic process fostering the principles of sustainable development.

A. Discussion of Definitions

The presented definitions of smartness show the variance in interpreting the concept amongst governments, international organizations, academia, private sector, civil society organizations and others. They focus on innovation and technology as being important elements of a SSC and the majority considers ICTs and other means as enablers for city's advancement and sustainability. They also consider it as a facilitator for ensuring integration and interoperability amongst the different systems of the city. Moreover, the approaches either consider smartness as the process of achieving urban efficiency at the aforementioned six different dimensions or along a subset of these dimensions.

In addition to achieving urban integration and interoperability, thus efficiency through innovative use of technologies and other means, several points are important to note. These are the adaptation to citizens' needs and their quality of life. Also, different definitions shed light on the role of citizen engagement and on selected means of implementation of a SSC like partnerships between the different stakeholders in a city as a mean for advancing the

realization of a SSC. Accordingly, smartness could be associated to the use of ICTs and other means to advance innovation throughout the different dimensions of a city to achieve urban efficiency. Smartness necessitates undertaking a series of actions to achieve urban efficiency; In other words, smartness is a process aimed at achieving urban efficiency. The latter is achieved by following an integrated approach which addresses the citizens' needs while advancing economic growth and being environmentally friendly. This lies at the core of the concept of Sustainable Development and its principles which commit to equality, inclusion and justice, the precautionary principle, and the integration of the complex interconnections that exist between the environment, economy, and society. Therefore, smartness of a city is related to the quest of sustainable development. In the following section, we will explore in more details the concept of sustainable development, its pillars and relation to the objectives of a SSC, thus its role in identifying the smartness of a selected SSC.

B. Alignment with the Principles of Sustainable Development

This section highlights the alignment existing between the goals of a SSC and the core principles of sustainable development. Thus, it justifies the mutually reinforcing linkage we create between smartness and sustainable development.

To start with, the concept of sustainable development became well known after the launch of "Our Common Future", a report published by the World Commission on Environment and Development in 1987. This report, also known as the Brundtland report, refers to sustainable development as "development which meets the needs of the present without compromising the ability of future generations to meet their own needs." The concept received global support after its acceptance by the United Nations General Assembly. In 1992, leaders of states around the world set out the principles of sustainable development at the United Nations Conference on Environment and Development in Rio de Janeiro, Brazil [27]. These principles focused among others on social equality and inclusion which is in itself challenging as it requires moving beyond meeting immediate needs and investing in solutions that lead, in the long term, to sustainable and resilient outcomes in the lives and livelihoods of populations [28]. The key principle of sustainable development underlying all others is the integration of environmental, social, and economic concerns into all aspects of decision making and governance systems. This integrated rather than fragmented approach is essential to urban efficiency in the context of SSCs and they are explicitly mentioned in the ITU definition of a SSC. Therefore, a relationship between the smartness and sustainable development is identified.

Since the Brundtland report and the Rio Summit, sustainable development has transitioned from being a debatable concept, to one that has widespread endorsement

by international institutions, governments, businesses, and civil society. It recognizes that growth must be inclusive and environmentally sound to reduce poverty and build shared prosperity for today's population and to continue to meet the needs of future generations. It focuses on carefully planning to deliver both immediate and long-term benefits for people, planet, and prosperity [29]. Also, sustainable and resilient livelihoods denote granting sustainable and resilient good quality of life which is an objective of a SSC.

The concept supports economic and social development, in particular for people with a low standard of living and in parallel highlights the need for protecting natural resources and the environment [19]. It has generally been recognized for main aspects, namely Economic, Environmental and Social along with synergies amongst them and implications on governance systems. The economic aspect focuses on the ability to produce goods and services on a continuing basis, to maintain manageable levels of government and external debt, and to avoid extreme imbalances. The environmental aspect maintains a stable resource base. The social aspect focuses on achieving distributional equity, adequate provision of social services including health and education, gender, and political accountability and participation. Fig. 2 shows the synergies between these aspects.

Given the above, sustainable development is considered as a process and sustainability is the state where the key goals of sustainable development are addressed: a high quality of life is achieved and the environment is preserved [30]. To attain an improved quality of life, which is one of the main goals of SSC, the city should be people-centered. It should address the needs of its citizens especially those of the poor to which main priority should be given as it constitutes the greatest challenge and indispensable requirement for achieving sustainable development [28].

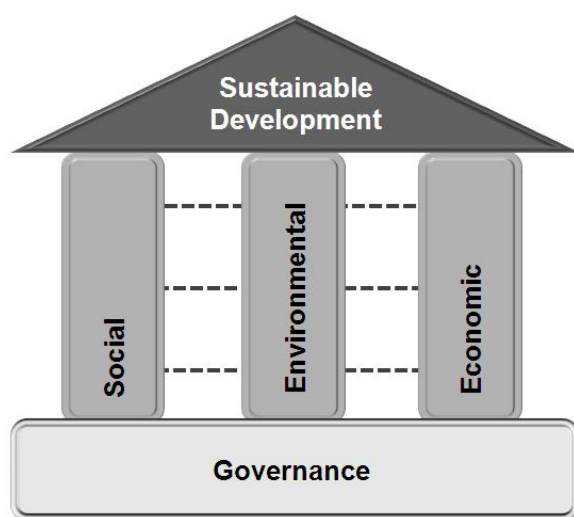


Figure 2. Aspects of Sustainable Development

Also, attaining a high quality of life requires reducing inequalities, considered to be a core driver for advancing sustainable development. Therefore, contributing to the process of sustainable development results in a contribution to smartness in the context of cities and vice versa, thus the relationship identified above could be regarded as mutual in nature.

It is important to note that culture can be a powerful driver for development, with social, economic and environmental impacts at the community level [30]. Development approaches that are responsive to the cultural context and the specificities of a place and community, and advance a human-centered approach to development, are most effective, and likely to yield sustainable, inclusive and equitable outcomes [28]. Acknowledging and promoting respect for cultural diversity can facilitate achieving development goals and improving quality of life. Culture, understood this way, makes development more sustainable, urban efficiency higher and cities smarter. Therefore culture further strengthens the linkage between smartness and the alignment with sustainable development

Last but not least, in September 2015, during the United Nations Summit, the Sustainable Development Goals were announced and adopted by the world governments. They replace the Millennium Development Goals (MDGs) to present a holistic approach to development by embracing integrated economic, social and environmental dimensions. They constitute a set of 17 goals and 169 global development targets defining the global sustainable development agenda [31]. Goal 11 is dedicated to SSCs and communities which further supports our approach in linking smartness to sustainable development.

This alignment is of utmost importance since, if properly implemented, it addresses many of the criticisms facing SSCs. For instance, one of the reported criticisms of SSCs is the possibility of widening digital gap and the alienation of a big portion of the society, namely the technology illiterate. Following this example, when measuring smartness bearing in mind the principles of sustainable development, we would not only measure availability of services but also equal accessibility. Therefore, smartness, when linked to sustainable development, will advance concepts of equality and inclusion and respond to comparable criticisms. It will also highlight the integration needed to be present among the different aspects of a city. Up to this point, smartness in addition to being associated to the use of ICTs and other means to advance innovation at the different dimensions of the city to achieve urban efficiency, it is proved to be a process that enjoys a mutually reinforcing relationship with sustainable development.

C. Smartness: a Multidimensional Dynamic Process

In what follows, a discussion highlighting cross cutting issues and enablers of SSCs and which affect smartness of cities is provided. The dynamicity of the smartness process is also underlined.

1) *Smartness Cross cutting Issues and Enablers*

As mentioned previously, the integration of environmental, social, and economic concerns into all aspects of decision making and governance systems are essential to sustainable urban efficiency [32]. Recalling the SSC definition of ITU, we note that not only integration is needed but also innovation. ITU refers to a SSC as an innovative city. Therefore, innovation lies at the core of SSCs and relates to the different dimensions of a city. Also, ICTs and other means are considered as the nerve connecting all dimensions of a city to grant efficiency.

The main challenge towards the transition to a more equitable and environmentally aware growth is to address the innovation issue not only from an economic, but also from social and environmental dimensions [30]. Also, for sustainable development, the challenge for innovation does not rest solely on economic benefits and opportunities, but also in the societal changes induced by innovative capacity and the consequences of this for the environmental and social sustainability. Innovation can lead to the transformation of systems, values and culture as well as the production of new and/or improved products or processes [33]. Innovation serves as a crucial driver of rising prosperity and improved national competitiveness [34]. It fosters the wheel of sustainable development [35], thus fosters the realization of SSCs and affects their smartness.

In addition to innovation, we regard ICTs as an enabler for achieving urban efficiency and improving quality of life of citizens. ICTs alone are rarely the key to unlocking economic value, but it induces real wealth creation when it is combined with new ways of doing business and provides an important opportunity for technological leapfrogging, in particular through mobile telephony [36]. ICTs allow the production of better statistics leading to better decision making, deployment of an intelligent infrastructure, advancement of social inclusiveness and citizens' engagement, enhancement of economic competitiveness, establishment of low carbon businesses and promotion of sustainability [37]. In addition, the fragmented approach to development resulted in having applications that live in silos. Business as usual cannot continue when implementing SSCs and trying to monitor smartness. Integration between the different dimensions of a city should be promoted to grant sustainability. This technical integration amongst different platforms constitutes one of the main roles that ICTs can play in a SSC, thus smartness.

Researchers refer to technology differently. Some of them consider technology as a crucial dimension of a SSC [21] while others believe that it is an indispensable ingredient of the SSC that acts as glue connecting different everyday living services to public infrastructures thus ensuring integration and interoperability. It is the orchestrator of the various elements of the SSC which should coexist [3]. The ITU-T/FG-SSC highlights the crucial existence of technologies due to their ability to act as a

digital platform from which an information and knowledge network can be created [5]. Such a network allows for the aggregation of information and data not only for the purpose of data analysis, but also towards an improved understanding on how the city is functioning in terms of resource consumption, services, and lifestyles. Information made available by these digital platforms would serve as a reference for stakeholders to take action and create policy directions that would eventually improve the quality of life for the citizens and the society as a whole. Therefore, ICTs constitute an enabler for SSCs and a tool to be harnessed for ensuring sustainable development. Therefore, ICTs provide opportunities for increasing integration among the different dimensions thereby attaining urban efficiency. Harnessing ICTs for realizing sustainable development enforces the importance of highlighting it in the definition of smartness as a tool to achieve urban efficiency. Therefore, smartness, up to this point, denotes the use of ICTs and other means to infuse innovation at all dimensions of a city thereby advancing urban efficiency.

2) *Smartness: a Dynamic Process*

Having defined the main elements of smartness, its enablers and the mutually reinforcing relationship with sustainable development, it is important to show whether it is a snapshot or a process and whether it is of dynamic or static nature. So far, we clearly see that there have been three distinct phases of how cities transformed from being technology driven to city government driven and lately to be citizens driven. The first phase of SSCs is characterized by technology providers encouraging the adoption of their solutions to cities without taking into consideration their impact on citizens and their quality of life. Thus, smartness is solely connoting the adoption of advanced technical solutions. A shift in the manifestation of SSCs occurred thus a new phase of cities with a different interpretation of smartness took place. This phase was led by city planners instead of technology providers and they focused on technology solutions aimed at improving the quality of life of citizens. In this case, the concept of smartness changed to include the impact of the adopted solutions on people. Lately, leading SSCs started to embrace citizen co-creation models for helping to drive the next generation of smarter cities where the engagement of citizens lie at the core of the advancement of cities. Smartness, in this case, focuses on citizen's engagement and social inclusion, a core principle in the sphere of sustainable development. These different phases or manifestations of SSCs denote the dynamicity of the concept of smartness. Also, it sheds the light on the need for technology to provide services and ensure coherence amongst the city's systems and governments to properly adopt technology enabled solution for the betterment of the city and the lives of its citizens. These objectives lie at the core of the philosophy of sustainable development. These concepts of equality added to the elements previously mentioned constitute the basis for sustainable development which is on its own a process, not an end in itself. [38].

Having discussed the dynamicity of smartness as a process, the dimensions to consider for urban efficiency, the cross-cutting issues and enablers, and the need for alignment with the principles of sustainable development principles, it becomes possible to introduce a new holistic definition which reads as follows: “*Smartness is a dynamic process through which ICTs and other means are used to advance innovative multidimensional urban efficiency in line with the principles of sustainable development*”. Each city is unique with distinctive economic, environmental and social contexts and will have to determine its own path to becoming smart and sustainable while benefiting from available and related good practices. Becoming a SSC is not an end goal but rather a process enabling change. Fig. 3 depicts the result of analyzing the concept of smartness.

IV. EXPECTED OUTCOME

The discussion above clearly indicates the lack of a clear harmonized and holistic definition of smartness in the context of SSCs. By following a hybrid approach, this research puts forward a definition for smartness. It highlights the importance of ICTs and other means as enablers to advance innovative multidimensional urban efficiency while ensuring alignment with sustainable development principles. This introduced concept is expected to constitute the foundation of a methodological model aimed at assessing the performance of a SSC, thus monitoring its smartness. This is important given the inexistence of such a model and its importance in assisting policy and decision makers in urban planning in the prioritization of efforts for the betterment of their cities [8] [39].

By observing smartness and the quest of sustainable development, we highlight a mutually reinforcing relationship among them. Both, to be achieved, for instance,

should be people centered and should grant people a high quality of life. By linking both processes, we note that smartness is not only about technologies and use of smart solutions but rather about achieving economic development with environmental ceiling and social foundation touching on, just to name few, social equity, gender equality, health, jobs, education and others.

V. CONCLUSION

There exists a theoretical debate as to what smartness means for cities in different contexts. In this research, we showed that smartness is a dynamic process enabling change. It uses technologies to infuse innovation in the systems of the city and achieve urban efficiency at different dimensions while being aligned with the principles of sustainable development which is in itself a process rather than an end.

Cities continue to develop and refine their environmentally friendly economic and social goals and the strategies to achieve them. To take advantage of how smarter city approaches can help advance those strategies, city authorities and stakeholders need to understand how their city is performing today and where progress is being achieved in infusing smartness into their systems. Defining smartness and setting its boundaries contribute to assessing the performance of a SSC. Such an assessment can identify emerging strengths and weaknesses and highlight where real progress is occurring and inform a plan for future improvements. It will assist city managers and policy makers in monitoring the complexity of the factors that make up a city smart and sustainable noting the uniqueness of each city in terms of its economic, environmental and social contexts.

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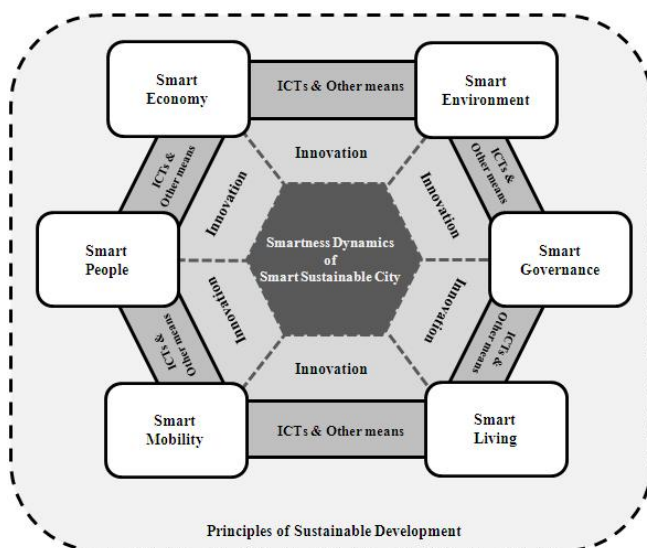


Figure 3. Smartness Dynamics of a Smart Sustainable City

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