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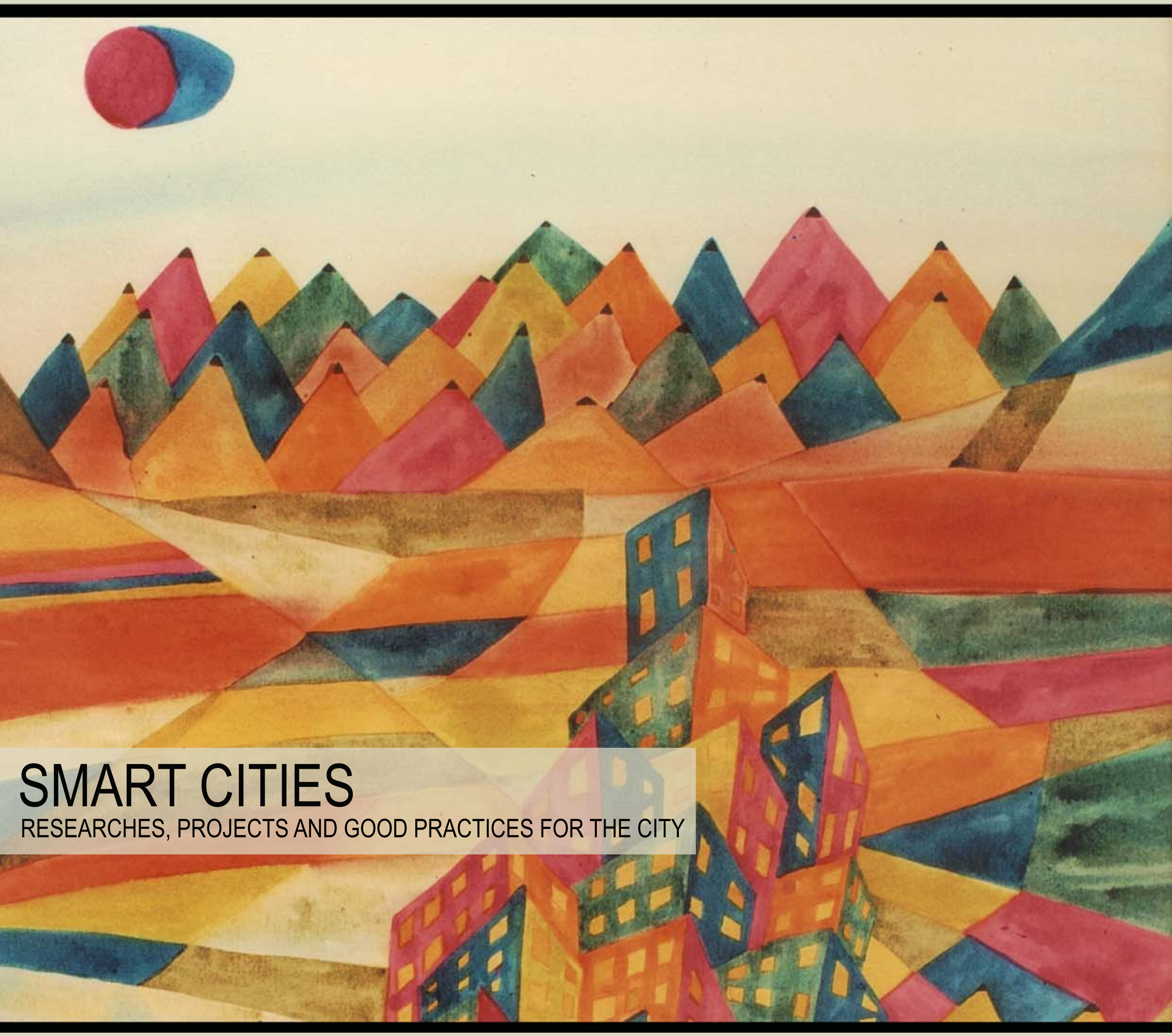

SMART CITIES

RESEARCHES, PROJECTS AND GOOD PRACTICES FOR THE CITY

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TOWARDS INTELLIGENTLY-SUSTAINABLE CITIES?

FROM INTELLIGENT AND KNOWLEDGE CITY PROGRAMMES TO THE ACHIEVEMENT OF URBAN SUSTAINABILITY

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ABSTRACT

In the quest for achieving sustainable cities, Intelligent and Knowledge City Programmes (ICPs and KCPs) represent cost-efficient strategies for improving the overall performance of urban systems, especially when compared with the costs of physical restructuring and/or retrofitting projects. However, even though nobody argues on the desirability of making cities "smarter", the fundamental questions of how and to what extent can ICPs and KCPs contribute to the achievement of urban sustainability lack a precise answer. In the attempt of providing a structured answer to these interrogatives, this paper presents a methodology developed for investigating the modalities through which ICPs and KCPs contribute to the achievement or urban sustainability. Overall, our research suggests that ICPs and KCPs can potentially contribute to all three dimensions of sustainability (i.e. economic, social and environmental), but their main efficacy lies in supporting cities achieve a sustainable urban metabolism through optimization, innovation and behavior changes.

KEYWORDS:
Sustainable urban metabolism, Smart city, Assessment criteria, Regional Planning

1 INTRODUCTION

As urban population growth is expected to increase dramatically in the following years (Cohen, 2006), governments all around the world urgently need to find solutions for accommodating huge influxes of citizens in a way that is socially, economically and environmentally sustainable (Angel et al., 2011). But if achieving sustainability appears as a straightforward solution, the same cannot be said regarding the strategies required for turning this new paradigm of development into concrete actions (European Environment Agency, 2006). Up to date, there are many and widely disputed plans and policies for enabling sustainable development in all its forms, but they all agree on one point: cities are called to take the lead in this transformation (United Nations, 2012). Stemming from the need to re-think how our cities function, how they are built and managed, Sustainable Urban Development (SUD) has affirmed itself as the new planning rationale of our century (Stren et al., 1992). However, there is still little agreement on the most desirable urban forms and management strategies that will make cities simultaneously more sustainable and competitive (Jabareen, 2006). This is partly the consequence of an ambiguous definition of the concept, which is relatively new and embedded in a complex multi-actor system (Wallbaum et al., 2011). Moreover, the strength of the sustainability concept is also its main weakness. In fact, sustainable development embodies multiple values, such as those represented by 'people', 'planet' and 'profit', which makes it possible to bridge conflicting interests between these values when defining ambitions. However, the wicked and intractable character of the concept surfaces when these ambitions have to be made tangible and measurable, prioritizing values and allocating costs and benefits, which make conflicting interests resurface (e.g. Hajer, 1995). Consequently, no consensus seems to exist among scholars and urban planners on the definition of SUD Indicators (Tanguay et al., 2010). At the present moment there is deep uncertainty concerning the strategies and policies that can effectively implement principles of sustainability within urban systems and how these can be measured and monitored (Robinson, 2004).

In this scenario, governments seem to favour investments in making their cities "smarter" while assuming that these will also reveal more sustainable. Intelligent and Knowledge City Programmes (ICPs and KCPs) are thus regarded as a cost-efficient strategy for making cities more flexible, efficient, sustainable, urban, aesthetic and functional (Mega, 1996), especially when compared with the costs of physical restructuring and/or retrofitting projects (Accenture, 2011). Nonetheless, there is little evidence supporting the argument that Intelligent and Knowledge Cities are necessarily more sustainable. No one disagrees on the fact that smarter cities are highly desirable and that enhancing their performance will improve the quality of life of its inhabitants (Santinha & Castro, 2010). The smart city is thus a positive management concept, just as sustainable development is, appraising a value that is rated positively by all actors (Hajer, 1995). But the contribution of ICPs and KCPs to the achievement of sustainability targets is often vague, left implicit, normative and affected by wishful thinking. Therefore, if ICPs and KCPs are to become a success story, the assumed positive relationship between cities being smart and consequently sustainable needs to be supported by evidence.

The aim of this study was to shed light on the connection between ICPs-KCPs and the concept of urban sustainability, thus providing public and private organizations with a framework for designing smarter cities that also reveal more sustainable. The main research question tackled was therefore: "How are Intelligent and Knowledge City Programmes contributing to the achievement of urban sustainability?" To answer this question, it was necessary to proceed step by step through a series of sub-questions concerning the following four elements: (i) sustainable development; (ii) urban sustainability; (iii) Intelligent and Knowledge City Programmes and; (iv) a methodology for tracking down the contribution.

Starting with the first question, the aim was to clarify the meaning of sustainable development and to identify its main features, providing a working definition of the concept to be used as a theoretical basis for the following parts of the research through a literature survey. With regards to the second, the main structural and functional characteristics of cities planning for sustainability were identified and successively used for formulating a working definition of this urban ideal. Moreover, a system for monitoring the progress of cities towards sustainability was developed, with the objective of defining a method for articulating the complexity of sustainable cities in a set of indicators. Third, the meaning, features and value added of ICPs and KCPs were explored, with the intent of developing a conceptual model for recognizing and describing the contribution of these two programs to the achievement of urban sustainability. Final conclusions and reflections, including a discussion on the limitations and value of the research are presented at the end of the paper.

2 KEY CONCEPTS

Developing a methodology for assessing the contribution of ICPs and KCPs to urban sustainability required to identify clear working definitions of these three concepts. A thorough bibliographic research was needed to perform this activity, mainly because there are many and contrasting views of what the assets and features of the Sustainable, Intelligent and Knowledge City should be.

2.1 SUSTAINABILITY AND SUSTAINABLE CITIES

Considering the first of these urban ideals, there are literally hundreds of definitions and visions currently under debate (for a review, see Alusi et al., 2011; Berke, 2002; Cooper et al., 2009; Dixon and Fallon, 1989; Guy and Marvin, 1999; Haughton, 1997; Jabareen, 2006; Robinson, 2004). This is certainly the consequence of the confusion that still exists on the meaning of sustainable development which represents the core principle of urban sustainability (European Sustainable Cities and Towns Campaign,1994; Lélé, 1991; Næs, 2001). Most of the disputes over what sustainability really is mainly derive from the multi-faceted nature of the concept, the fact that it can be approached with two opposite mindsets (i.e. *reductionism* versus *holistic thinking*), its dependency on the delineation of system boundaries, its ethical dimension which makes the concept cultural-dependent, the fact that it attracts different interests of a variety of actors, the lack of consensus on the level of criticality and elements of the problem that it should solve, and the physical contradictions and difficulties underlying the goal of achieving a sustainable system. Overall, the question of how (and if) should sustainable development be achieved comes through as a wicked problem: it is both un-tamed from a social perspective (there is a lack consensus among global leaders regarding the level of urgency and necessity of transforming current patterns of development, besides the ethical values that the principle should embody) and scientific (the effects of current development dynamics and human actions on the ecosystem are not fully demonstrated).
From these and other considerations regarding the origins, meaning and key features of sustainable development, we came to the conclusion that sustainability should be thought in terms of a verb indicating a process of change rather than a noun referring to an end state. We thus defined the concept of "*to sustainabilize*" in the following way (fig. 1):

To sustainabilize is the long-term process of transforming the structure and functioning of a system, in such a way that it uses progressively less non-renewable energy sources and exploits ecosystem services at a rate that is smaller than the time needed for self-regeneration, while improving the living standards, environmental well-being and economic performance of human settlements. The process needs to be guided by a vision accepted by stakeholders and needs embody the moral values and principles of good governance of the local community, while being aligned with globally shared objectives. Moreover, the process should be based on an integrated approach that considers the interactions within and outside the targeted system.

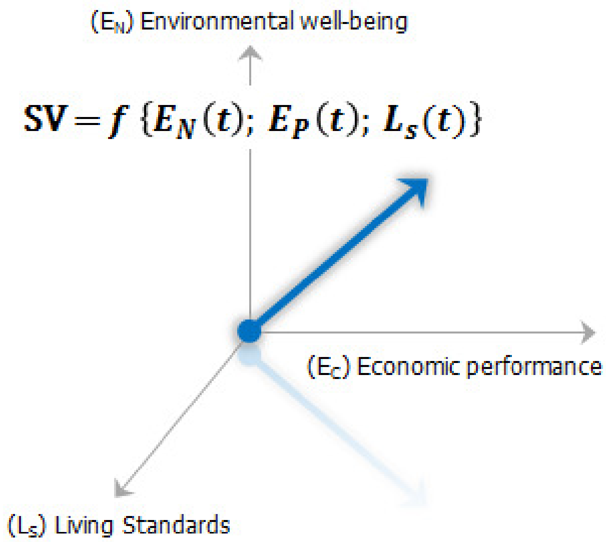

Fig. 1 A graphical visualization of the concept "to Sustainabilize"

Having formulated a working definition of sustainability, the following step consisted in transposing the concept to urban systems, thus resulting in a vision of the *"Sustainabilizing City"*. Moreover, following from the belief that "you cannot achieve what you cannot measure", the final goal of this activity was to identify a set of measurable Sustainable Development Indicators (SDI) applicable to urban settlements. But because "there is no single recipe for designing and conducting an evaluation of sustainable development" (Becker, 2004), we developed our own evaluation methodology based on considerations taken from the review of more than a dozen attempts to measure urban sustainability[1]. The methodology basically consisted in breaking down the vision of the Sustainabilizing City in a sequence of elements subdivided on three levels of progressive detail (fig. 2). These levels represent the "pillars", "parameters" and "indicators" of the Sustainabilizing City, and were formulated based on the following guiding principles:

1. the assessment methodology needs to be embedded within a conceptual framework and vision of the sustainable city;
2. recognize which features of urban sustainability are generally acknowledged as objective fundamental requirements ("*sustainable imperatives*") and which ones are specific for each city/actor ("*contingent sustainability*").
3. indicators need to be formulated in terms of rates of change (in order to comply with the definition of the verb "*to sustainabilize*")
4. the measurement system should focus on the essence of sustainable development and be kept as simple as possible.

[1] For example, Becker, 2004; Bossel, 1999; Brugman, 1997; Fricker 1998; Gaspartos *et al.,* 2009; Hopwood *et al.*, 2005; Levett, 1998; Li *et al.,* 2009; Moles et al., 2008; Parris & Kates, 2003; Reeds *et al.*, 2005; Tanguay *et al.,* 2010.

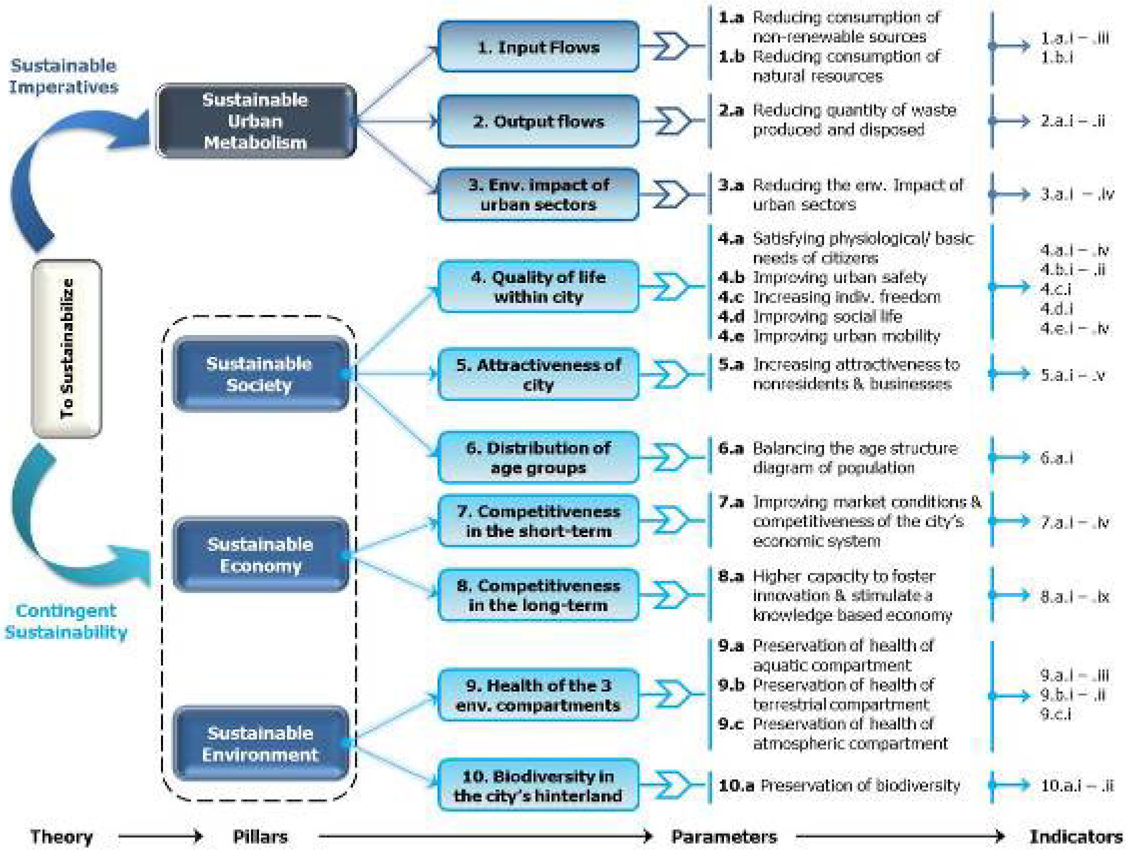

Fig. 2 The structure of the "Sustainabilizing City Tree"

The real element of innovation brought by the measurement system developed is given by the subdivision of SDIs among two fundamental categories that separate those elements that are inherently malleable and those that refer to more objective physical features of urban systems (Craglia et al, 2004). We called these two different sets "sustainable imperatives" and "contingent sustainability" and defined them in the following way:

- Sustainable imperatives: the *sine qua non* requirements of sustainability. These are the features that are generally acknowledged as representing the fundamental requirements that any system should possess in order to comply with the physical definition of sustainability. The *Sustainable Urban Metabolism pillar* is part of this set, and examples of SDIs pertaining to this group are: Share of renewable electricity in gross final electricity consumption (GFEC) of the city; Share of municipal waste recycled; Consumption of natural resources per urban sector and resources type; Green House Gas emissions per urban sector.
- Contingent sustainability: the features of sustainability which lack general consensus as they are subject to the different interests, values, and system of beliefs of the actors pertaining to the urban community. For this reason, these elements have to be determined specifically for each city through public participation and stakeholder negotiations. The *Sustainable Society, Economy* and *Environment pillars* belong to this set, and examples of SDIs pertaining to this group are: Share of population regularly using public transportation means; Provincial Gross Domestic Product by entertainment industry; Net exports of the city; Number of new start-ups per industrial sector; Share of land sealed.

Given the way with which we classified elements of urban sustainability, it is clear that there can be no universally definable set of parameters and indicators. In other words, what we mean by a sustainable economy, society and environment varies according to the system of beliefs and interests of urban stakeholders and the physical and cultural features of the city that we want to sustainabilize (Levett, 1998). Therefore, while the parameters of a sustainable urban metabolism should be the same for each city, those that belong to the "contingent sustainability" set necessarily have to be negotiated with the main stakeholders of the urban system. One final point to be mentioned is that, in order to comply with the definition of "to sustainabilize", all indicators of urban sustainability were formulated in terms of time derivatives (with a pre-defined direction of desired change) which provide a clear indication on the speed with which the implemented strategies are making the system more (or less) sustainable (an example is provided in tab. 1).

PILLAR 1: SUSTAINABLE URBAN METABOLISM

PARAMETERS		INDICATORS	SYMBOL
1. Input Flows	a. Reducing the consumption of non-renewable energy sources	*i. Share of renewable electricity in gross final electricity consumption (GFEC) of the region*	$\Delta RE/\Delta t \geq 0$
		ii. Gas consumption for heating building sector	$\Delta G_H/\Delta t \leq 0$
		iii. Total petroleum consumption of city's vehicle fleet	$\Delta P_{VF}/\Delta t \leq 0$
	b. Reducing the consumption rate of natural resources	*i. Consumption of natural resources (i.e. fresh water, wood, metals, non-urbanized land, limestone and other extracted rock material for construction) in each i-th urban sector*	$\Delta NR_i/\Delta t \leq 0$
2. Output Flows	a. Reducing the quantity of waste produced and disposed	*i. Total quantity of municipal waste produced per capita*	$\Delta W_{TOT}/\Delta t \leq 0$
		ii. Share of municipal waste recycled	$\Delta WR/\Delta t \geq 0$
3. Environmental Impact of Urban Sectors	a. Reducing the environmental impact of urban sectors	*i. GHG emissions per capita for the commercial, industrial, domestic and transport sector*	$\Delta GHG_i/\Delta t \leq 0$
		ii. Emissions of air pollutants (i.e. SO_X, NO_X, CO, CH_4, NH_3, CFCs, PM_{10}, $PM_{2,5}$ and Halons) per urban sector "i" (energy, industry, agriculture, waste management, transport and domestic)	$\Delta AP_i/\Delta t \leq 0$
		iii. Estimation of the polluting effect of different urban sectors on water compartments (i.e. natural flows, underground and superficial water bodies)	$\Delta WP_i/\Delta t \leq 0$
		iv. Emissions of soil pollutants (i.e. heavy metals and toxic substances) per urban sector "i" (waste, transport, agriculture and sewage system)	$\Delta SP_i/\Delta t \leq 0$

Tab.1 Identified Sustainable Development Indicators pertaining to the pillar "sustainable urban metabolism"

2.2 INTELLIGENT AND KNOWLEDGE CITIES

With a clear and articulated description of what we mean by "cities pursing a state of sustainability" (fig. 3), the following research activity concentrated on the Intelligent and Knowledge City ideals. More specifically, the main focus was placed on the plans and programmes currently being implemented for the achievement of these two urban visions, generally labeled as Smart City initiatives (e.g. European Smart Cities, 2007). In sum, these programmes exploit state of the art Information and Communication Technologies (ICT) and the city's digital infrastructure for different purposes. The goal of ICPs is to pursue urban operational excellence through the improved management of the city's sectors and infrastructure (Deakin and Al Waer, 2011; Harrison et al., 2010), while KCPs are designed for improving territorial governance systems and for turning the city into an innovation hub that nurtures knowledge and creativity (Divir and Pasher, 2004; Ergazakis et al., 2004; Kominos, 2006).

Given the broad definition of Intelligent and Knowledge Cities, recognizing the initiatives that are truly contributing to the achievement of these two urban concepts is not as straightforward as it seems. Therefore, for the scope of this study, it was necessary to define a framework for establishing whether a particular urban program fulfills the definition of Intelligent or Knowledge City adopted in this research. In other words, the objective was to identify the features that differentiate ICPs and KCPs from each other and from traditional urban (re-)development projects. These features were sorted in four levels that are briefly discussed below (fig. 3).

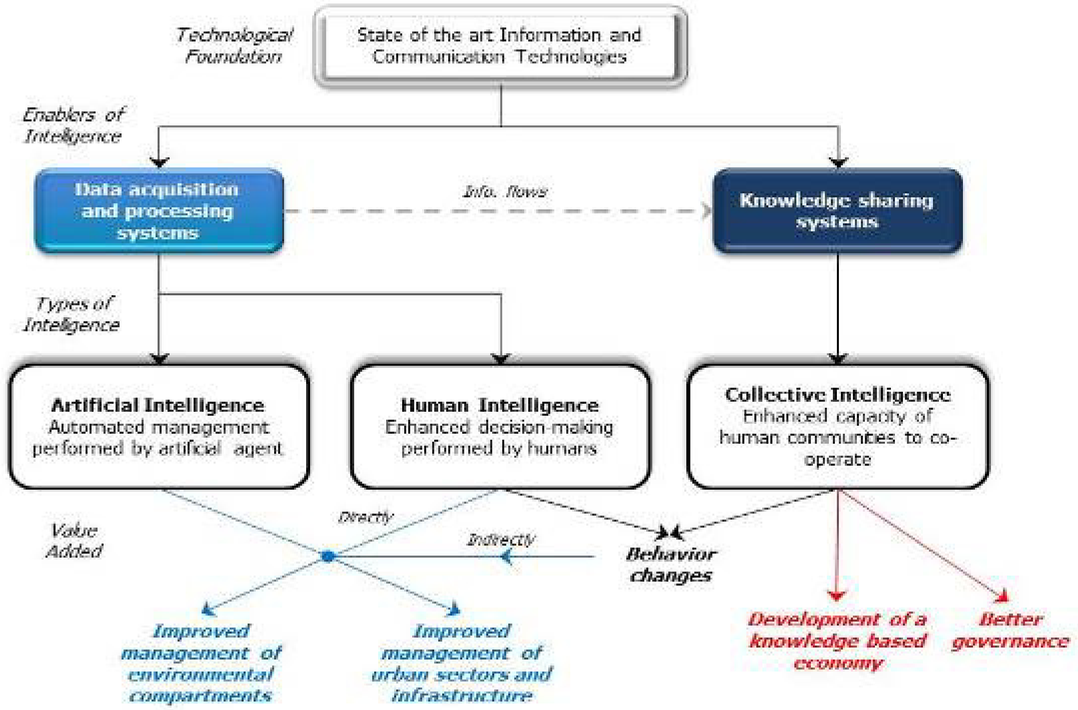

Fig. 3 A framework for identifying and characterizing Intelligent and Knowledge City Programmes (ICPs & KCPs)

Level 1: *Technological foundation*

The first feature that stands out for differentiating urban (re-)development projects from ICPs and KCPs refers to the means adopted for achieving the broad goal of improving urban systems. Generally speaking, the former focus more on the physical layout of the city and on the spatial organization of services and utilities. By contrast, the latter primarily exploit ICT to enhance the management of the different urban sectors and environmental compartments of the city.

Level 2: *Enablers of intelligence*

ICPs and KCPs introduce ICT within urban environments with the scope of providing them with three main systems: (i) data acquisition systems (i.e. data collecting and monitoring devices such as cameras and sensors that measure real world physical conditions and convert the resulting samples into digital numeric values that can be manipulated by a computer), (ii) Data processing systems (i.e. hardware and/or software processing units that format, re-format, translate or convert raw input data in a final form of output information), and (iii) Knowledge sharing systems (i.e. systems that exploit the city's digital infrastructure and ICT for creating virtual environments where online digital content and information is stored, shared and discussed).

Level 3: *Types of intelligence*

The technological means implemented by an ICP or KCP represent enablers of three types of intelligence: Artificial, Human and Collective (Kominos, 2006). Artificial intelligence refers to the ability of an artificial agent to study and monitor specific aspects of the environment and take actions that optimize the performance of the system (automated management). Human intelligence denotes the capacity of humans to use information in decision-making processes to solve problems or improve the functioning of a system. In this sense, we could state that ICPs allow human or artificial agents to transform complex managerial problems in more simple decision-making processes. Finally, collective intelligence refers to the capacity of human communities to co-operate in creation, innovation, invention through the exchange of knowledge.

Level 4: *Value added*

Data acquisition, data processing and knowledge sharing systems implemented by ICPs and KCPs are enablers of the three types of intelligence which drive different types of values to the city. The value added of ICPs and KCPs was sorted in the following five groups: (1) improved management of environmental compartments (i.e. aquatic, terrestrial and atmospheric), (2) improved management of urban sectors and infrastructure (i.e. transport, water, energy, waste, buildings, public administrations), (3) behavior changes, (4) development of a knowledge-based economy, and (5) better governance. While the first and last two groups belong to ICPs and KCPs respectively, the third one can belong to either programmes depending on the final goal: If a program aims at changing the conduct of humans (taken individually or as a collectivity) for optimization purposes, it will be considered an ICP, while if the final aim is to educate citizens towards more eco-responsible and sustainable lifestyles, the program belongs to the group of KCPs.

2.3 OVERVIEW OF THE ASSESSMENT FRAMEWORK

The working definitions and concepts developed throughout the first part of the study were combined together for the design of an assessment methodology having the final goal of systematically tracking down the contribution of ICPs and KCPs to urban sustainability. The framework consists of a table that connects the value added by an ICP or KCP to the indicators of the 'sustainabilizing city' previously defined (fig. 4). The procedure for using the assessment model is composed of three main steps:

1. characterize the ICP or KCP with the use of the framework previously illustrated;
2. assume possible relations between the value added by the program and the pre-defined parameters of the 'sustainabilizing city';
3. search for data that demonstrate which indicators of the assumed parameters are being affected, and to specify the direction of change.

The strength of the proposed methodology relies in its simplicity: it provides a clear picture of the speed at which an ICP or KCP is moving the city towards the achievement of urban sustainability in all its dimensions.

			Parameters of Sustainabilizing Cities																
			1		2	3	4					5	6	7	8	9			10
			a	b	a	a	a	b	c	d	e	a	a	a	a	a	b	c	a
Value Added by ICPs and KCPs	ICPs	**Improved mgmt. of env. compartments**																	
		• Aquatic																	
		• Atmospheric																	
		• Terrestrial																	
		Improved mgmt. of urban sectors & infra.																	
		• Buildings																	
		• Energy																	
		• Public administration																	
		• Transport																	
		• Waste																	
		• Water																	
	KCPs	**Behavior changes**																	
		Development of a Knowledge Based Ec.																	
		Better governance																	

Fig. 4 The Intelligent-Sustainable Assessment Table

3 TOWARDS INTELLIGENTLY-SUSTAINABLE CITIES? DISCUSSING THE INTERPRETATIVE FRAMEWORK

Developing With the goal of providing an answer to the main research question tackled by this study, the article shows how the concept "to sustainabilize" is transposed to urban settlements, resulting in four fundamental pillars subdivided between the two sets "sustainable imperatives" and "contingent sustainability". While the definitions of a sustainable society, economy and environment cannot be universally defined, what is meant for a sustainable urban metabolism should be common to all cities. According to our definition, a city possesses a sustainable urban metabolism when all input flows (energy and resources) are in equilibrium with the regeneration rate of the relative source, when output flows are recycled or naturally absorbed by the city's ecosystem and when urban activities have a marginal impact on the environment. Preliminary conclusions (recommendations for directing future research efforts are finally provided) can be resumed in the following four points (fig. 5):

A. through improved management of urban sectors and infrastructure (with particular emphasis on the electricity grid), ICPs mainly contribute to the achievement of a **sustainable urban metabolism** (i.e. reduced consumption of non-renewable energy and natural resources, and reduced environmental impact of urban sub-systems), while KCPs support this goal by promoting behavior changes within the community and, in some cases, through the promotion of innovation-based activities.

B. Through improved urban safety and mobility, better governance systems and the development of a knowledge-based economy, ICPs and KCPs contribute to the achievement of a **sustainable society** (i.e. improved quality of life and attractiveness of the city).

C. Through improved management of urban sectors and infrastructure and the development of a knowledge-based economy, ICPs and KCPs contribute to the achievement of a sustainable economy (i.e. higher short- and long-term competitiveness).

D. Through the improved management of environmental compartments, ICPs are facilitators for the achievement of a sustainable environment (i.e. preservation of the three environmental compartments and biodiversity). However, the main contribution of ICPs to this pillar derives from the optimization of the city's infrastructure and services, which reduces the environmental impact of urban sectors by lowering the emissions of toxic substances and consumption of natural resources. KCPs also contribute to this goal by promoting behavior changes within the community which are more eco-compatible.

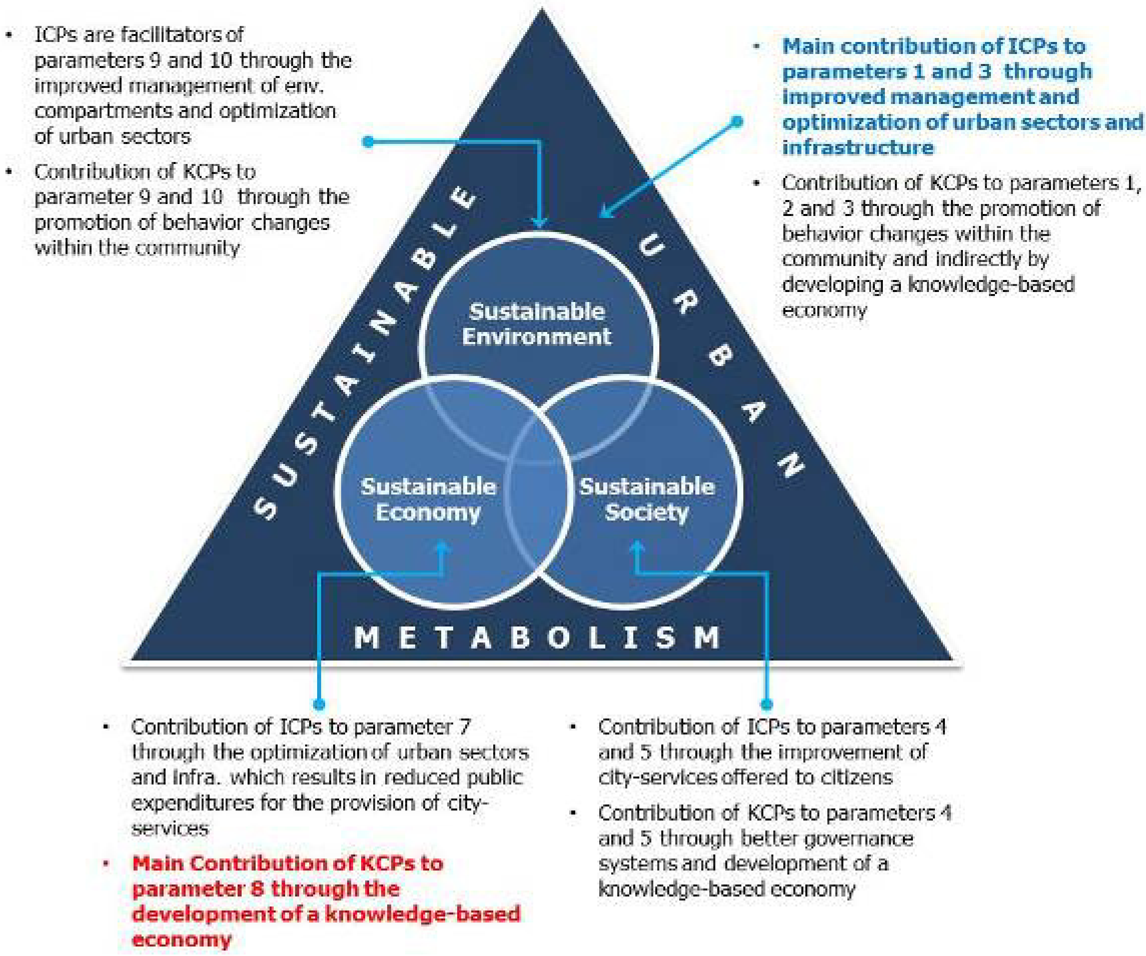

Fig. 5 The contribution of ICPs and KCPs to the 4 pillars of sustainabilizing cities

Even if ICPs and KCPs can potentially contribute to all pillars of the sustainabilizing city, the first point listed above is of particular relevance for two main reasons: (i) its importance within our definition of sustainable development, and (ii) the intrinsic limitations deriving from the application of the assessment methodology in this study.

Considering the first reason, recall the definition previously provided of "sustainable imperatives". One of the results reached by our research on urban sustainability was that the sine qua non requirement for cities to become sustainable is that their urban metabolisms progressively reduce their dependency on non-renewable energy, lower the consumption rates of natural resources and ecosystem services, reduce the quantity of wastes produced and decrease the environmental impact of all urban activities and sectors. The word "progressively" was evidenced to stress that succeeding in these goals is a process which requires the long-term commitment of the city, a clear vision and robust strategies approved by the main stakeholders of the system. In this context, the contribution of ICPs appeared critical. In fact, according to our research there are three main strategies for achieving a sustainable urban metabolism: (1) higher efficiency, (2) behavior changes (less energy and resource intensive lifestyles), and (3) Innovation. Being optimization of urban sectors and infrastructure the quintessence of these programmes, the role played by ICPs in sustainabilizing cities appeared evident: they embody the latest ICT technologies to leverage operational efficiency within the different sectors of the city. Moreover, both ICPs and KCPs came through as functional for incentivizing behavior changes within the community which are less energy and resource dependent. In this respect, their strength relies in showing the "carrot" (mainly in the form of savings deriving from a better use of resources) of adopting more sustainable lifestyles. Finally, in some specific cases, KCPs were observed to contribute to reducing the consumption levels of the city by stimulating innovation in the fields of energy efficiency.

Turning to the second reason that justified the importance of the first point, this derives from the limitations encountered while applying assessment methodologies like the one proposed in this paper. As previously argued, the SDIs pertaining to the "contingent sustainability" set cannot be universally defined. In fact, this research acknowledged that among the greatest difficulties in delineating the meaning of sustainability is the fact that defining what we mean by a "sustainable society and economy" is ultimately bound to political discourses. Politics is the art of protecting interests, and these interests cannot be aligned when negotiating on which elements of social and economic systems are to be sustained or developed and for how long (Parris & Kates, 2003). Surprisingly, this research observed that even with regards to the definition of a "sustainable environment" there are no universally accepted lines of thoughts, so even this pillar was considered as part of the Contingent Sustainability set. Therefore, in order to carry out the assessment of ICPs and KCPs in light of urban sustainability, this research provided a proposal of the features that a sustainable society, economy and environment should embody. It comes without saying that the conclusions drawn on the contribution of ICPs and KCPs to these three pillars are subject to the definitions provided. This brings to the conclusion that the role played by ICPs and KCPs in supporting cities achieve a sustainable society, economy and environment inevitably needs to be evaluated on site and with the adopted definition of these three pillars by the city.

4 CONCLUSIONS

In order to determine whether there is a robust connection between Sustainable and Intelligent Cities, a methodology for investigating the role of ICPs and KCPs in supporting cities become sustainable was developed. In this paper, we provide an illustration of the developed methodology and a summary of the main results achieved. The paper concludes with a discussion on the role of ICPs and KCPs within the current debates on sustainable development and future research opportunities.

Reflecting in general terms on the contribution of ICPs and KCPs to urban sustainability, this research noticed that a considerable number of these programmes deeply rely on the extent to which humans become "intelligent". In fact, both ICPs and KCPs are enablers of human and collective intelligence, which means that their implementation does not guarantee that citizens will change their behaviors as planned. While the effects of ICPs directly optimizing urban sectors and infrastructure (i.e. through automated management systems or by supporting urban managers take more efficient and effective decisions) are more quantifiable, the indirect contribution of programmes ultimately relying on the "good will" of citizens is hard to predict. In fact, most of these programmes dealing with human behavior are being implemented in the form of pilots, because they rely on the assumption that humans act rationally and that they are willing to change their consumption habits. Moreover, there is a certain limit to the extent to which ICPs and KCPs can enhance decision-making processes, given the fact that "management is both an art and a science". The basic principle is that, besides the obstacles faced by Intelligent and Knowledge Cities, becoming smart requires efforts, and not just in the form of investments in ICT and digital infrastructure.

A final point of concern arises in light of the prospects of a dramatic growth in urban populations and increasing consumption levels in emerging countries. These two trends seriously hamper the world's journey towards sustainability, and whether ICPs and KCPs will be able to accommodate these trends is a question that remains open to discussion. Furthermore, this research underlined that in order for ICPs and KCPs to successfully leverage sustainability, "optimization" of urban sectors and "behavior changes" need to be pursued in tandem. The main reason justifying this need is to reduce the probability that higher urban efficiency indirectly translates into increasing per capita consumption levels. In fact, it might well be the case that cities result less sustainable despite being more intelligent because of these three scenarios.

In conclusion, this contribution has demonstrated that urban intelligence and sustainability are strongly related, but it is incorrect to consider them as the two opposite sides of the same medal. At the present moment, ICPs and KCPs represent useful tools for supporting cities (especially the ones with significant infrastructure legacy) in their journey towards sustainability, but other actions are required for the achievement of this goal.

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IMAGES SOURCES

Fig. 1, 2, 3, 4, 5: Our elaborations.

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Vittorio achieved his Bachelor in Science degree in Environmental Engineering at the University of Rome 'La Sapienza', specializing in the fields of Urban Planning and Ecological Spatial Planning. Successively, Vittorio obtained his Master in Science degree in Engineering and Policy Analysis at Delft University of Technology, where he focused on subjects of Systems Modeling and Policy Analysis of Multi-Actor Systems, and completed his final thesis on Sustainable and Intelligent Cities. Vittorio has participated to several research projects concerning land-use change, urban sprawl and polycentric development, sustainable and intelligent cities and is author of one book and more than 10 scientific articles in English. He now works in Accenture's Sustainability and Strategy Team based in Milan.

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Margot has graduated in Chemical Technology and holds a PhD from TU Delft. She has worked for Shell in Amsterdam, Pernis and The Hague. From 1990 to 1995 she was scientific director of Interduct, the Delft University Clean Technology Institute and successively appointed Professor of Process and Energy Systems and became head of the Technology department (now Infrastructure Systems & Services) at the Faculty of Technology, Policy and Management. In 1998 she was appointed scientific director of the Delft Research Center for the Design and Management of Infrastructures and works is director of the Next Generation Infrastructures Foundation since 2003.

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Ellen holds a PhD in Technology, Policy and Management and is an assistant professor at Delft University of Technology. Her research and teaching focus on decision making for complex problems that require multiple actors to collaborate. She started her career in sustainable urban planning, which is still one of her favourite research domains. She is editor of Bestuurskunde (the Dutch journal of public administration) and regional associate editor of the journal Smart and Sustainable Built Environment.

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