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Intelligently-Sustainable Cities?

Assessing the contribution of Intelligent & Knowledge City Programmes to the achievement of urban sustainability

Vittorio Gargiulo Morelli

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Vittorio Gargiulo Morelli

Student Number: 4123999

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Faculty of Technology, Policy and Management

Delft University of Technology

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A Ludovica,

Il mio canto libero.

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Accenture

Joost Brinkman

External supervisor
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– Special thanks to –

(Alphabetical order)

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Senior Manager – Accenture

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Prunel Benoit
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Executive summary

The current challenges that the world is facing are urging us to re-think the structure and functioning of our social and economic systems. A critical paradigm shift is required if issues such as climate change, growing poverty, depletion of natural resources and uncertain energy futures are to be effectively solved. Global leaders and scientists all over the world have agreed that the time has come for a new form of development to radically transform our classic models of growth so that they embrace the concept of sustainability. 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.

In this scenario, cities are called to take the lead. In fact, cities are the systems where the three pillars of sustainability merge together (i.e. economy, environment and society), they are the largest consumers of resources and producers of waste, and they are the center of economic activities and engines of wealth production. But above all, their key role in guiding this transition is evidenced by the prospect of a dramatic increase in urban population. Cities urgently need new forms of urban planning and management that can deal with these challenges while remaining competitive as they enter in the era of *Global City Regions*. In a nutshell, they have to become socially, economically and environmentally sustainable.

In the quest for achieving Sustainable Cities, many governments have placed their bid on Intelligent and Knowledge City Programmes (ICPs and KCPs), mainly as a consequence of the uncertainties related to the performance of different urban structures in terms of sustainability, their excessively long implementation time and their significant costs. 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, while KCPs are designed for improving territorial governance systems and for turning the city into an innovation hub that nurtures knowledge and creativity. ICPs and KCPs are being mostly implemented in the more developed regions of the world, where mature cities characterized by abundant infrastructure legacy and scarcity of land are located. But as governments believe that the strategy of creating "smarter cities" will also result in the achievement of sustainability, the precise connection between the concepts of sustainable and intelligence is not entirely clear. **Nobody argues on the desirability of making cities smarter, but the fundamental questions of how and to what extent can ICPs and KCPs contribute to the achievement of urban sustainability lack a precise answer.**

The goal of this research project is to determine whether the connection between Sustainable and Intelligent Cities is supported by evidence or simply affected by wishful thinking. To accomplish the goal, a methodology for investigating the modalities through which ICPs and KCPs contribute to the achievement or urban sustainability is developed. The proposed assessment model is then applied to general theory on Intelligent and Knowledge Cities, and to case studies which will provide more insights on the nature of these two urban initiatives.

This research is structured as follows:

Chapter 1: Understanding the essentials of Sustainable Development.

The scope is to shed light the meaning of sustainable development and to identify its main features. Moreover, the chapter will provide a working definition of the concept to be used as a theoretical basis for the following parts of the project.

Chapter 2: Recognizing the configuration of Sustainable Cities.

The aim is to identify the main structural and functional characteristics that cities planning for sustainability should pursue, and to provide the project with a working definition of the urban ideal.

Chapter 3: Developing a system for monitoring the progress of cities towards sustainability.

The goal is to develop a system for articulating the complexity of sustainable cities in a set of parameters and indicators allowing the monitoring of their progress.

Chapter 4: Identifying the features and value added of ICPs and KCPs

The aim is to identify the value added by ICPs and KCPs and to develop a conceptual model for recognizing and describing these two types of urban projects

Chapter 5: Assessing the contribution of ICPs and KCPs to urban sustainability

The fifth chapter combines the working definitions and conceptual models developed so far in order to accomplish the final objective of this project. Moreover, the developed methodology is applied to four case studies in order to support the theoretical conclusions reached by the project. The chapter also includes a list of future research opportunities in the fields of Sustainable and Intelligent-Knowledge Cities.

Chapter 6: Final conclusions

The last chapter presents the final conclusions and reflections of the research, including a discussion on its limitations, value and future research opportunities.

The number of case studies analyzed only allows the formulation of preliminary conclusions (the project provides recommendations for directing future research efforts). The results of this research evidence that:

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.

Despite the positive contribution of ICPs and KCPs to the achievement of urban sustainability, this research evidences that other actions are required for pursuing truly sustainable urban environments. In fact, the achievement of Sustainable Cities is compromised by the prospects of a dramatic growth in urban population and increasing consumption levels in emerging countries. These two trends seriously hamper the world's journey towards sustainability, and there is not much that ICPs and KCPs can do to slow them down. These programmes can, however, limit the negative impacts of these two trends, but other actions are urgently required. Furthermore, this research underlines 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.

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 (i.e. Amsterdam Smart City). Whereas the costs of ICPs and KCPs are quantifiable, their exact benefits are still vague and too dependent on the assumption that humans act rationally and that they are willing to change their consumption habits. 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.

In conclusion, this research demonstrates 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 the best tools for supporting cities (especially the ones with significant infrastructure legacy) in their journey towards true sustainability, but other actions are required for the achievement of this goal. Altogether, the conclusions of this research indicate that Intelligent and Knowledge City Programmes are the best known enablers of sustainable urban environments.

Being an Intelligent-Knowledge City is a necessary but not sufficient condition for being a Sustainable City.

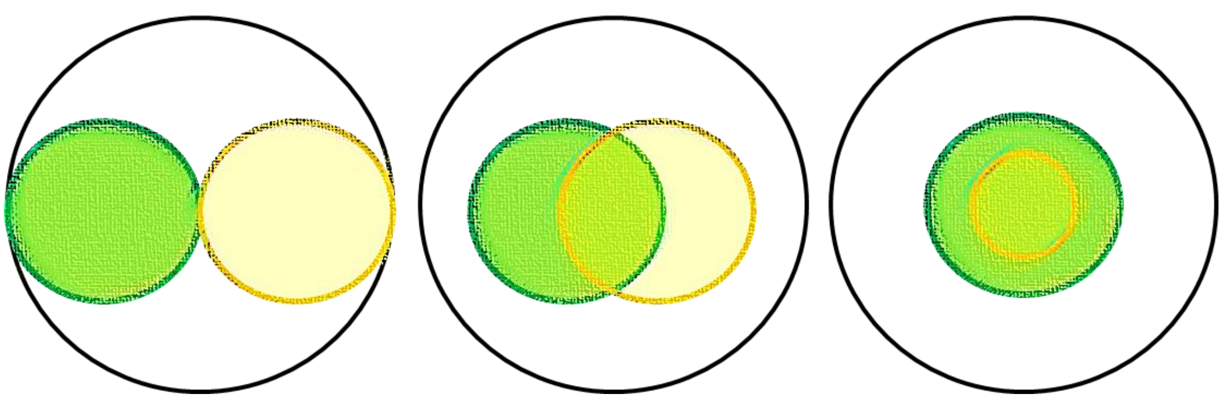

Figure A: "Being an intelligent-Knowledge city is a necessary but not sufficient condition for being a Sustainable City". The black circles represent the entire set of cities; dark blue circles represent the Sustainable City subset; and light blue circles represent the Intelligent-Knowledge City subset. In the first diagram on the left, the two sets are disjointed, in the second they intersect, and in the third Intelligent-Knowledge Cities are the core subset of Sustainable Cities.

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Introduction

The current challenges that the world is facing are urging us to re-think the structure and functioning of our social and economic systems. A critical paradigm shift is required if issues such as climate change, growing poverty, depletion of natural resources and uncertain energy futures are to be effectively solved (United Nations, 2002). Global leaders and scientists all over the world have agreed that the time has come for a new form of development to radically transform our classic models of growth so that they embrace the concept of sustainability. 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 (Lélé, 1991).

In this scenario, cities are called to take the lead. In fact, cities are the systems where the three pillars of sustainability merge together (i.e. economy, environment and society), they are the largest consumers of resources and producers of waste, and they are the center of economic activities and engines of wealth production (van Bueren *et al.*, 2012; Campbell, 1997). But above all, their key role in guiding this transition is evidenced by the prospect of a dramatic increase in urban population (United Nations, 2010). Cities urgently need new forms of urban planning and management that can deal with these challenges while remaining competitive as they enter in the era of *Global City Regions* (Scott, 2001). In a nutshell, they have to become socially, economically and environmentally sustainable.

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, White & Whitney, 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). In fact, 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 (Satterthwaite, 1997).

In the quest for achieving Sustainable Cities, many governments have placed their bid on Intelligent and Knowledge City Programmes (ICPs and KCPs), mainly as a consequence of the uncertainties related to the performance of different urban structures in terms of sustainability (Jabareen, 2006), their excessively long implementation time and their significant costs. 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 (ICPs), while KCPs are designed for improving territorial governance systems and for turning the city into an innovation hub that nurtures knowledge, creativity and technological innovation (KCPs). ICPs and KCPs are being mostly implemented in the more developed regions of the world, where mature cities characterized by abundant infrastructure legacy and scarcity of land are located. But as governments believe that the strategy of creating "smarter cities" will also result in the achievement of sustainability, the precise connection between the concepts of sustainable and intelligence is not entirely clear. **Nobody argues on the desirability of making cities smarter, but the fundamental questions of how and to what extent can ICPs and KCPs contribute to the achievement of urban sustainability lack a precise answer.**

Figure B: Sustainable and Intelligent Cities – Where is the connection?
Source: www.sustainabilecityblog.com and http://www.pikeresearch.com/research/smart-cities

The context, question, aim, structure and relevance of the project

In the following paragraphs, the context, question and scope of the project are discussed. Moreover, the overall structure of the report and the research methodologies adopted are presented.

➢ The context

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. Given the uncertainties related to the performance of different urban forms in terms of sustainability (Jabareen, 2006), **governments favour investments in making their cities "smarter" in the *hope* that these will also reveal more sustainable**. In this optic, Intelligent and Knowledge City Programmes (ICPs and KCPs) are regarded as the most cost-efficient strategy for making cities more flexible, efficient, sustainable, urban, aesthetic and functional (Mega, 1996).

The word "hope" has been deliberately used in order to underline that, at the present moment, there is little evidence supporting the argument that Intelligent and Knowledge Cities are necessarily more sustainable. No one disagrees with the fact that smarter cities are highly desirable and that enhancing their performance will improve the quality of life of its inhabitants. **Nonetheless, the contribution of ICPs and KCPs to the achievement of sustainability targets is often vague, left implicit and affected by wishful thinking. Therefore, if ICPs and KCPs are to become a success story, this "hope" needs to be transformed as much as possible into a "conviction".**

➢ The question

Given the lack of a robust rationale supporting the connection between urban intelligence and sustainability, the main question tackled by this research is:

How are Intelligent and Knowledge City Programmes contributing to the achievement of urban sustainability?

In order to answer this question, it is necessary to proceed step by step through a series of sub-questions. These pertain to the four elements that together characterize the main question tackled, namely: (i) sustainable development; (ii) urban sustainability; (iii) Intelligent and Knowledge City Programmes and; (iv) a methodology for tracking down the contribution. More precisely, the sub-questions of this research are articulated as follows:

1. **Sustainable Development**
    a. What is the essence of sustainable development?
    b. How and from where has the concept evolved?
    c. How is sustainable development being interpreted by NGOs, International Institutes, Private Organizations, Scientific Research Centers and Private Organizations
    d. What are the main features and complexities that characterize the sustainability principle?
    e. How can we define sustainable development in the form of a working definition functional to the scope of this project?

2. **Sustainable Cities and indicators of urban sustainability**
    a. How is the principle of sustainability being transposed to urban systems?
    b. What are the main features that characterize the ideal "Sustainable City"?
    c. How has urban planning evolved in order to embrace the challenges set by sustainable development?
    d. What are the main urban strategies for achieving sustainable cities?
    e. How can we define Sustainable Cities in the form of a working definition functional to the scope of this project?
    f. Why is it so important to define indicators of sustainable development?
    g. What are the reasons determining the abundance and heterogeneity of methods for measuring sustainability at the settlement level?
    h. How can we articulate the high-level objectives that characterize Sustainable Cities in a set of meaningful parameters?
    i. How can we translate these parameters into a list of Sustainable Development Indicators (SDI)?
    j. What are the guidelines that should be followed in defining these indicators?

3. **Intelligent and Knowledge Cities**
    a. What is the essence of the "Intelligent and Knowledge City" and what are their characterizing elements?
    b. What are the goals that Intelligent and Knowledge Cities are expected to achieve and how are they supposed to achieve them?
    c. What is the role played by ICT in making urban systems more intelligent?
    d. What are the obstacles that Intelligent and Knowledge cities face?
    e. What are the features that distinguish Intelligent and Knowledge City Programmes from traditional urban (re-)development projects?
    f. How can we identify and characterize ICPs and KCPs in a way that is functional to this project?

4. **A methodology for assessing contribution of ICPs and KCPs to the achievement of urban sustainability**
    a. How can we systematically assess the contribution of ICPs and KCPs to the achievement of urban sustainability?
    b. What is the theoretical contribution of ICPs and KCPs to the pursuit of more sustainable urban environments?
    c. What are the strong and weak points of ICPs and KCPs?

➢ The aim

The aim of this research is to shed light on the connection between ICPs-KCPs and the concept of urban sustainability. In achieving this aim, the research will provide public and private organizations with a framework for designing ICPs and KCPs in such a way that their contribution to the achievement of Sustainable Cities is more visible**. In fact, by making this contribution explicit in the design phase of ICPs and KCPs, their strength and attractiveness in the eyes of governmental decision-makers will be increased**.

The aim of this research can be articulated in the following two goals:

I. The development of a methodology for systematically assessing the contribution of ICPs and KCPs to the achievement of urban sustainability, and;
II. The formulation of an hypothesis regarding the modalities through which ICPs and KCPs support cities in implementing sustainable development within their structure and metabolism.

➢ The structure and research methodologies

The structure of the entire research can be divided in two main phases (see Figure C):

1. The first phase, characterized by a linear approach, focused on answering the first four aforementioned sub-questions in series.
2. The second phase consisted in several iterative cycles for developing, refining and adopting the assessment methodology in order to answer the main research question.

For the first phase, which consists of chapters 1 to 4, a **bibliographic research** was adopted as main methodology (see References). A thorough investigation of the available literature (i.e. online scientific journals, documents, books and newspaper articles) was performed with the aim to acquire information on the main concepts that characterize the research question. The sources of information were identified using the *Google Scholar* search engine and selected according to the following three criteria:

A. Highest ranking attributed by the Google Scholar when typing the words "Sustainable Development", "Sustainability", "Sustainable Cities", "Sustainable Urbanization", "Urban Sustainability", "Sustainable Development Indicators", "Measuring Urban Sustainability", "Intelligent Cities", "Intelligent Urban Management Systems";
B. Highest impact factor of scientific journal;
C. Date of the sources (the most recent articles published were favored).

With regards to the second phase (i.e. chapters 5 and 6), several **case studies** were analyzed in order to improve both the assessment methodology developed and the hypothesis regarding the theoretical contribution of ICPs and KCPs to the achievement of urban sustainability. These case studies were provided by Accenture, a global management consulting, technology services and outsourcing company, currently involved in many Brownfield and Greenfield Intelligent City Projects throughout the world. A set of **interviews** were given to the people in charge of the projects implemented by the company (ref. Appendix 1). Various iterations between the three activities aforementioned were carried out before formulating the final conclusions and answer to the research question.

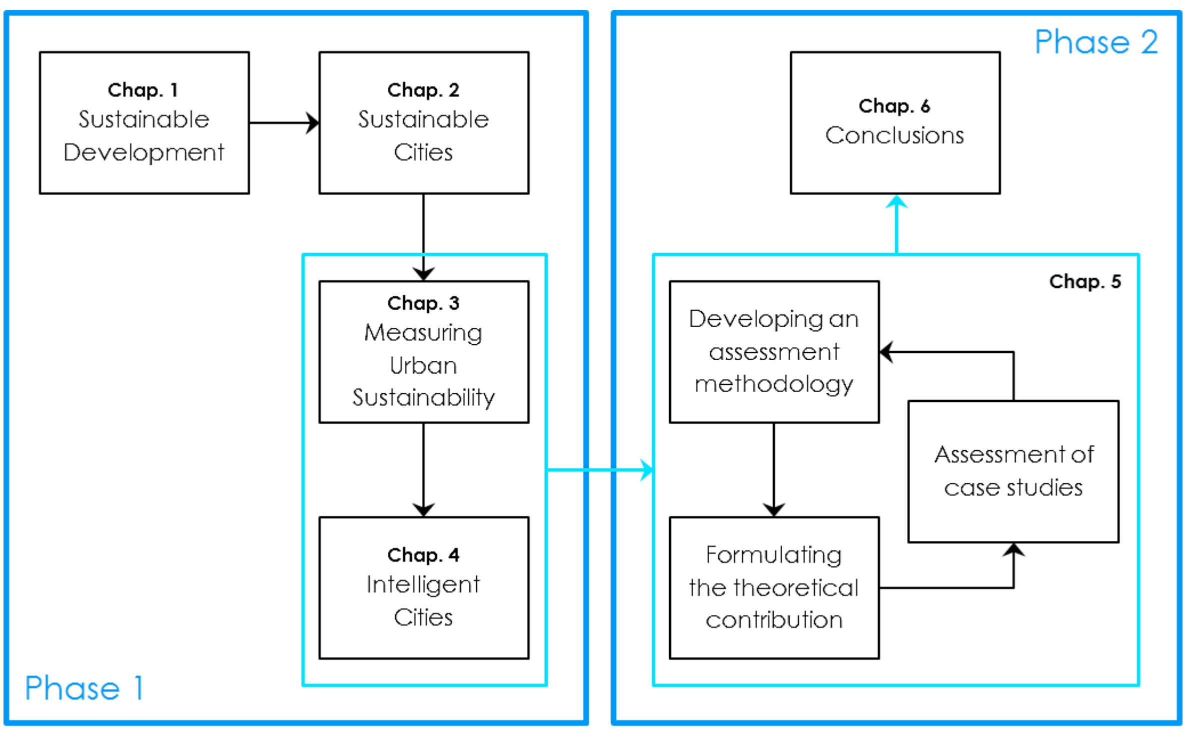


Figure C: The structure of the research project

To improve the readability of this work, all chapters besides the last one recall the research sub-questions tackled, the goals pursued and include a summary of the content. Moreover, the first four chapters end with a section dedicated to the conclusions reached.

➢ The scientific and social relevance

The research is considered to be relevant from the scientific and social perspectives. With regards to the former, this research:

- Provides insights and a review of actual and highly discussed topics such as Sustainable Development, urban sustainability, Intelligent and Knowledge Cities;
- Develops a rationale for systematically characterizing urban sustainability;
- Designs an approach for planning and monitoring Sustainable Cities;
- Develops a conceptual framework for characterizing ICPs and KCPs;
- Develops a methodology for assessing ICPs and KCPs in light of specific parameters of urban sustainability, and a tool for designing *"intelligently-sustainable" city solutions*;
- Formulates an hypothesis regarding the theoretical contribution of ICPs and KCPs to the achievement of Sustainable Cities.

Considering the second perspective, the project has relevance for the society as it investigates on the modalities through which citizens of future Intelligent and Knowledge Cities will contribute to the achievement of sustainable development. The importance for society of exploring strategies for achieving sustainability is ever so urgent as the need to reconcile principles of equity, preservation of the environment and economic development grows.

Sustainable Development

Overview of a highly debated topic

Chapter 1

"It is said that to everything there is a season. The world today needs to usher in a season of transformation, a season of stewardship. Let it be a season in which we make a long-overdue investment in the survival and security of future generations."

Kofi Annan, 2002

Summary

In order to assess the modalities through which Intelligent City Programmes (ICPs) are supporting the creation of Sustainable Cities (SC), it is necessary to start with a solid understanding of this controversial, often abused and highly debated concept of sustainable development. Given this requisite, Chapter 1 aims at constructing a meaningful paradigm of sustainable development that will be used in the following phases of the project. In order to pursue this objective, the chapter starts with a historical review of the evolution of the concept from the first energy revolution to the present day. Successively, the intrinsic complexity of the sustainability ideal is discussed and presented as the main reason for which the concept is still so intensely debated. The chapter then investigates how a selection of different actor typologies are approaching the ideal of sustainability and implementing it in the real world, providing the reader with the "bigger picture" of sustainable development. Taking from a selection of popular definitions and from the knowledge gathered on its origins, the chapter concludes by presenting a practical formulation of sustainable development, a working definition of the concept that will be used throughout this research project.

Keywords
Sustainability; Development; Environment; Economy; Society

Goal of Chapter 1

The goal of this chapter is to provide a solid body of knowledge on sustainable development and a working definition of the concept, which will serve as the foundations of the research. More specifically, the following questions will be tackled in this chapter:

1. What is the essence of sustainable development?
2. How and from where has the concept evolved?
3. How is sustainable development being interpreted by NGOs, International Institutes, Private Organizations, Scientific Research Centers and Private Organizations
4. What are the main features and complexities that characterize the sustainability principle?
5. How can we define sustainable development in the form of a working definition functional to the scope of this project?

1.1 Tracking the origins of sustainable development

Every principle originates from a specific social context and streamline of thoughts, and sustainable development is no exception to this general rule. Therefore, an analysis on the birth of this principle has to initially focus on the thoughts and beliefs that have characterized the environmental debate leading to sustainable development.

1.1.1 Energy revolutions and the growing impact of the human species on the biosphere: the history of sustainable development

Since the first human societies began inhabiting the world, the impact of mankind on the natural environment has progressively grown. Like every living species, humans exploit the resources available in their environment in order to sustain their lives. However, like no other living specie, since the Neolithic (approximately 10,000 years ago) humans have constantly increased their level of impact on the environment.

Free from philosophical dilemmas regarding the state of the environment, humans have taken advantage of natural resources and ecosystem services for expanding their communities. Neglecting the consequences of an uncontrolled exploitation and management of the environment was perfectly comprehensible, since at that time human population accounted to approximately 10 million individuals (Meadows, Meadow, & Randers, 1992), and their impact on the biosphere was practically insignificant.

The Neolithic revolution (also known as the first agricultural revolution) marked the first step of an astonishing transformation that human societies are experiencing since then. Approximately 10,000 years ago, humans began to develop innovative food-producing techniques that allowed them to gain access to larger and more stable flows of energy. Consequently, as agriculture started to develop, small groups of hunter-gathers started establishing themselves on the territory, giving birth to the first settlements of human history. Since then, population slowly (but persistently) started growing, adding up over centuries to an enormous increase (Mebratu, 1998).

The first industrial revolution marked another turning point in the history of energy exploitation, giving a tremendous boost to the growth of human settlements. The event had profound effects on the societies of the old continent, substantially transforming their physical and cultural structure. By the end of the 18th century, despite a total population which accounted to less than 15% of current demographic figures (Meadows, Meadow, & Randers, 1992), the first formal concerns regarding the impressive rates of population increase started to appear. Among these official proves, probably the most representative is the work by Thomas Robert Malthus, *An Essay on the Principle of Population* (1798). According to many scholars[1], the Anglican clergyman was among the first pioneers of the concept that the growth of human societies is inevitably limited to the finite quantity of resources available in the biosphere. Rephrased in straightforward terms, the earth is simply unable of supporting an unlimited growth of human societies. However, given the infinite possibilities represented by technological innovation, setting the boundaries of growth is an arduous, if not impossible, problem to solve. As Malthus points out, "a careful distinction should be made, between an unlimited progress, and a progress where the limit is merely undefined" (Malthus, 1798).

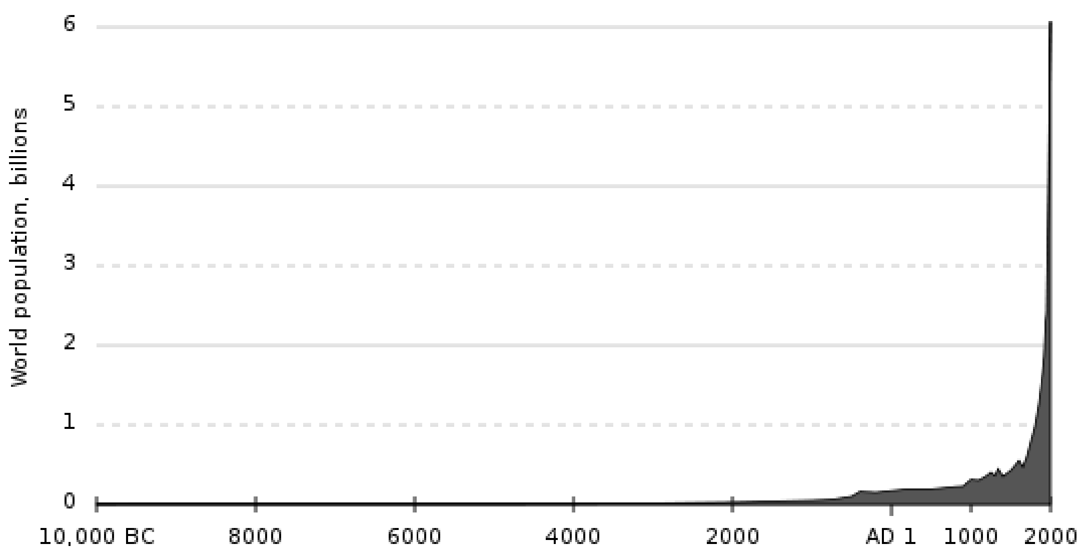


Figure 1.1: History of world population growth.
Source: http://www.census.gov/population/international/

If Malthus was among the first to claim that population growth cannot proceed reluctant of the physical limits set by the biosphere, many scholars after him started investigating on the exact meaning of these limits and on the consequences of neglecting them. What are the results of an uncontrolled and irresponsible form of exploitation of the environment for human societies? To answer this question, various historians[2] have studied the causes that have led to the fall of great civilizations. Representative in this field is the work by D. Wall, that investigates on the consequences that certain human actions leading to pollution, deforestation, and land degradation have had on the survival of their own societies (Wall, 1994). With regards to these types of researches, D. Mebratu underlines the fallacious belief of many that pollution and environmental degradation is a pure product of the industrial revolution (Mebratu, 1998). Humans, like any other living specie, have always affected the environment in which they live. However, the point is that the level of impact has dramatically grown since the advent of the first industrial revolution, mainly due to the immense increase in human population (see Figure 1.1).

[1] See, for example, Dixon and Fallon, 1989
[2] See, for example, Niragu, 1994.

The 1960s signed another milestone in the evolution of the environmental debate. One of the key events of this decade was the Intergovernmental Conference for Rational Use and Conservation of the Biosphere[1] (UNESCO) that took place in 1968, where the concept of "ecologically sustainable development" was presented to the world. The following year, the formation of NGOs like Friends of the Earth, and local governmental actions such as the approval of the National Environmental Policy Act in the U.S. where among the first tangible signs of the growing environmental debate.

Following this trend, several Intergovernmental conferences (e.g. The UN Conference on Human and Environment[2] in 1972, Habitat[3] in 1976, International Conference on Environment and Economics in 1984) and international research institutes (e.g. The Worldwatch Institute[4] in 1975, Independent Commission on International Development Issues in 1980, World Resource Institute[5] in 1982) took place in the 1970s and 1980s. The publication of the Brundtland report, *Our Common Future*, in 1987, constituted the climax of this political movement and the formalization of the concept of sustainable development (World Commission on Environment and Development, 1987). Nonetheless, this was neither the starting point nor the end of the evolution of the concept (Mebratu, 1998).

1.1.2 Sustainable development today: a *political cliché?*

Sustainable development, contrarily to its predecessor "eco-development", is progressively gaining worldwide popularity (Lélé, 1991). Since it was formalized by the World Commission on the Environment and Development (WCED), the concept has been introduced in the agendas of politicians and private organizations with a wide range of different meanings and finalities, further attracting the attention of the academic world. Meaningful for illustrating the immense popularity of the concept is the number of results obtained when typing its words on Google: the search engine displays more than 250.000.000 results, of which 1.640.000 are academic articles.

The UN Conference on Environment and Development (Rio de Janeiro, 1992) and the World Summit on Sustainable Development (Johannesburg, 2002) represent the two most significant attempts for trying to bring more rigueur to a concept that was "(…) laden with so many definitions that risks plunging into meaningless, at best, and becoming a catchphrase for demagogy, at worst" (Workshop on Urban Sustainability, 2000). Nonetheless, these attempts and many others (see Table 1.1) have failed in the objective

[1] www.unesco.org
[2] www.unep.org
[3] www.unhabitat.org
[4] www.worldwatch.org
[5] www.wri.org

of turning the concept of sustainable development from a pure *political cliché,* a commonplace portfolio in most major government agendas, to a concrete set of actions and goals (Holden, Roseland, Ferguson, & Perl, 2008).

Box 1.1: Sustainable development and evolutionary psychology: is sustainability a problem only for the rich?

It is no coincidence that sustainable development has first appeared and found fertile ground in the Western societies of the post-industrial era. As the population of these regions has achieved a considerable level of wealth, people have the chance to shift their planning perspectives from the short-term (e.g. a time frame of weeks or months) to the long-term (e.g. a time scale of years). If natural selection once favored a behavior which focused on immediate issues (like the procurement of food for survival) (Wright, 1994), today the more developed populations of the world can allow themselves the "privilege" of worrying about problems which might appear in the far future (e.g. climate change). This consideration brings to the following doubt: is sustainable development a problem only for the rich?

It is, however, arguable whether providing a precise set of rules and objectives for achieving sustainable development is desirable. Politicians and diplomats are familiar with the so called "constructive ambiguity", a phenomenon for which leaving key terms undefined may benefit negotiation processes (Robinson, 2004). Thus, voluntarily leaving sustainable development in a state of vagueness, besides being dictated by practical difficulties and limitations, might be a political strategy for divulgating the concept in the agendas of global leaders and obtaining total consensus. Furthermore, leaving the agenda of sustainable development undefined is a simple yet effective strategy for inviting all participating actors to share their ideas and creativity in the discussion (Holden, Roseland, Ferguson, & Perl, 2008), capture the imagination and support of a wide range of political groups and intellectual currents (Stren, White, & Whitney, 1992). Hempel (1999) resumes this idea in observing that "the symbol of sustainability is sufficiently ambiguous to be embraced by diverse interests, yet coherent enough to inspire movement in a particular direction . . . it's [*sic*] potential may depend more on strategic uses of ambiguity than on conceptual precision and clarity" (Hempel, 1999).

"Sustainable Development draws much of its resonance, power, and creativity from its very ambiguity." (Kates, Parris, & Leiserowitz, 2005)

Nonetheless the risk of allowing sustainable development to remain vague and vulnerable to subjectivity is that it attracts hypocrites and fosters delusions (Gibson, 1991), ending up as an etiquette that politicians and corporate leaders[1] use to

[1] See, for example, Ayres and Simonis, 1995

embellish their policies (Redclift, 2005). In fact, today sustainable development is still struggling in the process of transforming into a meaningful paradigm of development rather than a *political cliché* (Lélé, 1991). Said in the words used by Pearce *et al.* (1989), at the present moment sustainable development sounds more like "mother hood and apple pie".

"Constructive ambiguity" has been useful in the early stages of the origin of sustainable development. The strategy of leaving the concept vague and attractive to everyone has turned sustainability in a fundamental word of political vocabulary. But, as Kofi Annan said during the UN conference on Sustainable Development in 2000, the time has come for political leaders to be more courageous and start giving some rigueur to the concept, formulating it in terms of a meaningful paradigm of development.

> *"It is said that to everything there is a season. The world today needs to usher in a season of transformation, a season of stewardship. Let it be a season in which we make a long-overdue investment in the survival and security of future generations"* (Opening declaration of the Secretary-General of the UN, Mr. Kofi Annan. United Nations, 2002)

Table 1.1: Timeline of major conferences on sustainable development and related events. (1)

Name	Year	Location	Description
United Nations Educational, Scientific and Cultural Organiz.	1968	Paris	UNESCO organizes first international conference with the scope of reconciling environment and development, resulting in the creation of *Man and the Biosphere Prog.*
UN Conference on Human Environment	1972	Stockholm	The conference leads to the establishment of various environmental protection agencies and the United Nations Environment Programme (UNEP).
Publications of Limits to Growth	1972	-	The Club of Rome, a global think tank that deals with a variety of international political issues, commissions and publishes a controversial study that highlights the limits and danger of uncontrolled societal growth.
Habitat	1976	Vancouver	First global meeting that makes explicit the link between environment and human settlements.
World Conservation Strategy	1980	-	Released by the International Union for the Conservation of Nature, the report calls for a new international development strategy to readdress societal and environmental issues.
Int. Conference on Environment and Economics (OECD)	1984	Paris	The meeting aimed at emphasizing that environment and economics are mutually reinforcing components of the same system.

Source: Adapted from The International Institute for Sustainable Developlment, 2009.

Table 1.1: Timeline of major conferences on sustainable development and related events. (2)

Name	Year	Location	Description
World Commission on Environment and Development (WCED)	1987	Copenhagen	Release of the Brundtland report “Our Common Future” and commitment of attending nations to the objective of sustainable development
Establishment of the Intergovernmental Panel on Climate Change (IPCC)	1988	-	The Intergovernmental Panel on Climate Change (IPCC), an international body of scientific experts in charge of assessing the risks of climate change associated to human activity is endorsed by the UN.
UN Conference on Environment and Development (UNCED)	1992	Rio de Janeiro	Also known as the Earth Summit, the conference was set in order to find global agreement on the action plan “Agenda 21” to be implemented by all nations committed to sustainable development
First meeting of the UN Commission on Sustainable Development (WCSD)	1993	New York	The commission was established in order to keep track of the progress made from the UNCED, to enhance international cooperation and rationalize intergovernmental decision-making capacity
Habitat II	1996	Istanbul	The second conference on human settlements ends with the publication of the Habitat Agenda, a “global call to action” for adequate shelter and sustainable human settlements for all.
UN General Assembly review of the Earth Summit	1997	New York	The assembly was held for reminding nations that little progress was made in implementing Agenda 21.
United Nations Framework Convention on Climate Change	1997	Kyoto	The conference was held for the ratification of the Kyoto protocol, an international environmental treaty with the goal of fighting climate change.
UN Millennium Summit	2000	New York	The largest-ever gathering of world leaders agrees to a set of time bound and measurable goals (the Millennium Development Goals) pertaining to the overall objective of sustainable development
World Summit on Sustainable Development	2002	Johannesburg	The meeting was held at a distance of 10 years from the UNCED. In a climate of general political frustration, participating nations officially re-establish their commitment to the responsibilities and objectives included in Agenda 21.
Green economy enters mainstream of national policies	2008	-	National governments all around the world place environmental actions and low-carbon policies in their agendas.

Source: Adapted from The International Institute for Sustainable Developlment, 2009.

Table 1.1: Timeline of major conferences on sustainable development and related events. (3)

Name	Year	Location	Description
Copenhagen Climate Conference	2009	Copenhagen	Parties of the United Nations Framework Convention on Climate Change reach final negotiate on strategies for fighting global warming caused by human activities.
Rio +20 UN Conference	2012	Rio de Janeiro	193 states sign the document "the future we want" and re-affirm their commitment to sustainable development

Source: Adapted from the The International Institute for Sustainable Developlment, 2009.

1.2 Recognizing the intrinsic complexity of sustainable development

Since it was first coined, sustainable development has been one of the preferred victims of scholars and politicians trying to find the best definition of the concept[1]. Paradoxically, all of these "definition works" have brought to the inexistence of a sustainable development-ism (Giddings, Hopwood, & O'Brien, 2002). At the present moment, sustainable development still lacks a clear verbal formulation, not to mention a set of implementation strategies and objectives to be achieved, and the "definitional challenge" remains alive in the political and scientific community (Holden, Roseland, Ferguson, & Perl, 2008). This section discusses the features of sustainable development that make it such a hard concept to define.

1.2.1 Obstacles hampering the road towards a single definition of sustainability

While many academicians have focused on reviewing the immense panorama of definitions of sustainable development[2], for the scope of this research it is more useful to concentrate on the reasons that have fostered such a large and diverse quantity of lemmas. After having reviewed a significant body of articles and several books discussing the concept of sustainable development, the main obstacles hampering the formulation of a universal and globally accepted definition of the concept are summarized in the following points.

1. **Interdisciplinary nature and broadness of the concept;**

One of the main assumptions underlining the *sustainability paradigm* is that the only way to achieve the viability of social systems is by considering the complex feedback structure connecting the economy, environment and society together (World Commission on Environment and Development, 1987). Consequently, sustainable development is a concept that cuts through the fields of economy, sociology and ecology, which make use of different vocabularies, approaches, and perspectives, focusing on diverse features of the concept. Furthermore, the concept embodies a large quantity of meanings and ideals, all of them subject to different interpretations, which make sustainable development come through as a complex multi-faceted concept.

[1] See, for example, Pezzey, 1992.
[2] See, for example, Pezzoli, 1997.

2. Approachable in two opposite ways;

Sustainable development can be studied through two fundamentally different mindsets: (i) holistic thinking and (ii) reductionism (Giddings *et al.*, 2002). According to the choice of the systems thinking adopted, sustainable development embodies a complete different set of meanings. Considering the former, when defining sustainable development all aspects of the system's viability, performance and sustainability are covered, while never assessing the system in isolation from the systems with which there is a mutual dependency (Reed, Fraser, Morse & Dougill, 2005). On the other hand, the latter aims at describing the sustainability of a system as a whole by reducing it to different sub-systems, studied independently through the perspectives of the economy, society and environment (Gasparatos, El-Haram & Horner, 2009).

3. Dependent on delineation of system boundaries;

There are no clear indicators or set of rules for assessing the sustainability of cities and policies (Pezzey, 1992). In fact, designing strategies for implementing sustainable development and defining sustainability goals are activities highly dependent on the modalities with which the system boundaries have been delineated (Satterthwaite, 1997). It is, however, agreed that urban ecosystems have open boundaries through which energy and matter is exchanged with the external environment (Expert Group on the Urban Environment, 1996). This aspect needs to be considered when designing policies that pursue sustainability objectives.

4. Attracts the interests of different types of actors;

Sustainable development is affecting and stimulating the interest of a wide range of actor typologies. According to D. Mebratu (1998), these typologies determine three fundamental approaches to sustainable development: Institutional, Ideological and Academic. Consequently, defining and assessing sustainable development are two activities that depend on the type of the actor performing them (some examples are provided in section 1.3). Moreover, because of diverging interests, moral values and objectives among the proponents of sustainable development, there is no consensus on *what is to be sustained*, *what is to be developed* and *for how long* (Parris & Kates, 2003).

> *"We recognize the diversification of actors and stakeholders engaged in the pursuit of sustainable development. In this context, we affirm the continued need for the full and effective participation of all countries, in particular developing countries, in global decision-making."* (United Nations, 2012)

5. Ethical dimension of the concept;

Sustainable development has a strong ethical, besides scientific connotation. The concept embodies moral and political values such as freedom, equity, intra- and inter-generational responsibility, needs and justice, all extremely subjective other than culturally-dependent (Kates, Parris, & Leiserowitz, 2005). Some people may be more selfish while other more altruistic, some may value economic growth as an absolute priority while others believe in the importance of preserving the state of the natural environment. As many philosophers have argued in the past, it is impossible to prove a right system of ethics, which means that the moral debate over the necessity and importance of sustainable development is potentially endless.

6. Political interests underlying different definitions;

As sustainable development becomes more popular on the stage of geopolitics, the implications that different definitions of the concept will have on the agenda of global leaders is comprehensible. Consequently, the "framing battle" among governmental decision-makers is growing fiercer, as each political actor strives to frame the definition of sustainable development according to its own interests and ideology (Parris & Kates, 2003).

7. Lack of consensus over basic terms;

There is a lack of consensus on the basic terms that together compose the concept of sustainable development. In fact, the idea of "sustainable" adopts a wide range of different meanings according to the field of application. For example, in ecology sustainability refers to the rates of increase and decrease of natural resources (Lélé, 1991), while in economics the word sustainable is adopted to indicate growing societal welfare over time (Pezzey, 1992). The same confusion holds for the term "development" which is often confused with the one of "growth". For example, some economists consider development as a form of growth that takes account of environmental issues (Pezzey, 1992), while others regard it as "the qualitative improvement in the structure, design and composition of physical stocks and flows" (Daly, 1987).

8. Disagreement on the level of criticality and elements of the problem

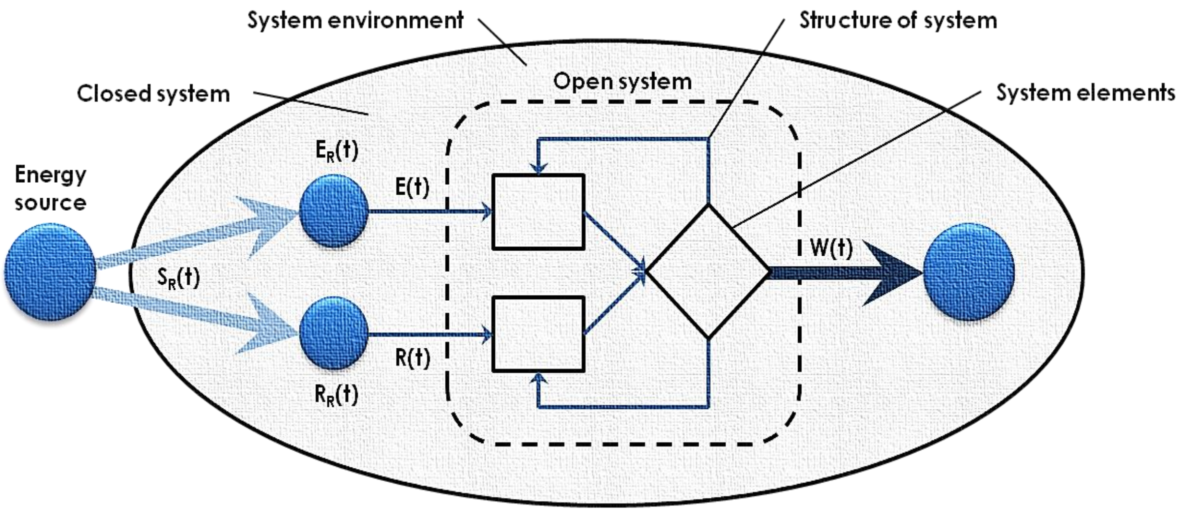
There are still several and deep uncertainties regarding the maximum carrying capacity of specific ecosystems, the rates of generation and depletion of natural resources and the impact of human activities on the climate and natural environment (Gibson, 1991). The consequence of this lack of knowledge can be regarded as responsible for the present disagreement on the level of criticality of the problem. As long as the importance and urgency of sustainability are undervalued, the political debate over the meaning and objectives of sustainable development is likely to proceed. Furthermore, there is also little consensus within the scientific and political community as per the problems that sustainable development has been called to solve (Redclift, 2005).

9. Physical contradictions and limitations.

If we focus on the purely practical meaning of sustainable development, the principle becomes vulnerable to critics based on physical considerations, as evidenced by

Redclift in his article "Sustainable Development 1987 - 2005: An Oxymoron Comes of Age" (Redclift, 2005). Physically speaking, sustainable development is composed by the following two concepts:

- *To Sustain:* to provide the conditions for a system to survive/endure[1]
- *Development*: a pattern of social and structural economic transformations (Goodland & Ledec, 1987)



- $S_R(t)$ = Tot. solar radiation absorbed by earth's surface
- $E(t)$ = Energy input to system
- $R(t)$ = Resource input to system
- $W(t)$ = Waste output generated by system
- $R_R(t)$ = Resource regeneration rate
- $E_R(t)$ = Energy regeneration rate
- $A_C(t)$ = Absorption capacity of environment

A system is sustainable if:

1. $E(t) \leq E_R(t)$
2. $R(t) \leq G_R(t)$
3. $W(t) \leq A_C(t)$

Figure 1.2: Physical asset of sustainable systems.
Source: Adopted from Bossel, 1999.

Thus, literally speaking, sustainable development implies the structural change of a system so that it can survive indefinitely, preserving the ecosystem in a state which is suitable for supporting life as we know it today. To achieve this objective, that is to become entirely sustainable, the flow of resources entering a system has to be in balance with what the region can supply continuously through natural processes such as photosynthesis, biological decomposition and biochemical processes that support life (Van der Ryn & Calthopes, 1991). This means that systems would have to exploit energy and material resources at a rate which is inferior or equal to the one of self-regeneration, meaning that their stocks are never being depleted and that their carrying capacity is never exceeded. A state like the one just described could only be achieved if systems would be able to survive exclusively on renewable energy sources and on utilization rates of natural resources which do not exceed their own regeneration time. As the rough

[1] Definition of the verb according to the MacMillan Dictionary

estimations presented in Box 1.2[1] demonstrate (ref. page 21), under the current conditions, this goal seems like an arduous mission to accomplish. Furthermore, according to the Global Ecological Footprint calculations made by Wackernagel *et al*., (2002) an indicator of the consumption and waste of human societies relative to the Earth's capacity to create new resources and absorb waste, in 1999 the global consumption rates exceeded by a factor of 1.22 the renewable supply of resources (Wackernagel, Schulz, Deumling, Linares, & Jenkins, 2002). But what is most important is that this factor is progressively increasing as the economy of the less developed regions of the world is strengthening. Placing sustainability *vis-á-vis* with the constraints set by the laws of nature and physical environment, at the present state the concept comes through as goal almost impossible to achieve (Bossel, 1999).

1.2.2 Sustainable development as a wicked problem

There is growing acceptance for the concept of sustainability despite our inability to objectively define it (Fricker, 1998). However, it seems as though sustainable development is destined to a future of political and scientific debates that will probably never reach full consensus. In this sense, the question of how can sustainable development be achieved and rooted in our societies will persist in the category of global "wicked problems" (Rittel & Webber, 1973). In other words, at the present moment the problem seems both socially (there is a lack consensus amongst 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 scientifically (the effects of current development dynamics and human actions on the ecosystem are not fully demonstrated) un-tamed (van Bueren, Klijn, & Koppenjan, 2003).

Albeit the social dimension of the problem seems to be potentially impossible to tame, there are strong hopes for leading stakeholders towards consensus on the scientific dimension of the dilemma. In this sense, by shedding light over the effects that certain plans and policies (in particular, Intellgent City Programmes) have in terms of achieving sustainability goals, one of the main objectives of the present research project is to tame the problem from the technical perspective.

The conclusion of this analysis on the intrinsic complexity of sustainable development is that scientists and politicians should abandon the project of finding a single definition of the concept. Instead, efforts should be directed at defining sustainable development in the form of a conceptual paradigm, a vision or guideline that policy-makers can use for implementing principles of sustainability in their organizations and cities.

[1] Sources of the data used in the calculations of the earth's energy balance:

- BP - Statistical Review of World Energy, 2010
- http://www.eia.gov/state/state-energy-rankings.cfm?keyid=60&orderid=1

Box 1.2: Is sustainability a realistic goal?

Regardless of the difficulties and strategies for making our societies sustainable, is this goal actually possible or does it represent an utopia? To answer this question, a rough estimation regarding the energy balance of the earth and the actual consumption of energy worldwide can reveal useful. This estimation, which does not intend to represent a precise calculation of the problem, is based on the following assumptions and operations:

I. *Hypothesis 1: All of the earth's potential renewable energy is exploited*
II. *Hypothesis 2: Energy is converted with an efficiency of 100% and there are no losses during transmission and distribution*
III. *Hypothesis 3: All human beings have living standards similar to the ones of the average citizen of Alaska (USA)*

- **Pot $_{RE}$ (t):** Total potential energy deriving from renewable sources: 834×10^3 TW·h of which:
  - Potential of solar energy: 444×10^3 TW·h
  - Potential of wind energy: 167×10^3 TW·h
  - Potential of geothermal energy: 139×10^3 TW·h
  - Potential of biomass energy: 70×10^3 TW·h
  - Potential of hydroelectric energy: 14×10^3 TW·h
  - Potential of tidal wave energy: 280 TW·h
- **WAEC(t):** World Average Energy Consumption calculated according to living standards in Alaska (USA): 630×10^3 TW·h

$$\mathbf{Pot_{RE}(t) = 834 \times 10^3\ TW{\cdot}h > 630 \times 10^3\ TW{\cdot}h = WAEC(t)}$$

Under Hypothesis 1, 2 and 3, there would be apparently just enough energy deriving from renewable sources to support the populations' demand. Thus, from the energy perspective, under current conditions sustainability could be achieved. However, if technological innovation in the exploitation of energy sources will not be able to keep up with the growing demands of a constantly increasing world population, in the future sustainability might well turn into an utopia.

1.3 The bigger picture of sustainable development

With the aim of reaching an operational and complete definition of sustainability for the scope of this project, a theoretical review of the concept alone was not sufficient. An overview of the meaning of sustainable development for society and the scientific community should also take into consideration how the concept is being applied in the real world. Thus, this section investigates on how different actors are attempting to implement sustainable development in daily practices. In sum, the objective is to define the bigger picture of sustainability today.

This part of the research was based on the links identified by the "Sustainable Development Online" web site[1], a gateway to significant web pages supporting many aspects of sustainability, and on indications provided by Senior Managers of Accenture working in the field of Sustainability Services. Actors and organizations were grouped according to five types: (i) Private organizations; (ii) National Governments; (iii) NGOs, (iv) Scientific Research Institutes and (v) International Institutes. For each actor typology, the vision, objectives and strategies for implementing sustainable development were investigated.

A total of 19 different organizations, governmental authorities and institutions were analyzed (see Table 1.2). Clearly, the dimensions of the sample are such that it cannot be representative of the entire population. Nonetheless, it was useful in providing the thesis with an indication of how sustainability is evolving on the global stage. In the paragraphs below, the conclusions of this research are presented (for more detail, ref. Appendix 2).

- **Non-Governmental organizations**

The vast majority of NGOs around the world have adopted, in some ways, the concept of sustainability, which testifies the "noble connotation" that the term has acquired. This result is not surprising given the fact that, as previously argued in this chapter, sustainable development embodies a wide spectrum of positive meanings and objectives. Depending on the mission and field of engagement, each of the investigated NGOs claims to be working towards a more sustainable world. For example, Greenpeace and other environmental NGOs tend to present every action aimed at protecting the environment as leading to sustainability. The wide adoption of the words "sustainable development" was noticed also in the propaganda of other major NGOs such as Friends of the Earth and WWF.

Interestingly, after having scrutinized their websites and published documents, most of these NGOs lack a precise definition of what sustainable development means. Nonetheless, the word is constantly included in their vision and mission statements.

[1] http://sdo.ew.eea.europa.eu/

Together with the observations made in the previous paragraph, it can be concluded that the investigated NGOs have developed the habit of focusing only on those specific elements of sustainable development that are in line with their actions and of keeping the term vague and attractive to its public. For example, leaving aside other ethical and political considerations, how does blocking the use of Genetically Modified Organisms in agriculture contribute to sustainable development?

Table 1.2: List of investigated organizations handling sustainable development.

Actor typology	Name
Private organizations	• Accenture Sustainability Services • IBM • Cisco • The Boston Consulting Group
Non-Governmental Organizations	• Friends of the Earth • Greenpeace • EarthAction • WWF
National and international governmental authorities	• European Commission • Federal Government of Belgium • Italian Government
Scientific research Institutes	• Barkley Centre for Sustainable Resource and Development • Platform for scientific co-operation on Indicators for Sustainable Development • Centre for Social and Economic Research on the Global Environment • Ecologic – Pathways to Sustainability
International institutes	• Earth Watch Inst. • International Inst. for Sustainable Development • International Inst. for Environment and Development • European Business Council for Sustainable Energy • World Business Council for Sustainable Development

- **Scientific research institutes**

Sustainable development has become an independent field of research. Many Universities have established since some years departments that specifically deal with sustainability, and several governments (including International organizations) have founded research institutes with the aim of identifying strategies for implementing principles of sustainable development.

The amount of knowledge that has been developed by these research institutes is abundant and impressive. It mainly focuses on the analysis of the nature and size of the problem that sustainable development is called to solve, including the different policies, strategies and approaches for implementing sustainability. Even if in general the results of these studies are aligned with some basic principles, there are, however, many points of contrast, emphasizing once again the complexity of the concept. For example, all research institutes agree on the necessity of having to define a set of sustainable development indicators (confirming the shared belief that “you cannot manage what you cannot measure”), but each one of them identifies a different set of measurement parameters and methods. Often the result of all these studies is that decision-makers willing to implement sustainable development are overwhelmed with information (Fricker, 1998).

- **International Institutes**

The investigated International institutes involved in sustainable development issues come through as organizational bodies that mainly act as platforms for knowledge exchange, lobbying activities and advocacy. Their main purpose is to act as catalysts for the implementation of sustainability by supporting international cooperation between private organizations or governmental authorities. Finally, in carrying out their objectives, they focus on certain specific sectors of society (e.g. the World Business Council for Sustainable Development mainly targets the economic aspects of sustainability by working with private organizations) or adopt a more holistic perspective of the issue (e.g. the International Institute for Sustainable Development).

- **National and international governmental authorities**

Sustainability is a recurring topic in the political agendas of many governments. From the investigated cases, the impression is that sustainable development is not viewed as a specific, well-defined goal. Rather, it is perceived as a new paradigm for policy making, that preaches the objective of “harmonizing the economy, ecology and social protection” (Federal Government of Belgium, 2000).

> *“Action starts with Governments. The richest countries must lead the way. They have the wealth. They have the technology. And they contribute disproportionately to global environmental problems.” (Opening declaration of Mr. Kofi Annan, UN 2002)*

- **Private organizations**

To see how sustainability is unfolding in the world of business, four different consultancy organizations were investigated. The results of the research showed how, in general, all of them manifest a positive attitude towards sustainable development, depicting it both as an opportunity and a challenge. Their main line of argumentation is that sustainability is leveraging an entire new set of competitive advantages that private organizations and governments have to grasp and implement in their business models.

The four investigated consultancy companies offer different “sustainability services and practices” to different clients (private organizations or governments). Some offerings are more conceptual (e.g. defining a "sustainability vision") while other are more practical (e.g. operational excellence, sustainable supply chains and emissions management). Nonetheless, all of them are mostly oriented to the goals of efficiency, optimization, waste reduction and eco-responsibility.

1.4 Towards a working definition of sustainable development

The extensive research carried out on the meaning of sustainable development suggested that sustainability is a political act, not just a scientific concept (Robinson, 2004). Because of its intrinsic complexity, conflicting values and moral principles, it is wise not to concentrate further research efforts on the formulation of a single globally accepted definition of sustainable development. This is both potentially impossible and conceptually wrong. Probably the best way to proceed is by formulating a working definition of the concept, which is aligned with the basic principles of sustainable development and accepted by the main stakeholders of the system. Following this belief, for the scope of this research a working definition of sustainability was formulated[1]. The definition does not intend to be exhaustive nor claim its superiority over the others. Instead, it aims at summarizing the main considerations made up to this stage of the research, providing a new approach for analyzing sustainable development and a theoretical basis for the following steps of the projects.

1.4.1 Thinking of sustainable development as a process

The first step towards the formulation of a working definition of sustainable development is to abandon utopia and become more realistic. Following on from the discussion on the intrinsic complexity of sustainable development (ref. Section 1.2), it can be concluded that sustainability presents itself a long-term goal which requires full commitment of the main stakeholders of the system and clear strategies. A state of complete sustainability represents more of a vision guiding present actions rather than a state that will be achieved in the near future. In this sense, strategies for implementing sustainability should be formulated on dynamic goals in the short-term that progressively lead to the defined vision of a sustainable system. Consequently, we should consider sustainable development more as a process than as a final state. J. Robinson also is in favor of this approach, suggesting that we should think of sustainable development as "an approach or process of community-based thinking for achieving a set of agreed objectives, remaining open to fundamental differences on the modalities for achieving them" (Robinson, 2004).

Thinking of sustainable development as a process rather than an end state implies that it should be formulated in terms of a verb rather than a noun. This verb should give the idea of a process aimed at making systems progressively more sustainable. But at the same time, it should stay attractive and be presented in such a way that it results easier to

[1] N.B. For the scope of this research, the working definition was not formulated with the participation of stakeholders as the project does not target a particular system but treats the topic in more general terms.

accept by stakeholders. With these considerations in mind, the verb was defined in the following way:

- ***To Sustainabilize*: the process of transforming the structure of a system so that it moves towards the state of sustainability, a state in which the system can endure potentially indefinitely in harmony with its environment.**

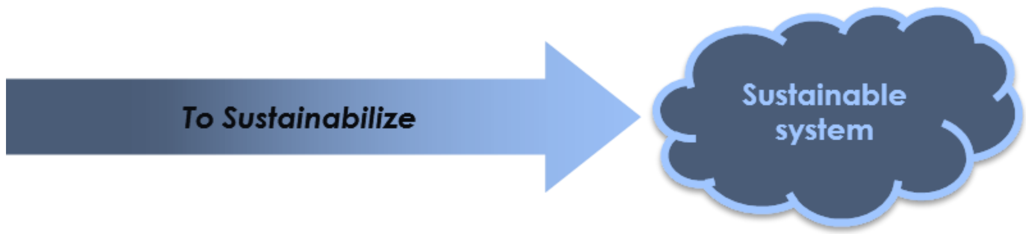


Figure 1.3: Sustainable development as a process of transformation bringing systems to a state of sustainability.

1.4.2 Key elements of the working definition

The second step towards the formulation of a working definition of sustainable development is to identify the key elements of the concept. This was done by reviewing more than a dozen of popular definitions of sustainable development, formulated according to different perspectives (ref. Appendix 3). These definitions were searched in scientific articles, books, declarations of public and private organizations, magazines and websites. Among all these sources, 16 definitions have been selected based on two main criteria: (i) the level of popularity of the definition and (ii) assuring that all three perspectives (i.e. economic, environmental and social) would be equally represented in the sample. Regarding the first selection criteria, the popularity of the definition was determined based on the rank assigned by the algorithm of the web search engine Google. In other words, the definitions that ranked highest were considered to be the most popular ones. Concerning the second criteria, the group of selected definitions (whether formulated by scientists, businessmen or politicians) had to equally represent the environmental, economic and social perspectives.

The key elements, requirements and constraints that the working definition of sustainable development should embody are presented in the following paragraphs.

- ✓ **A dynamic process of societal transformation**

Sustainability is to be regarded as a dynamic process of transformation rather than a static principle or state of change. In this sense, instead of thinking of sustainable development as a noun, it is more correct to consider it as a verb: *to sustainabilize*. By adopting this idea, we should start considering sustainability as a vision for guiding the transformation of our societies.

- ✓ **Global system boundaries**

Sustainable development is a global challenge that requires action of each and every single local authority. This is because many environmental and economic problems have global boundaries and need worldwide cooperation in order to be solved (e.g. climate change). For this reason, when designing "sustainabilizing policies" at the regional level, the boundaries of the system used for assessing these plans and strategies necessarily have to be delineated on continental scale. If system boundaries are drawn around the globe instead of the single region, it will be possible to unmask those policies that claim to be sustainable but are actually transferring their costs and negative effects to future generations or external environments (Satterthwaite, 1997).

- ✓ **Requires an integrated approach**

Sustainable development is a process that embodies the "systems thinking" principle. By virtue of this theory, human settlements are viewed as dynamic systems composed of a set of interacting elements (or sub-systems) deeply interwoven in a complex feedback structure. The sustainability paradigm thus sponsors a new way for observing the world, following the belief of Einstein that "we cannot solve the problems that we have created with the same thinking that created them". Figure 1.4 provides a graphical representation of the *classic three ring model* of sustainable development, composed of three main interconnected sub-systems.

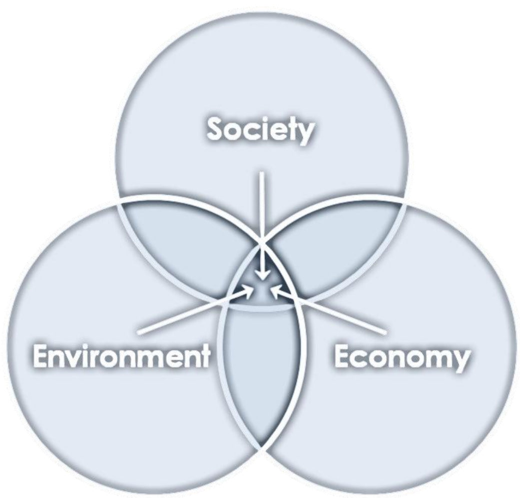


Figure 1.4: The classic three-ring model of sustainable development.
Source: Adapted from Giddings *et al.*, 2002.

- ✓ **Indefinite time frame of action**

If we agree that sustainable development is a process of change aiming at improving the performance of human settlements under various aspects, there is in theory no point of arrival. In other words, sustainabilizing is a project that will go on forever as there are no limits to the improvements that can be made in the performance of human societies. Moreover, sustainable development is the very antithesis of "short-term development", that is a development that ignores the environment and future generations.

- ✓ **A development that embodies moral values**

Sustainable development is often regarded as a rephrased version of the old popular Kenyan proverb *"we do not inherit the earth from our ancestors; we borrow it from our children"* (Pezzoli, 1997). In this reformulation of the concept, the values of collective responsibility, social justice and intergenerational equity clearly stand out as fundamental elements of sustainable development. In fact, in some ways an appropriate synonymous of sustainable development could be "responsible growth". The opening statement by the Secretary-General of the UN, Mr. Kofi Annan, clearly emphasizes the ethical component of sustainable development:

> *"And if there is one word that should be on everyone's lips at this Summit, one concept that embodies everything we hope to achieve here in Johannesburg, it is responsibility. Responsibility for each other, but especially the poor, the vulnerable, and the oppressed, as fellow members of a single human family. Responsibility for our planet, whose bounty is the very basis for human well-being and progress. And most of all, responsibility for the future, for our children, and their children."* (Opening declaration by Mr. Kofi Annan. United Nations, 2002)

Thus, *to sustainabilize* is not only about improving the living standards, environmental and economic performance of human settlements, but it is an action that should be guided by a spirit of collective responsibility and democracy, that propagates the values that people want to live by (Robinson & Tinker, 1997). It is precisely on this moral component of sustainable development that most of the political battles and debates have concentrated (Luke, 2005). Cultural differences between populations and contrasting political ideologies determine various different interpretations regarding the statement of the World Summit on Sustainable development accepted by the all global leaders:

> *"We commit ourselves to building a humane, equitable and caring global society, cognizant of the need for human dignity for all." (United Nations, 2002)*

- ✓ **The recognition of environmental constraints to the growth of societies**

Sustainable development recognizes that the environment poses thresholds to certain human activities. There are natural constraints to the growth of our societies that cannot be neglected in the moment that we start evaluating our actions in the long-term (Bossel, 1999). These limitations mainly refer to the *carrying capacity* of each ecosystem, which determines the maximum level of resource exploitation that can be sustained[1]. One of the fundamental principles of sustainable development is that by no means should human activities exceed the carrying capacity of an ecosystem, and that trade-offs between the economic objectives and the health of the environment should be avoided as much as possible. The imperative of respecting and safeguarding the environment indicates that reducing the use of natural resources, increasing durability and closing resource loops will contribute to sustainability (Expert Group on the Urban Environment, 1996).

- ✓ **Welfare efficiency**

Sustainable development embodies the idea of *welfare efficiency*: increasing the efficiency of economic activities in order to obtain greatest societal benefits. According to the Expert Group of the Urban Environment (1996), putting economic assets to the greatest possible range of social uses and increasing economic and social diversity are the main guidelines for achieving welfare efficiency.

- ✓ **The importance of "Trade-offs" in decision-making processes**

If the essence of sustainable development could be captured in one single word, that would be "trade-offs". The immense level of information that we have gathered during centuries of scientific research and our capacity to rapidly process and store such knowledge have made us understand the complexity of the world we live in. Today more than ever we are aware of the feedback structure that underlies the behavior of our urban and ecological systems. This has brought us to realize the importance of adopting a systems thinking approach for managing our societies. The sustainability paradigm embodies this principle, stating that any action needs to be assessed from an environmental, economic and social perspective. If this action is in line with the objective of sustainable development, it should respect all three dimensions. Consequently, trade-offs and negotiations during policy-making will become an essential ingredient for guiding our societies towards sustainability. Sustainable development may, in fact, be regarded as "a grand compromise" between those who are principally concerned with nature and environment, those who value economic development, and those who are dedicated to improving the human condition (Kates, Parris, & Leiserowitz, 2005).

1.4.3 Giving form to the verb *"to Sustainabilize"*

Building on the key elements of sustainable development, the following working definition of "to sustainabilize" is given:

[1] The *carrying capacity* of an environment is defined as the number of organisms of a given species that can be supported by the region, given its (biomass) productivity and the demands of its organisms (Bossel, 1999).

- ***To Sustainabilize***: 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.

The working definition embodies a series of key concepts (highlighted in bold) that are explained in more detail in the following points:

"… less non-renewable energy sources …"

The process of making a system more sustainable mainly implies reducing its dependency from energy deriving from non-renewable sources. Non-renewable sources are defined as natural resources which cannot be produced, grown, generated, or used on a scale which can sustain their consumption rate. Once depleted[1], for a very long period of time these resources will no longer be available for future needs and generations. Typical examples of non-renewable energy sources are petrol and carbon.

"… self-regeneration (of ecosystem services) …"

Ecosystem services (e.g. drinking water, air, carbon sequestration and climate regulation, waste decomposition and detoxification, etc.) are natural resources essential for supporting the life of biotic organisms. Humans exploit these services also for a multitude of purposes (e.g. economic activities) that go beyond the mere goal of supporting life. To allow the continuation of these fundamental activities, the rate of exploitation of ecosystem services has to be in balance with their rate of self-regeneration. In sum, to sustainabilize a system means to adjust its metabolism in accordance with the carrying capacity of its environment.

"… improving the living standards, environmental well-being and economic performance …"

To sustainabilize considers development as a structural transformation of a system for its overall improvement. The difference between its predecessor term "growth" is that development is a vector composed of a set of variables that attain to the living standards, economy and environment (Pearce, Barbier, & Markandya, 1988). Thus, the

[1] There are contrasting theories regarding the time when non-renewable energy sources (such as petrol and carbon) will be exhausted. Many economists claim that market dynamics will regulate the rate of exploitation of these sources so that they will potentially never end.

objective of "to sustainabilize" is that this vector increases monotonically through time, using renewable energy sources and respecting the carrying capacity of the environment (see Figure 1.5).

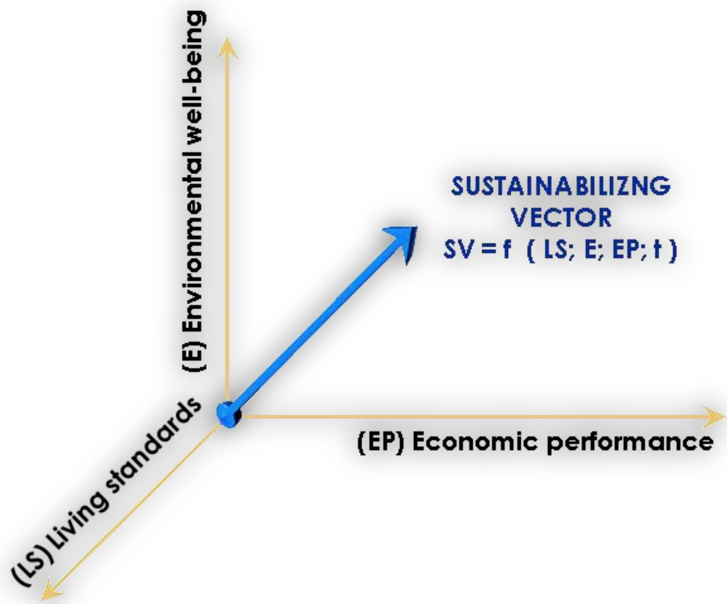


Figure 1.5: The Sustainabilizing Vector.

"… guided by a vision accepted by stakeholders …"

Sustainabilizing a system is a long-term process of change, and for this reason the importance of having a clear vision guiding this transformation is absolutely fundamental. Moreover, it is necessary that this vision is accepted and is defined with the participation of the stakeholders of the system. The need of a shared vision derives from the fact that sustainabilizing looks at both the interactions within the system (i.e. society, economy and environment) and between subsystems, which means that it depends on the cooperation and commitment of many different actors.

"… embody the moral values and principles of good governance of the local community, while being aligned with globally shared objectives …"

Given the ethical dimension of sustainable development, to sustainabilize is an action that needs to be shaped according to the specific moral values and principles of good governance of a community, which are subject to the culture each region. While some of these principles will be shared on global scale, others may vary between different areas of the world. For example, the concept of democracy and thus public participation may be significantly different between Asian and Western countries. Therefore, to sustainabilize is an action that cannot be defined universally. Rather, it needs to be planned according to the specific features of the system undergoing this process of change.

However, sustainabilizing strategies need to remain faithful to globally shared objectives, following the basic principle of "think globally, act locally". Certainly, the differences between developed and developing countries will have to be taken into account when agreeing on the efforts and commitments of each country to certain sustainabilizing policies. For example, policies aimed at reducing carbon emissions need to be implemented by all but according to different obligations and requirements. These need to be negotiated based on the economic and social conditions of the specific country and principles of fairness (e.g. Western countries should keep into consideration that their industrial revolution has occurred almost two centuries ago while developing nations have only recently started their industrial activity). In this sense, international relations are crucial for the success of sustainabilizing policies. Watchdog mechanisms that operate within an international regulatory framework need to be strengthened in order to verify that global leaders are being faithful to the agreements signed at the various World Summits (Adil Khan, 1995), to encourage them to do so and to resolve the "prisoner's dilemma" that local communities are facing in relation to global and national environmental problems (Næs, 2001).

"… integrated approach …"

Sustainabilizing policies need to be designed adopting an integrated approach and systems thinking principle. In other words, the process of sustainabilizing any system requires out-of-the-box thinking and the abandonment of compartmentalized analysis. In more practical terms, a policy that improves one of the three "performance dimensions" but, simultaneously has evident side effects on the other ones or on areas outside the region's boundaries will not be considered a sustainabilizing action. Therefore, a sustainabilizing policy needs to be socially, environmentally and economically sustainable (Adil Khan, 1995) and requires that communities reach beyond their individual interests in future development to account for global (and regional) needs (Berke, 2002).

The process of sustainabilizing any system requires ***out-of-the-box thinking*** *and the abandonment of compartmentalized analysis.*

Conclusions

The overview on the evolution of human settlements presented at the beginning of this chapter has evidenced how mankind has progressively increased its ecological footprint since the Neolithic, when the first agricultural (or energy) revolution took place. In tracing the history of the environmental debate, which derives from major concerns for the capacity of the biosphere to tolerate the growth of human societies, the origin of sustainable development was illustrated. The conclusion reached was that, since its first formulation in 1987, sustainability has turned into a *political cliché* (above all in the richest democracies of the world, where people have the "privilege" of adopting a long-term planning perspective), a common place that sounds like "motherhood and apple pie" and an over recurring term in political discourses. It embraces such a wide spectrum of ethical values that many perceive sustainability as a form of "responsible development". Albeit keeping the concept vague has contributed to its global popularity and acceptance, it is widely acknowledged that the time has come for framing sustainable development in a meaningful paradigm of development.

Following on, the chapter made an attempt to capture the intrinsic reasons that make sustainable development such a complex and disputed concept. According to the research performed, these refer to:

- The multi-faceted nature of the concept;
- The fact that it can be approached with two opposite mindsets (*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 political interests underlying different formulations;
- The lack of consensus on the level of criticality and elements of the problem;
- The physical contradictions and difficulties underlying the goal of achieving a sustainable system.

Successively, the chapter explained why 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).

What this research aspires to is to help tame the problem from the technical perspective by shedding light over the effects that certain plans and policies, in particular Intelligent and Knowledge City Programmes, have in terms of achieving sustainability goals.

To provide a bigger picture of how sustainable development is evolving in the real world, nineteen different organizations (NGOs, Scientific Research Institutes, International Institutes, Private Organizations and National/International Governmental Authorities) were investigated in this chapter (ref. Appendix 2). The results of this research were that:

- NGOs are particularly "fond" of the term sustainability, tending to attribute it to all of their activities, thus testifying the "noble connotation" of the principle. Nonetheless, they are not very precise as per what sustainable development actually means, besides depicting it as something that favors social equity and the well-being of the environment.
- Scientific Research Institutes focus on defining the concept (especially in the form of measurable indicators) and identifying and assessing strategies of implementation. Interestingly, even among scientists there is an intense discussion regarding the methods for measuring sustainable development.
- International Institutes mainly embark in the mission of creating platforms for knowledge exchange, acting as "catalysts of sustainability" by supporting the cooperation between organizations and governments.
- Governmental Authorities are generally very good in placing sustainability as a main goal in their policy agendas, but not as good in designing clear strategies and goals.
- Consultancy companies speak of sustainability in terms of a "competitive advantage" that private organizations and governments need to grasp, emphasizing the business opportunities that come along with the principle of sustainable development.

All the research efforts made in this chapter culminate in the final section, where a working definition of sustainable development was elaborated. The aim was not to provide the best, most complete and appealing formulation of the principle, rather to summarize the main findings in a working definition useful to the following parts of the research. The working definition delineated embraced the key features characterizing the essence of sustainability that were observed throughout the bibliographic research performed:

- Sustainability needs to be thought in terms of a process of societal change rather than an end state to achieve;
- Sustainable development embodies the principle "think globally, act locally", which means that system boundaries must be delineated on global scale;
- Sustainability can only be pursued through an integrated approach, which considers simultaneously the economy, environment and society.
- Sustainable development embodies moral values such as social equity and collective responsibility;

- Sustainable development is a paradigm of development which recognizes that the growth of society has to occur in accordance with the limits set by the environment;
- Sustainable development aims at welfare efficiency
- Sustainable development is a process of change based on the concept of "trade-offs" (policy-making in the optic of sustainability needs to find a balance between economic, environmental and societal interests)

All of the above elements were merged together in the formulation of the following working definition:

- ***To Sustainabilize:*** 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.

Chapter 1 is meaningful to the entire scope of this research as it provided knowledge regarding the denotation of sustainable development, which is fundamental for the following phases of the project. The aim was to formulate a working definition of the concept that will guide the following research activities required for accomplishing the final goal. Moreover, the importance of Chapter 1 is given by the fact that it has acknowledged that, at the present moment, the problem of how to design "sustainabilizing policies" remains wicked: it is both socially and technically un-tamed. While it is very difficult to find agreement in the social dimension of the problem, much can be done for taming the problem from the technical perspective. By shedding light on the effects of certain policies (in the specific case, Intelligent and Knowledge City Programmes) in supporting the transition to sustainable societies, the following parts of this research will contribute to the resolution of the problem from the technical perspective.

Sustainable Cities

Urban systems embracing principles of sustainability

Chapter 2

"You say you want a revolution,
Well, you know,
We all want to change the world."

The Beatles, 1968

Summary

Following on from the knowledge gathered on the concept of sustainable development (ref. Chapter 1), Chapter 2 of this research investigates on the question of how the sustainability ideal is being transposed to urban systems. In order to answer this question, the chapter starts by explaining why cities play such an important role for the achievement of a sustainable world. Successively, the key elements of sustainability (identified in the previous chapter) are transposed to the city, with the intent of defining the ideal sustainable city. This attempt will result with the rejection of a single vision of sustainable urban systems and with the proposal of a new working definition of the concept: *sustainabilizing cities*. The chapter then presents an overview of how urban planning is evolving in order to embrace new challenges and objectives, such as urban sustainability. This overview allows recognizing a new set of elements and features that characterize sustainable urbanization, a new form of urbanism which is gaining momentum since a couple of decades. Finally, the chapter illustrates the strategies and methodology that are being developed in order to implement sustainability within cities. The high level goals of these strategies are also explained. The chapter concludes by presenting a new framework for sustainable urbanization: *the sustainabilizing city cycle*.

Keywords
Sustainability; Sustainable Urbanization; Sustainable Cities; Urban Planning Framework

Goal of Chapter 2

The goal of this chapter is to investigate on how the concept of sustainability is currently being transposed to urban systems, with the finality of developing an image of the ideal Sustainable City. In pursuing this goal, this chapter intends to understand how traditional urban planning paradigms are evolving in order to implement principles of sustainability in the city. In sum, the goal of Chapter 2 is to find an answer to the following questions:

1. How is the principle of sustainability being transposed to urban systems?
2. What are the main features that characterize the ideal "Sustainable City"?
3. How has urban planning evolved in order to embrace the challenges set by sustainable development?
4. What are the main urban strategies for achieving sustainable cities?
5. How can we define Sustainable Cities in the form of a working definition functional to the scope of this project?

2.1 Acknowledging the role of cities as main drivers of sustainability

It is widely acknowledged that urban planning plays a key role in guiding our world towards a more sustainable future (Expert Group on the Urban Environment, 1996). After all, "throughout history cities have always been sources of innovation, places where human creativity has flourished" (Mega, 1996). But in the case of supporting the transition towards more sustainable forms of development, the contribution of urban planning is immense and extremely valuable. This belief is supported by four main arguments:

1. Cities represent the systems within which the three fundamental pillars of sustainable development merge together (Campbell, 1997)
2. Cities are the main producers of waste and consumers of resources (Van Bueren *et al.*, 2012),
3. There are strong beliefs that most cities of the world will grow significantly in the following decades (United Nations' Dep. of Economics and Social Affairs, 2010).
4. Cities are the largest producers of wealth and the systems were economic activities cluster.

Among the reasons that indicate cities as the main drivers of a sustainable (or unsustainable) future, there is one that stands out from all: urban growth. According to the report on world urbanization prospects, developed by United Nations' Department of Economic and Social Affairs (2010), today more than 50% of the total population is urban and this figure is projected to reach 68% by the year 2050. Translated in absolute numbers, this means that in the following 40 years, cities will have to accommodate approximately 3 billion new citizens. Faced with this huge demand for new urbanization, the challenges for sustainability are considerable (Cohen, 2006).

If the scientific community agrees that cities are called to lead the path towards a more sustainable future, even among politicians the belief that new forms of urban planning and management represent the most promising tools for guiding this transformation has gained strength since the past two decades. This last statement is proved by the numerous international conferences and agreements of the last decade, which focused on the relation between urban planning and sustainable development. Their aim was to invite governmental leaders to take urgent action in favor of sustainability and to provide a series of strategies and objectives for guiding them in the process of making cities more sustainable[1].

[1] See, for example, The European Commission Green Paper on the Urban Environment (1990), the Fifth Environmental Action Programme 'Towards Sustainability' (1993), European Sustainable Cities (1994), the UN World Earth Summit at Rio (1992), and Habitat II – Second UN Conference on Human Settlements (1996).

> *"We recognize that, if they are well planned and developed, including through integrated planning and management approaches, cities can promote economically, socially and environmentally sustainable societies."* (United Nations, 2012)

However, even if most governmental leaders of the world have agreed in placing sustainability goals in their urban policy agendas, few have begun to put in place the fiscal and institutional frameworks required for sustainabilizing their cities (Haughton & Hunter, 1994). As D. Satterthwaite suggests, this might be caused by the confusion that still today exists on the concepts of "sustainable cities", "sustainable human settlements" and "sustainable urbanization" (Satterthwaite, 1997). If the answer to the pressuring question of *how can a future of increasing rates of urbanization be reconciled with sustainability objectives?* is, indeed, the "sustainable city", it is essential to delineate the general features of this urban ideal. This will require both scientific research and political negotiations. Only after having succeeded in this task will it be possible to define a new paradigm of urbanization, a conceptual model for spatial planning and management that embodies the principles of sustainability.

> *"They try to become more intelligent, more flexible, more efficient, more urban, more aesthetic and functional: they all want to be the cities of tomorrow."* (Mega, 1996)

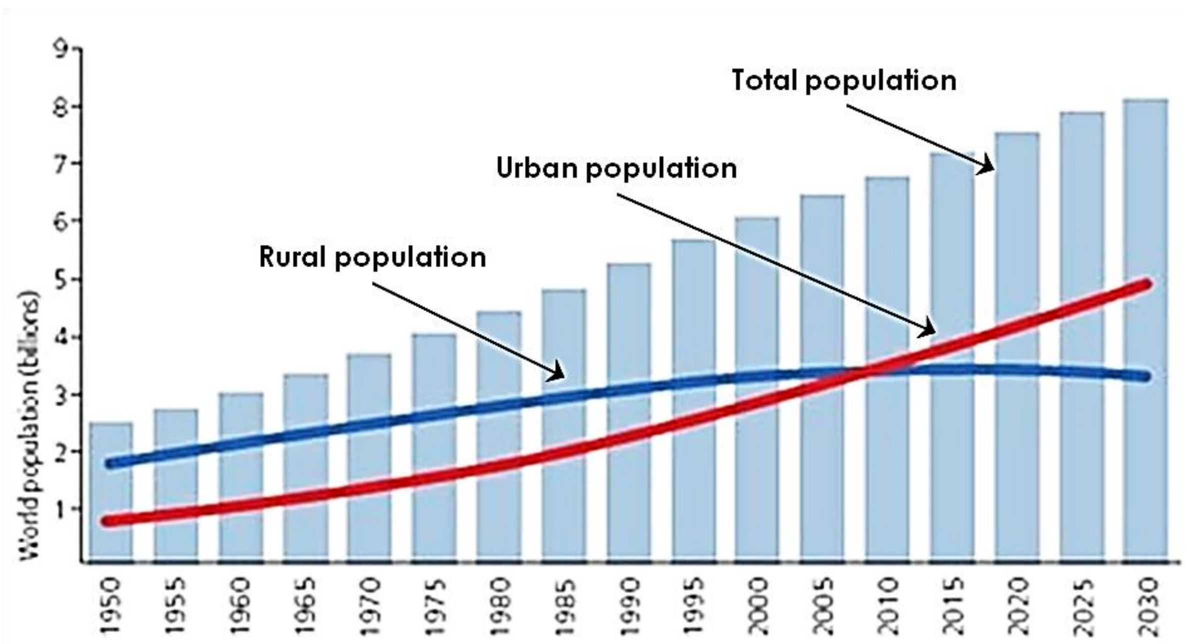


Figure 2.1: World population prospects, 1950-2030.
Source: United Nations' Dep. of Economics and Social Affairs, 2010.

2.2 Sustainable Cities: simple transposition of the sustainability ideal to urban systems?

From sustainable development to Sustainable Cities: how has the vague and highly disputed concept of sustainability been transposed to cities? Considering the fact that cities are large systems, characterized by complex feedback structures, dependent on the local cultural and geographical characteristics of their region and embodying a wide range of different actors, the process of defining the Sustainable City ideal inherently presents many obstacles. But in order to implement sustainability in our societies, it is necessary to work with a vision of what the Sustainable City aspires to. For developing such vision, it is important to have a list of features that together compose the urban ideal.

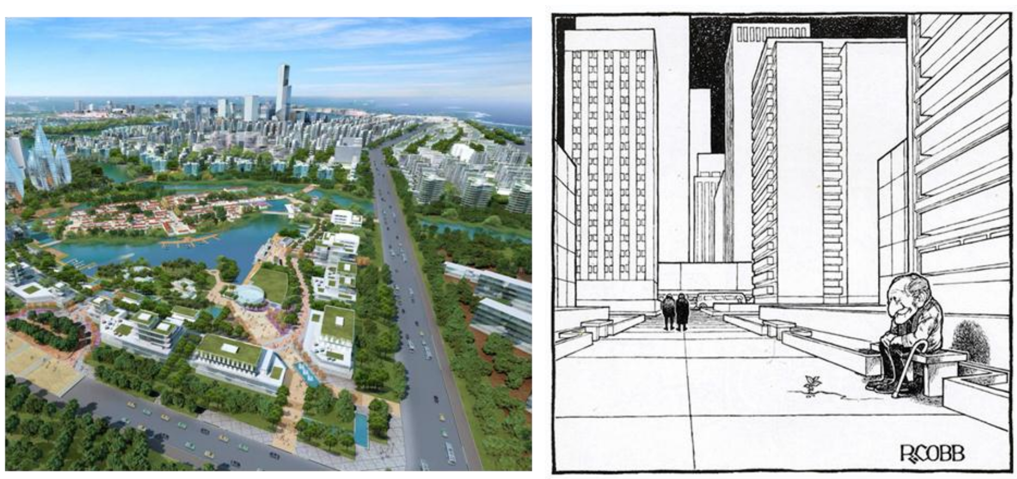


Figure 2.2: Images of Sustainable and Unsustainable Cities?
Source: http://www.urenio.org and Ron Cobb.

"Drawing on the unfulfilled dreams of the ancient Greek city-states, the shining example of the medieval Italian hill towns, and the many uncompleted projects in urban thought and literary imagination, the sustainable city presents itself as the top priority on the new agenda of the dawning millennium" (Yanarella & Levine, 1992). Despite the growing success of this urban ideal, more than twenty years after it was first formulated there is still confusion as per what the sustainable city should look like, not to mention how it can be achieved (Alusi, Eccles, Edmondson & Zuzul, 2011).

The first formal attempt for giving rigueur to the idea of Sustainable Cities was made at the *Second United Nations Conference on Human Settlements* (Habitat II) held in Istanbul in 1996 (UN Centre for Human Settlements, 2000). Since then, several UN conferences were organized for further articulating the concept of Sustainable Cities and for defining the guidelines for sustainable urbanization. Probably the most significant attempt made in this direction is represented by the *Sustainable City Conference* (Rio de Janeiro, 2000).

At the International conference, which brought together different academics, professionals and practitioners from a wide range of disciplines to exchange ideas and identify best practices for a viable urban environment, the concept of sustainability was applied to urban systems in the following way:

> "*(…) the ability of the urban area and its region to continue to function at levels of quality of life desired by the community without restricting the options available to the present and future generations and causing adverse impacts inside and outside the urban boundary*." (Brebbia, Ferrante, Rodriguez, & Terra, 2000)

The above definition of Sustainable Cities is subject to the same problems and criticisms faced by the concept of sustainable development: it is vague, too broad and generalist. Consequently, the physical and functional features of the Sustainable City are many and widely debated (Guy & Marvin, 1999). A single vision regarding the physical asset of Sustainable Cities does not exist, mainly as the consequence of the fact that urban development occurs within a complex multi-actor context. The different interests, values and objectives possessed by the actors involved in urban development activities make sustainable urban development a multi-faceted concept. Stakeholders in urban planning are numerous and highly fragmented and for this reason it is important to prioritize "sustainability criteria" (Wallbaum, Krnak, & Teloh, 2011). Moreover, the geographical and cultural characteristics of cities are so variable that the goal of defining a universal vision of the sustainable city becomes impossible to achieve. Consequently, when trying to define urban visions of a sustainable city, it is recommendable to initially develop a conceptual framework for guiding the process of urban transformation and later proceeding with an *ad hoc* analysis of the specific case.

> "*We recognize the important role of municipal governments in setting a vision for Sustainable Cities, from the initiation of city planning through to revitalization of older cities and neighbourhoods (…)*" (United Nations, 2012)

2.2.1 Identifying the main features of the Sustainable City

Among the diverging "urban visions" that exist, the bibliographic research performed suggests that there are some general features of the Sustainable City on which consensus has been reached. Similarly to what has been done in the previous chapter, in this section these characterizing elements are discussed and summarized.

- ✓ **Sustainable urban metabolism, designed to function on own carrying capacity**

The ideal sustainable city is an urban system designed to exist, in principle, without exceeding the limits imposed by the carrying capacity of its environment (Stren, White, & Whitney, 1992). In other words, it should possess a sustainable urban metabolism, a system that supports the functioning of the city while tuning the input (materials, energy and labor) and output flows (waste, products and services) with the region's capacity (Mega & Pedersen, 1998). This implies exploiting resources at a rate which is inferior or equal to the one of re-generation and reducing the quantity of waste produced and disposed. As P. H. Brunner points out, many cities are still far from achieving this goal, acting as linear reactors heavily dependent on their hinterlands for both supply of resources and disposal of waste (Brunner, 2007). P. R. Berke arrived to a similar conclusion, stating that the Sustainable City embodies the principle of "system reproduction": its rate of change must be sustained over time without exceeding the innate ability of the surroundings to support the process, including the ability to absorb the impacts of such process" (Berke, 2002).

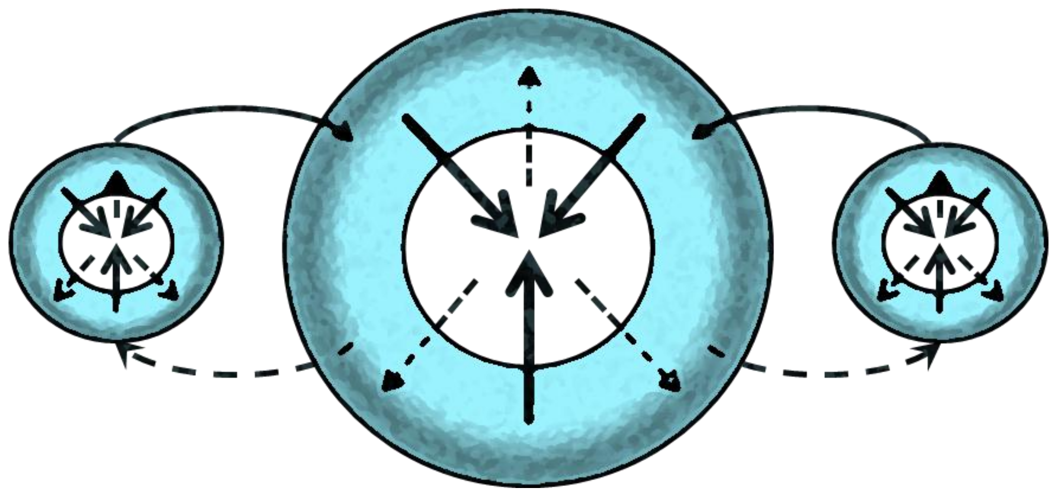


Figure 2.3: System reproduction of an Unsustainable City. Dashed arrows represent waste expelled from the city, while continuous arrows represent appropriation of the environment's carrying capacity. The central city expands and lives to the expense of other urban systems.
Source: Adapted from Stren, White, & Whitney, 1992.

- ✓ **Compactness and mixed land uses as favored patterns of urbanization**

Despite the lack of consensus on the performance of different urban forms in terms of their contribution to sustainability (Jabareen, 2006), it is widely acknowledged that certain patterns of urbanization, such as urban sprawl, negatively affect the performance of cities under various perspectives (Gargiulo Morelli & Salvati, 2011; Moles, Foley, Morrissey, & O'Regan, 2008). Consequently, it is generally agreed that the ideal Sustainable City is characterized by urban compactness combined with diversity and mixed land uses (Jabareen, 2006; Department of Foresight and Planning and International Affairs, 2007; Rogers, 1997; United Nations, 2012).

- ✓ **Embedded in a global network of exchange and competition**

Following on from the previous point on the carrying capacity of cities, the Sustainable City is aware of being part of a global network in which resources, as well as problems, are exchanged. Translated into practical terminology, this means that Sustainable Cities need to be competitive (they battle for natural, human and financial capital) and at the same time responsible for the consequences of their actions on the planet. In other words, they have to act as global city regions (Scott, 2001), linking local to global concerns.

> *"We recognize the diversification of actors and stakeholders engaged in the pursuit of sustainable development. In this context, we affirm the continued need for the full and effective participation of all countries, in particular developing countries, in global decision-making."* (United Nations, 2012)

✓ **Seeking the balance between three typologies of cities: the green city, the growing city and the just city**

According to S. Campbell, the ideal Sustainable City arises from the equilibrium from three competing typologies of cities (Campbell, 1997). The first one is the Green City, the city that grows in symbiosis with its natural environment, reducing its ecological footprint and subduing plans of expansion to the safeguard of the ecosystem. The second one is the Growing City, the city that gives priority to the overall growth and efficiency of its economy. The final one is the Just City, the city that sponsors social justice and cohesion, economic opportunities and equality amongst its citizens. Thus, the Sustainable City can be seen as the one that achieves a stable and long lasting equilibrium between the conflicting interests of these three urban models (Campbell, 1997).

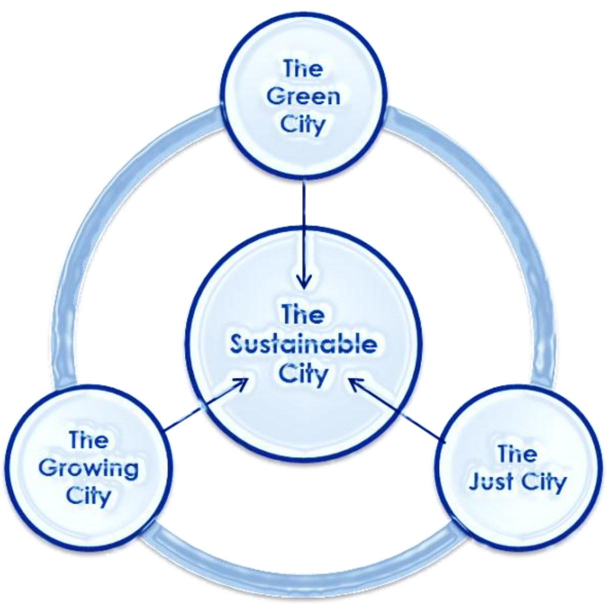


Figure 2.4: The Sustainable City as the equilibrium between the Green, Growing and Just Cities. Source: Adapted from Campbell, 1997.

✓ **Responsiveness to change**

The sustainable city is responsive to change. Said differently, it has the ability of promptly adapting to the state of its environment, to the needs of its citizens and to the economic context. In this sense, the sustainable city embodies one of the key elements of sustainability discussed in the previous paragraph: fitness.

Box 2.1: Is the Sustainable City an oxymoron?

R. Stren *et al*. argue that developed countries have created over the years cities which are fundamentally unsustainable, as they have expanded to the expense of the carrying capacity of the developing regions of the world, the ex-colonies of the Western empires (see Figure 2.3). For these cities to become sustainable, they have to re-shape their entire metabolism so that it can survive with the resources and limits of their own carrying capacity. This implies, for example, to develop a place-based economy instead of activities not compatible with local characteristics. But precisely for this reason, many scholars claim that the Sustainable City comes through as a pure oxymoron: cities are inherently unsustainable as they cannot survive in isolation and rely on a symbiotic relationship with their hinterland (regional, national or global scale). It is thus impossible to avoid that cities make substantial demand on resources and have effects on the natural environment. In response to such criticisms, Stren *et al.* suggest that is not the total elimination of such demands and effects that makes a city sustainable, rather *the definition and maintenance of acceptable limits* (Stren, White, & Whitney, 1992).

- ✓ **Engagement of citizens and main stakeholders in the definition of objectives and strategies for urban sustainability**

A typical feature of the Sustainable City, that has not to do with its physical form, is the engagement of citizens to the political and social life of the city. If the sustainable city is, indeed, pursuing to satisfy the "quality of life desired by the community", it has to be able to communicate with citizens in order to understand their needs, problems and desires. Thus, the ideal Sustainable City incentives public participation in decision-making processes over urban projects, and commits to the task of keeping citizens informed and up to date with events and issues taking place in the community, incentivizing social cohesion (Friedmann, 2007; UN Centre for Human Settlements, 2000). It should be evidenced, however, that the conflicts between the different stakeholders involved in urban planning arise precisely from this issue. For example, the "quality of life" within a city is an actor specific attribute that cannot be entirely generalized. For this reason, it is recommendable that stakeholders of the system engage in an open discussion to agree and to prioritize sustainability criteria and objectives (Wallbaum *et al*., 2011). Furthermore, the engagement of citizens is a necessary requisite for achieving a change in the life styles of urban citizens so that these result "less unsustainable". Their participation is absolutely crucial for a city to approach the state of sustainability. Thus, the ideal Sustainable City is constantly promoting actions that are in line with the principles of sustainable development, such as waste recycling, lower energy and resource consumption levels, the use of mass transportations systems, etc.

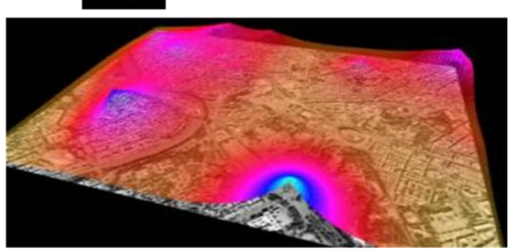
> *"We further acknowledge efforts and progress made at the local and subnational levels, and recognize the important role that such authorities and communities can play in implementing sustainable development, including by engaging citizens and stakeholders and providing them with relevant information, as appropriate, on the three dimensions of sustainable development. We further acknowledge the importance of involving all relevant decision makers in the planning and implementation of sustainable development policies."* (United Nations, 2012)

- ✓ **Pursue of development objectives over growth and expansion**

Sustainable cities act as "nodal points in the transformation from quantitative change into qualitative change" (Yanarella & Levine, 1992). These types of cities give priority to initiatives that focus on improving the existing built environment, limiting investments in expanding their boundaries unless strictly required by an increasing urban population. This means that sustainable cities should, in theory, reject urban sprawl by all means and strive for compactness and improved efficiency.

Box 2.2: Example of "urban fitness"

A practical example illustrating the concept of "fit city" is provided by the project carried out by the MIT *senseable city lab.*, in collaboration with Accenture, to improve the transport system of Singapore. In essence, the project consisted in evaluating how the implementation of digital technologies in the city's structure could support a more efficient and responsive management of the urban system.



Picture of the digital masterplan Developed by the MIT research group.
Source: http://senseable.mit.edu/

The MIT research group was in charge of creating a digital masterplan that would integrate data deriving from various sources (e.g. Taxi GPS, smart phones and weather forecast data) in order to calculate the most efficient distribution of Taxis on the city's territory during critical moments (e.g. during times of heavy rainfall and rush hours).

2.2.2 Sustainable or *Sustainabilizing Cities*?

The main features of the ideal sustainable city point out to a series of considerations on the nature of the concept. To begin with, most of these features, for practical or conceptual reasons, do not contemplate an end state or final outcome. For example, the self-reliant city is, in practice, an impossible objective to achieve for cities of the Western world. These have grown over the years to the expense of the carrying capacity of their colonies or other regions of the world (Stren, White, & Whitney, 1992), developing an urban metabolism which is far from being self-reliant and at this stage very difficult to render completely sustainable. Turning to the conceptual reasons, some of these features simply cannot be associated to a final outcome as there is potentially always margin of improvement. There are, for example, no limits to the responsiveness of cities to change, to the engagement of citizens, to their ability to compete on regional and global scale or reach a perfect balance between economic, social and environmental objectives. Moreover, as already evidenced in the previous sections, there is no single vision as per how the sustainable city should be and most of these features adopt diverse forms and meanings according to the different stakeholders of the urban system.

> *"The sustainable city is about creativity and change. It challenges traditional government responses and seeks new institutional and organizing capacities and relationships." (Expert Group on the Urban Environment, 1996).*

The result of these observations seems to be that, likewise with the principle of sustainable development, pursuing a universal definition of the Sustainable City is not a useful strategy to follow. The ideal can reveal useful in providing an overreaching framework to dramatically shift the practice "from dominance by narrow interests towards a more holistic and inclusive view" (Berke, 2002), but it should not become the focal point of research efforts, avoiding that a single vision of the Sustainable City might "blind policy approaches to alternative logics of environmental innovation" (Guy & Marvin, 1999). Multiple visions and pathways towards the Sustainable City should be favored over the implementation of a single urban model.

> *"In order to make sustainable communities, radical changes will have to take place within our cities and it is vital to provide a vision so that people may engage themselves"* (Commission of the European Communities, 2007).

To conclude this investigation on the Sustainable City ideal, I would like to propose a working definition with the objective, once again, of providing a conceptual framework that will support the following parts of this research. Likewise to the approach adopted for defining a working definition for sustainable development, the idea of focusing on the dynamic nature of the concept rather than its ultimate state was privileged. Therefore, this research will speak of "*sustainabilizing*" rather than *sustainable cities*.

By transposing the definition of the verb "to sustainabilize" (ref. Chapter 1) to the city, and by including the main features and elements that characterize the sustainable city ideal, the following conceptual framework was formulated:

- ***The Sustainabilizing City***: The city that, in line with an urban vision accepted by stakeholders, invests in policies and urban projects that sustainabilize its urban metabolism while seeking social, economic and environmental sustainability. Sustainabilizing urban systems implies **making their urban metabolism circular**, **less dependent on non-renewable energy sources** and **respectful of the carrying capacity** of its region; finding an **equilibrium between the pursue of economic, environmental and social objectives**; improving the overall performance of the city by rendering it more **responsive, fit, attractive and competitive**: prioritizing **development goals** over unjustified urban expansion; and **involving citizens** in urban planning decision-making processes and achievement of sustainability goals.

The main elements of the working definition are evidenced in bold and refer to the features of the Sustainable City illustrated in the previous section. Furthermore, they are mostly in line with ones that characterize the definition of the verb "to sustainabilize". But probably the most important aspect of the definition that needs to be stressed is the fact that sustainabilizing cities are transforming systems that follow an urban vision. This vision must be developed through open discussions with the stakeholders of the system, as they are the ones that give meaning to several aspects of sustainable development (e.g. quality of life).

It should be also underlined that a sustainabilizing city should never neglect that its citizens have to appreciate life within it. Achieving total self-reliance, very compact and efficient urban environments and a completely sustainable urban metabolism is pointless if the inhabitants of the city are not satisfied with the quality of life. For this reason local governments, which are "generally bad and unimaginative in telling the story of their development" (European Foundation for the Improvement of Living and Working Conditions, 2012), need to be very careful in defining a clear and shared urban vision.

> *"No doubt it is the culture of 'maxima', the current dominant culture of the world, which has been posing the maximum threat to the prospects of sustainable development. (…) unless we do something drastic and immediate to curb our consumption behavior, no amount of methodological and/or technological innovations will ever enable us to achieve the goals of sustainable development"* (Holden, Roseland, Ferguson, & Perl, 2009)

Placing "negotiated urban visions" as guiding principles for sustainabilizing cities could determine significant obstacles to several sustainability goals. For example, if the predominant culture of a city's population favors urban sprawl, zoning and private transport, then implementing principles of sustainability such as reduced energy consumptions and self-reliant urban metabolisms will inherently find many resistances. As M. Holden *et al.* argue, it is the culture of consumerism that poses the greatest threat to the process of sustainabilizing our (and especially the Western) world (Holden, Roseland, Ferguson, & Perl, 2009). The passage from "ego-citizens" to "eco-citizens" will certainly require time and educational efforts (Mega, 1996), but it represents a key step for the achievement of a truly sustainable world.

> *"The passage from ego-citizens to eco-citizens will certainly need a lot of mobilization and education"* (Mega, 1996).

2.3 A new framework for sustainable urbanization

At the beginning of this chapter, the advantages of considering the structure and functioning of cities as the pivot of a sustainable (or unsustainable) future were discussed. The consequences of this belief are that urban planning, being the tool for managing human settlements, needs to be re-framed in light of the "sustainabilizing city" ideal. This requires a radical shift in the approach of traditional urban planning, which cannot be obtained by simply changing its name to "sustainable urban development", planting trees and curbside recycling. Sustainable urbanization implies "an holistic approach to the reconstructing of our global society, including international relations" (Stren, White, & Whitney, 1992).

2.3.1 The evolution of traditional urban planning

Up to the 1960s, urban planning was mainly a static and isolated discipline (Berke, 2002). The classic spatial planning paradigm interpreted the city as a quasi-immobile and compartmentalized entity, mostly relying on master plans as the main tool for planning the expansion and functioning of human settlements. These tools were extremely static, difficult to update and hard to connect with other more detailed plans of the city. For this reason, decision-making in urban matters mainly followed the *incrementalism model* (Lindblom, 1959), being incapable of taking rapid and radical decisions and fundamentally problematic regarding irreversible interferences with nature[1].

After the 1960s, the traditional planning paradigm was facing major difficulties in coping with the speed at which human settlements were evolving (Berke, 2002). Impressive urban growth rates coupled with major societal transformations and increasing globalization radically changed the entire concept of cities (Scott, 2001). In those years, the multiple crises that struck cities and their metropolitan areas urged for a change in the approach used for planning urban systems.

> *"Cities have to start acting lie corporations… service as a core business is dead, it is now a requirement to be playing in the premier leagues, people expect top-class service everywhere and now sustainability will be expected to be in place… cities have to be looking for competitive advantages everywhere… cities have to find, improve, define their competitive position by creating their own brand… you have to bring attention, talent and money to your city by creating a corporate identity – a city brand that burns." (Quoted in* Hern, 2006)

[1] For example, land sealing for the construction of new urban structures (i.e. transport infrastructure and buildings) has an irreversible impact on certain the properties of the soil, like permeability (Munafó, Norero, Sabbi, & Salvati, 2010).

In this context, the rational planning paradigm affirmed itself in various regions of the world (Berke, 2002). The paradigm was goal oriented and systematic, adopting a decision-making structure composed of four main steps: (i) define goals; (ii) specify goals in the form of measurable objectives; (iii) collect information to evaluate all possible alternatives; and (iv) select alternative (or combination of alternatives) that maximizes the achievement of goals at minimal costs. But this approach to planning was soon challenged by the need to introduce democratic principles and public participation, which stemmed from the civil rights movement of the 1970s. Thus, in those years, a shift from "dehumanized to advocacy planning" took place (Næs, 2001), changing once again the entire decision-making structure.

"Sustainable urban development means the continuing maintenance, adaptation, renewal and development of a city's physical structure and systems and its economic base in such a way as to enable it to provide a satisfactory human environment with minimal demands on resources and minima adverse effects on the natural environment" (Maclaren, 1992)

2.3.2 Elements of the sustainable urban development paradigm

Today, new urbanism faces a whole set of fresh challenges deriving from different issues and conditions. Above all, the greatest challenge is the one of having to adopt the "sustainabilizing principle" as the main guideline for planning cities. Thus, the new paradigm will have to:

- involve citizens and main urban stakeholders in the decision-making process;
- be guided by a vision of the sustainable city defined through stakeholder negotiations;
- adopt an integrated and holistic approach, looking simultaneously at the economy, the environment, and the society;
- transcend disciplines and knowledge boundaries, opting for a more out-of-the-box thinking and multidisciplinary approach;
- become more dynamic, responsive and able to process and combine live data deriving from different urban sectors

The elements of the new planning paradigm call for a switch towards innovative approaches able to capture the holistic principle needed for sustainabilizing systems. This approach has been defined by several academicians as "the ecosystem approach" (Van Bueren, van Bohemen, & Visscher, 2012). In essence, the approach consists of decomposing complex systems (i.e. cities) in different sub-systems (i.e. urban sectors) and analyzing them without losing sight of the bigger picture. The advantage of this methodology is that it allows analyzing complex systems without neglecting the feedback structure connecting together their different elements. Moreover, it adopts basic ecological principles by focusing planning and policy-making activities on the carrying capacity and resilience[1] of the city's ecosystem. This last aspect is the one that differentiates the approach from the "metabolism approach" which only focuses on modeling the entire urban system in terms of stocks (i.e. the built environment) and flows of energy and resources required for maintaining it. The disadvantages mainly rely in the sensitivity of the approach to the delineation of system boundaries. In fact, "different system demarcations may lead to different problem diagnosis calling for different solutions" (van Bueren, Klijn, & Koppenjan, 2003)

Thus, sustainable urban development calls for a new set of instruments to be used within a new planning framework which embodies sustainability objectives. Moreover, it requires urban planners to take the role of mediators, managing the conflicting interests of different stakeholders within a new decision-making process (Campbell, 1997). This will not be an easy task to accomplish, given the complexity and non-linearity that characterize the design and selection of urban projects, which is both a "dynamic art and process" (Cooper, Evans, & Boyko, 2009).

[1] The resilience of a system its capacity to absorb disturbance and reorganize while undergoing change so as to still retain essentially the same function, structure, identity, and feedbacks (Walker, 2004)

2.4 Strategies for sustainabilizing cities

Despite the ongoing discussions between urban planners regarding the strategies needed for implementing sustainable development (Campbell, 1997), there seems to be some consensus on certain guidelines that planning for sustainability should embody. These guiding principles, which are discussed in the following paragraphs, mainly refer to the planning procedure and high level objectives pursued by sustainabilizing cities.

2.4.1 The concept of *ad hoc sustainabilizing best practices*

The fact that there are contrasting images of Sustainable Cities is probably the main reason for the ongoing dispute regarding best-practices for making urban systems more sustainable. This is because the notion of best-practices is "simply too narrow and static to capture the multiple perspectives on sustainable cities" (Guy & Marvin, 1999). Furthermore, reaching consensus over a list of recommendable strategies is made even more complicated by the fact that each policy needs to be designed and selected based on an *ad hoc* analysis of the territory.

> *"European towns and cities are all different, but they face similar challenges and are trying to find common solutions"* (Commission of the European Communities, 2007).

Even within the same continent, the diverse cultural and physical features of each region, not to mention the different socio-political conditions, lead to the conclusion that "there is no single policy that can be equally applied to all European cities" (Expert Group on the Urban Environment, 1996). Consequently, sustainable urban development strategies cannot be imposed using the traditional top-down approach, but require each local community to come up with a set of policies that are compatible with the characteristics of their territory. The idea that sustainable urbanization should follow a bottom-up approach is in line with in the *principle of subsidiarity*, formalized with the Maastricht treaty (2002), which states that matters ought to be handled by the smallest, lowest or least centralized competent authority.

But the fact that a general set of strategies for sustainabilizing cities is not conceivable does not mean that governmental authorities and private organizations need to operate autonomously. On the contrary, various global communication platforms (e.g. the European Sustainable Cities and Town Campaign) have been created for allowing governments to share their experience in this relatively new field of sustainable urbanization, and for speeding up their learning process. Moreover, another fundamental aim of these knowledge exchange channels is to provide governments with general policy guidelines for urban sustainability (United Nations, 2012).

The idea of *ad hoc sustainabilizing best practices* thus points out to the need of implementing policy guidelines according to the specific characteristics of the region. The general ad hoc procedure should comprise the five steps presented in Figure 2.5 (please note that even if presented as a linear procedure, various iterations are likely to take place between each step) and requires the planning department of the municipality to collaborate with the main stakeholders of the city and its citizens.

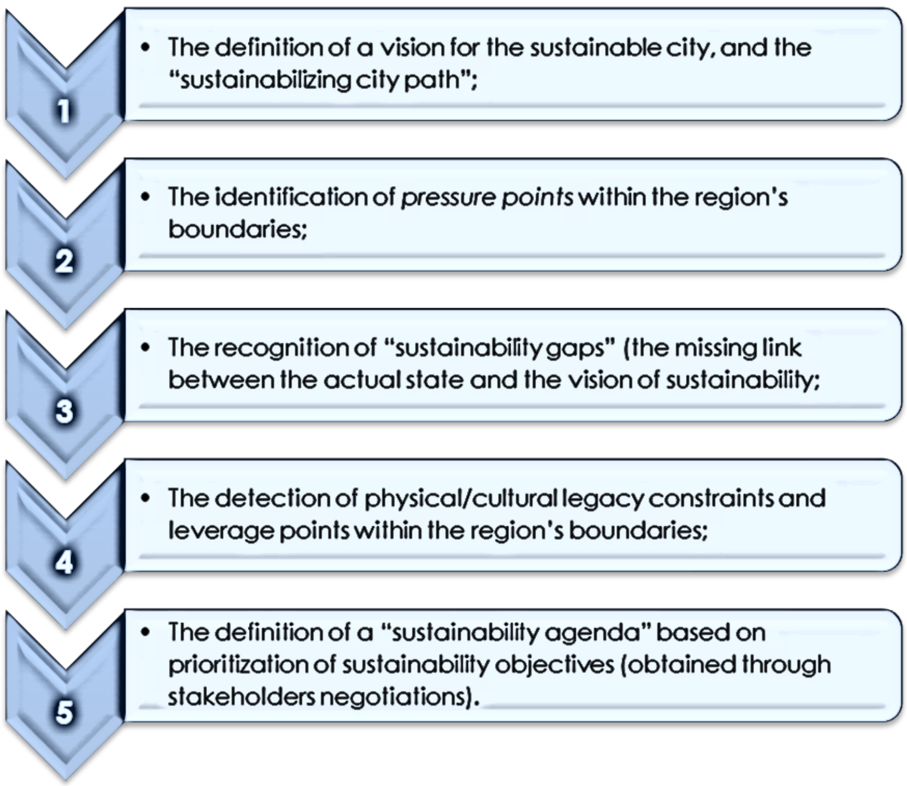


Figure 2.5: Steps for designing sustainabilizing policies[1].

The fourth point, due to its relevance, requires further explanation. It is acknowledged that the structure and metabolism of mature urban systems are the result of centuries of growth and transformations. Their territories reflect long development paths shaped by incremental decision-making processes[2], while their societies embody a whole world of traditions and cultures. These physical and cultural features represent the "legacy constraints" of the region, intrinsic characteristics of the territory that strongly limit the efficacy and applicability of certain strategies. For this reason, D. Satterthwaite argues that developing countries have an advantage in the race towards a sustainable future, as their relatively young infrastructure allows them to take radical decisions, outpacing

[1] According to Stren *et al.* (1992), pressure points of large and medium urban centers are: job opportunities, food, water, energy, education, transportation, recreation, health, environment, crime and housing.

[2] Due to the large investments, level of risk and uncertainties associated to many urban projects, decision-making processes in urban planning generally follow the "incrementalism model" (Lindblom, 1959). For this reason, many System Dynamics models have been developed to explore the effect of different solutions in terms of achieving urban sustainability (see, for example, Shen *et al.*, 2009).

richer countries that have to deal with large past investments (Satterthwaite, 1997). On the other hand, they also represent leverage points that urban policy-makers should exploit. For these two reasons, when designing and selecting sustainabilizing policies, the recognition of physical and cultural constraints (or possibilities) is essential.

2.4.2 High-level goals within a new policy-making framework

Albeit the lack of a single vision of the ideal Sustainable City and ongoing debates regarding the strategies through which human settlements can meet requirements of sustainability (Jabareen, 2006), the research performed has revealed the existence of six high-level goals for sustainabilizing cities (see Figure 2.6):

1. Reducing the consumption rate of natural resources to the level that equals their rate of self-regeneration;
2. Achieve a circular urban metabolism that reduces the quantity of waste disposed;
3. Reducing the consumption of non-renewable energy sources;
4. Reducing the environmental impact of the targeted urban sector;
5. Improving the economic performance of the city (e.g. competitiveness and ability of attracting human and financial capital)
6. Improving the living standards of citizens

> *"Urban planning for sustainability is clearly not as straightforward as simply making decisions that might lead to the reduction of material and energy throughput"* (Sustainable Urban Metabolism for Europe project, 2009)

Sustainable urban development can achieve these overall goals through a wide range of alternatives. Some are more practical and concrete (e.g. the adoption of smart building solutions) while other are more theoretical and target the decision-making process for selecting urban projects. An example of the latter is provided by R. Cooper *et al.*, who suggest including a "project sustainability group" in charge of controlling that sustainability issues are addressed holistically in the various decision-making phases by the traditional "project development team" (Cooper, Evans, & Boyko, 2009).

Unfortunately, simply contributing to the achievement of one of these six high level objectives does not necessarily mean that the strategies implemented are actually sustainabilizing cities. For example, S. Campbell argues that achieving higher energy efficiency in different urban sectors is useless, from a sustainability perspective, if per capita consumption levels grow (Campbell, 1997). Consequently, increasing the efficiency of a targeted urban sector needs to be combined with the participation of stakeholders and citizens, and with an evaluation of the environmental impact of the alternative. Similarly, converting central and peripheral urban districts to green areas, with the objective of lowering the ecological footprint of cities, might probably lead to higher energy and resource consumption levels due to urban sprawl dynamics (Gargiulo Morelli & Salvati, 2011). In this sense, fundamental values of the "green city model" are not aligned with sustainability goals, "but rather landscape-esthetical and architectural ideals, coupled with an ideology of decentralization" (Næs, 2001).

To sum up, high level goals need to be considered simultaneously and as part of single frame of action. This idea of interconnected goals (illustrated in Figure 2.6) embodies one of the main principles of to sustainabilize, which is the need to adopt an integrated approach for policy-making.

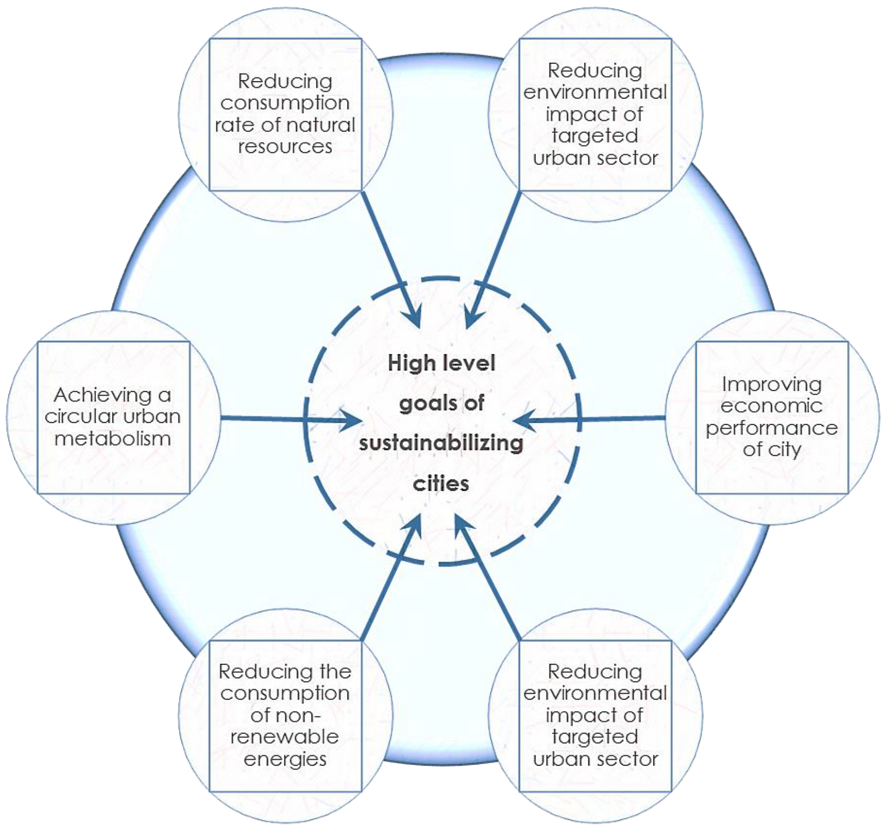


Figure 2.6: The interconnected high-level goals for sustainabilizing cities.

As a final remark, it should be noted that the strategies for implementing these six high level goals depend on the level of maturity of the urban system. In fact, cities of more developed countries with a consolidated urban structure will mainly focus on modifying and upgrading existing infrastructure for achieving a sustainable urban metabolism. On the other hand, emerging cities have the possibility of implementing these high level goals right from the beginning, having the possibility to outpace Western societies in the achievement of sustainable human settlements. Therefore, it is necessary to assess the state of the city's existing infrastructure before starting to design strategies for urban sustainability (Satterthwaite, 1997).

Table 2.1: A sample of strategies for sustainabilizing cities.

Strategy	Urban sector	Specific objectives
Smart Buildings	Building	Improve lighting, heating and overall design of buildings
Smart grids	Energy	Optimize energy production and reduce losses during transmission and distribution
Progressive energy tariffs	Energy	Penalize profligate users and reduce peaks in energy demand
Car sharing, mass transit transport systems and traffic limited zones	Transport	Discourage the use of private transportation for reducing congestion
Bicycle sharing and dense networks of priority lanes	Transport	Incentivize the use of bicycles and other eco-friendly means of transportation
Waste taxes and incentives for waste differentiation	Waste	Encourage the use of recyclable materials and reduce the flows of disposed waste
Fiscal incentives for green businesses and polluter pays principle	Business	Promote socially and environmentally responsible businesses activities
Integrated digital masterplans	Urban management	Improve urban management practices through the integrations of different urban data a faster/better D-M processes
Public participation in decision-making processes	Urban management	Engage citizens' participation in the design and selection of urban projects
Contrasting urban sprawl	Buildings, Energy, Transport	Contrast urban sprawl dynamics for avoiding increases in resource and energy consumption
Adoption of Strategic Environmental Assessment and other D-M tools	Urban management	Adopt tools in D-M processes that oblige projects to be evaluated under a system perspective
Infrastructure Analytics	Transport, Building, Energy, Waste	Identify inefficiencies in urban infrastructure and collect data for infrastructure use optimization
Promote local culture and regional identity	Urban management	Incentivize a place-based economy and celebrate uniqueness of each place
ICT and Interactive eServices	Urban management	Deliver on time information to citizens and stimulate public participation

Sources: van Bueren *et al.*, 2012; European Foundation for the Improvement of Living and Working Conditions, 2012; Accenture Sustainability Services, 2012; and Næs, 2001.

2.4.3 A framework for sustainable urbanization: the *sustainabilizing city cycle*

> *"The pursuit of sustainability does not mean stasis but development paradigm shift."* (Holden, 2009)

The knowledge gathered throughout the performed research on sustainability (ref. Chapter 1) and sustainable urban development culminates in the design of a conceptual framework for planning sustainabilizing cities. This pragmatic policy-making methodology is presented in the diagram provided at the end of this section and was named *the sustainabilizing city cycle*. It is an iterative process composed of 10 main activities which arise from the combination of the classic policy cycle (e.g. problem definition, agenda setting, policy development, implementation and policy evaluation) and the concept of to sustainabilize. The activities are explained in the following paragraphs. Some of the activities are colored in red in the diagram in order to highlight where public participation and stakeholders' negotiations will be crucial.

1. Definition of a sustainable city vision

The first step of the proposed methodology consists in defining a clear vision of the city's ideal sustainable urban environment (Rotmans *et al.*, 2000; Phdungslip, 2011). Because commitment by all actors of the urban system is crucial, this activity requires public participation and stakeholders' involvement (Wallbaum, Krnak & Teloh, 2011). During the negotiation phase, urban planners will have to act as mediators, attempting to reconcile or balance economic, social and environmental interests. Furthermore, in leading the process, they should systematically introduce the main features of the sustainabilizing city illustrated, crystallizing key principles of sustainability in the defined urban vision and assuring commitment to the six high level goals of sustainabilizing cities. Also, planners have the responsibility of including in the process the objectives established by international agreements.

2. Agreement on an "urban sustainability auditing" tool

Following from the defined vision of the sustainable city, stakeholders need to engage in negotiations over the selection of urban sustainability indicators. Therefore, this phase should deliver an "urban sustainability auditing" tool, containing indicators pertaining to all three dimensions of sustainable development (i.e. economy, environment and society), that all actors agree on (this research will provide a proposal of such tool in the next chapter). These indicators will define the variables of the *sustainabilizing vector,* which will be used for assessing the progress of cities towards a more sustainable state.

3. Transposition of the urban vision to the real system

The third step considers the overlapping of the two layers: the urban vision and actual system. The overlap should proceed in line with the ecosystem approach, which means that each urban sectors needs to be studied individually, but without losing sight of the bigger picture of the city (van Bueren *et al.,* 2012).

4. Identification of "sustainability gaps"

In the fourth step of the design process, urban planners are called to identify the main "sustainability gaps": the differences between the actual state of the urban system and the sustainable city vision. Because of the complexity of urban systems, an ecosystem approach should be adopted in this analytical phase, according to the belief that sustainable development requires to "think globally, act locally". This means that each urban sector (i.e. waste, energy, water, transport, telecommunication, business, etc.) should be considered initially as an autonomous sub-system of the city, and later positioned in the bigger picture. This will allow to simplify the process and to identify eventual issues or considerations that arise from a systems' thinking perspective.

5. Definition of a "sustainabilizing agenda"

After having identified the sustainability gaps, a list of objectives has to be created. The "sustainabilizing agenda" will require further negotiations between stakeholders, together with active public participation, in order to determine the priority of each objective and its level of importance within the agenda (Wallbaum, Krnak & Teloh, 2011; Cooper, Evans & Boyko, 2009). The model presented in Figure 2.6, showing the six high level goals for sustainabilizing cities, can be used as a guide for this activity.

6. Recognition of physical and cultural legacy constraints and leverage points of the region

The sixth phase of the process is where the concept of *ad hoc* sustainabilizing best practices comes in. Before selecting and evaluating sustainabilizing strategies, an analysis of the physical and cultural legacy constraints and opportunities of the region needs to be performed (Stren *et al.,* 1992). This will serve as a powerful filter for discarding urban policies that are clearly incompatible with the characteristics of the city, and for identifying the potential synergies of certain strategies.

7. Definition and evaluation of sustainabilizing strategies

During the seventh phase of the process, the working definition of sustainabilizing policies is adopted. The aim is to evaluate the strategies identified in the previous phase in light of a pragmatic view of sustainabilizing policies (ref. Chapter 1). This requires strategies to be assessed based on the following criteria:

- Expected impacts on the economic performance of the city;
- Expected impacts on the living standards of citizens;
- Expected impacts on the natural environment of the city;
- Expected contribution to the features of the sustainabilizing city contained in the defined vision, and the five high level goals for urban sustainability.
- Alignment of strategy with principles of good governance of the region;

- Alignment of strategy with global action plans.

In other words, in this phase of the planning cycle, decision-makers are called to forecast the effects of identified strategies on the variables that define the sustainabilizing vector. Those strategies that prove to be most effective in increasing the vector should be favored.

8. Possible formation of public-private partnerships

Most urban projects require significant investments, high risk and uncertain benefits distributed over large time horizons. For this reason, many of these sustainabilizing strategies will require new forms of public-private partnerships that can guarantee the success and economic profitability of projects. This is probably one of the biggest obstacles in the implementation of urban sustainability, and still today private organizations and governmental decision-makers are exploring together new forms of partnership to be adopted in urban projects (Giles, 2011).

9. Implementation of strategies and progress monitoring

The ninth phase, the longest in terms of time needed for its execution, consists of the implementation and monitoring (using the auditing tool defined in step 2) of the selected sustainabilizing strategies. A "sustainability review group", similar to the one thought by Cooper *et al.*, should evaluate whether the identified "sustainability gaps" (step 4) are in the process of being solved (Cooper, Evans, & Boyko, 2009). The assessment reports produced by this group should be used for revising the sustainable city vision (step 10), improving sustainabilizing strategies (step 7) and identifying new "sustainability gaps" (step 4).

10. Periodic update of the sustainable city vision

Based on reports delivered by the sustainability review group and on changing socio-political and economic conditions of the system, the sustainable city vision should be periodically revised. After each revision, the cycle should be performed from the beginning.

2.4.4 Some considerations on the *sustainabilizing city cycle*

Four final considerations ought to be made regarding the proposed framework for sustainable urban development.

First, the *sustainabilizing city cycle* is more suitable for mature cities that focus their efforts on improving the performance of the overall system, rather than new urbanization. For emerging cities, where new land is progressively being urbanized due to high demands for housing and population growth, another sustainable urbanization framework needs to be designed.

Second, there could be some problems in implementing the cycle due to differences between the time scales of the entire process and political agendas. Urban projects and many sustainabilizing initiatives require several years for their design and implementation, which could face various obstacles if political agendas would change after elections. For this reason, regardless of the ideology of a political party, it is essential for sustainable development to be perceived as a necessity rather than an option (Campbell, 1997).

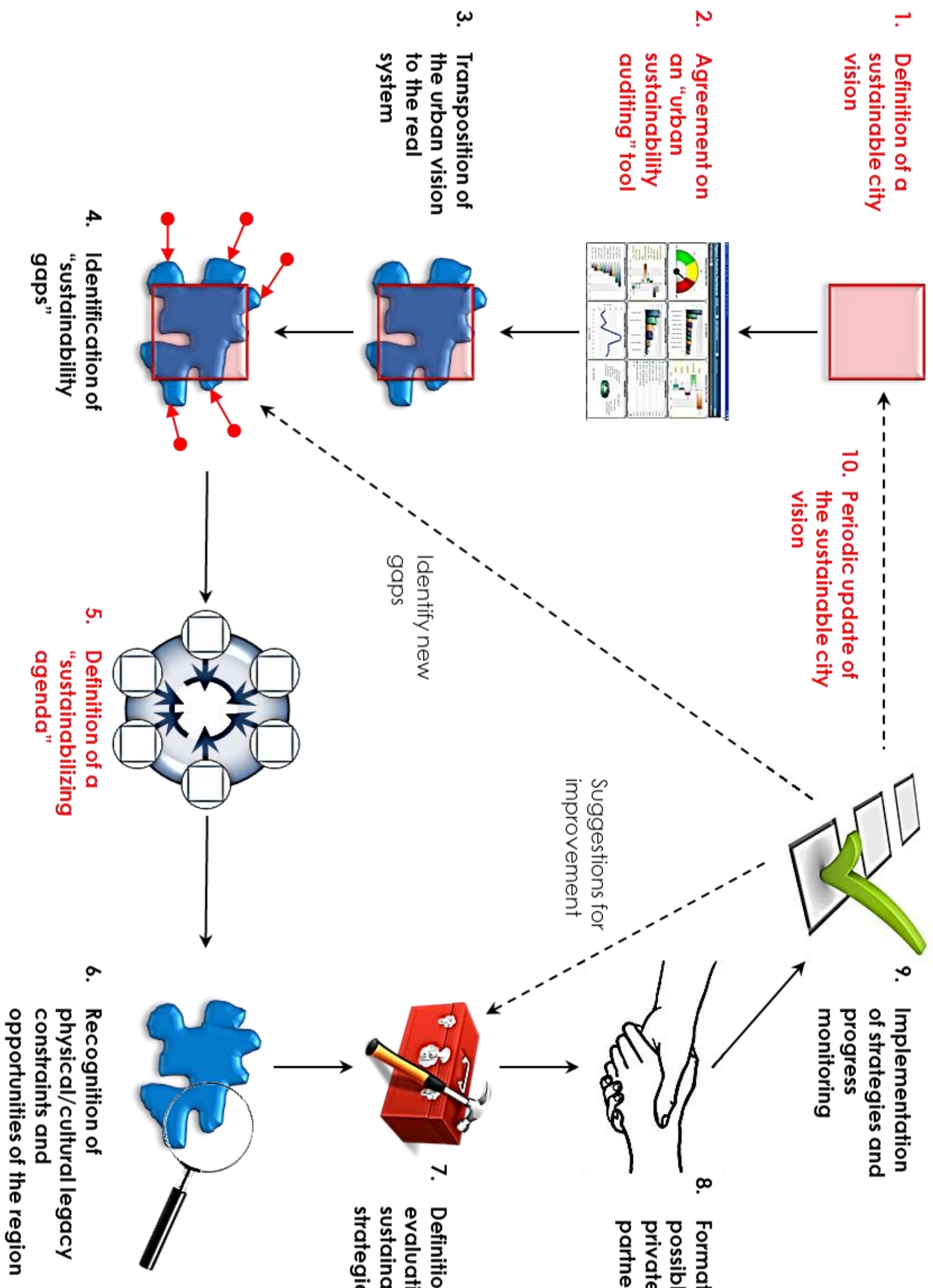
Third, the spatial scale of intervention of urban strategies has not been specified in the sustainabilizing city cycle framework. Urban policies are designed according to three different territorial levels: (i) the neighborhood, (ii) the municipality and (iii) the city-region. With regards to the latter level, the city-region can be defined according to two different spatial scales:

- *The Metropolitan Area*, consisting of a core city and a set of neighboring cities and suburbs, arising, to a large extent, from the expansion of the initial nucleus of a city, built in successive crowns of space, to reach sizes of national or international importance.
- *The Conurbation*, resulting from a geographical continuity of cities and other types of urban centers, generated by their own growth, to assume a type of polycentric structure, in other words, devoid of the clear predominance of a polarizing centre[1].

It is recommendable to consider all three levels, in order to grasp urban dynamics which can only be recognized if the concept of city is simultaneously contracted and expanded (Department of Foresight and Planning and International Affairs, 2007). The contraction of the city will make intra-urban dynamics stand out, while the expansion will shed light on the economic function of the city. Thus, the spatial level considered will strongly determine the goals and types of urban policies to be implemented for achieving urban sustainability.

Fourth, for reasons of simplicity, the sustainabilizing city cycle has been presented as a rational and linear decision-making process. In reality, urban policy-making is much more complex and less linear, involving several iterations between different phases. When applying the framework to the real world, it is important to keep in mind that urban planning (and especially sustainable urbanization) is both a "dynamic art and process" (Cooper, Evans, & Boyko, 2009).

[1] Definitions provided in Department of Foresight and Planning and International Affairs, 2007.


1. Definition of a sustainable city vision
2. Agreement on an "urban sustainability auditing" tool
3. Transposition of the urban vision to the real system
4. Identification of "sustainability gaps"
5. Definition of a "sustainabilizing agenda"
6. Recognition of physical/cultural legacy constraints and opportunities of the region
7. Definition and evaluation of sustainabilizing strategies
8. Formation of possible public-private partnerships
9. Implementation of strategies and progress monitoring
10. Periodic update of the sustainable city vision
Identify new gaps
Suggestions for improvement

Conclusions

It is widely acknowledged that cities play a key role in the achievement of a sustainable (or unsustainable) world. The reasons underlying this belief are that (i) cities are the systems where the three pillars of sustainability merge together (i.e. economy, environment and society), (ii) they are the largest consumers of resources and producers of waste, (iii) their population is expected to grow tremendously in the near future according to the United Nations' world population prospects, and (iv) they are the center of economic activities and engines of wealth production. Thus, both the scientific and political community agree that the road towards a sustainable world starts by the way cities are managed and designed.

The question of how the principles of sustainable development are being transposed to urban systems was the next question tackled by this chapter. To answer this question, various definitions of the ideal Sustainable City were investigated. However, in trying to identify a single formulation of this urban ideal, the same problems that were encountered in the intent of formalizing sustainable development presented themselves. Despite a formal definition provided during the *Sustainable City Conference* (Rio de Janeiro, 2000), there is lack of agreement as per what the ideal Sustainable City is and should resemble. Nonetheless, among the diverging "urban visions" that exist, the bibliographic research performed suggested that there are some general features of the Sustainable City on which consensus has been reached. In sum, the ideal sustainable city should:

- Pursue a state of self-reliance: the structure and urban metabolism of the ideal sustainable city are designed to function on the carrying capacity of the surrounding environment;
- Favor patterns of urbanization characterized by compactness and mixed land uses over urban sprawl and zoning;
- Be embedded in a global network of exchange and competition;
- Seek the balance between three typologies of cities: the Green City, the Growing City and the Just City;
- Be responsive to change;
- Pursue development objectives over growth and expansion;
- Incentivize the engagement of citizens.

Given the fact that most of these features, similarly to the ones characterizing the sustainability principle, do not consider an achievable end state for practical or conceptual reasons, the chapter concluded that it is more correct to speak in terms of *sustainabilizing cities* rather than Sustainable Cities. In this sense, our efforts should be directed towards making cities progressively more sustainable. Based on this idea, the following working definition was presented:

- ***The Sustainabilizing City***: The city that, in line with an urban vision accepted by stakeholders, invests in policies and urban projects that sustainabilize its urban metabolism while seeking social, economic and environmental sustainability. Sustainabilizing urban systems implies **making their urban metabolism circular**, **less dependent on non-renewable energy sources** and **respectful of the carrying capacity** of its region; finding an **equilibrium between the pursue of economic, environmental and social objectives**; improving the overall performance of the city by rendering it more **responsive, fit, attractive and competitive**: prioritizing **development goals** over unjustified urban expansion; and **involving citizens** in urban planning decision-making processes and achievement of sustainability goals.

The relation between the concepts of *to sustainabilize* (ref. Chapter 1) and *sustainabilizing cities* was illustrated, demonstrating how the concept of sustainability is being transposed to urban systems. Moreover, in the same section it was stressed that sustainabilizing cities must involve citizens in the process of urban transformation, and especially in the definition of a sustainable city vision. The point is that achieving more sustainable cities is meaningless if their citizens are not satisfied with the quality of life offered.

In light of new challenges and objectives that cities all over the world are facing, the chapter provided an overview of how urban planning has radically evolved since the 1960s, resulting in a new form of urbanism. The new urban planning paradigm shows commitment to the implementation of sustainability principles in the management and design of cities. The following elements were recognized as the most innovative features of this new form of urban planning:

- Involvement of citizens and main stakeholders in the decision-making process;
- The importance of working with a vision of the sustainable city defined through stakeholder negotiations;
- The adoption of an integrated and holistic approach, which looks simultaneously at the economy, the environment, and the society;
- The rejection of isolated disciplines and knowledge boundaries, opting for a more out-of-the-box thinking and a multidisciplinary approach;
- More dynamic, responsive and able to process and combine live data deriving from different urban sectors

Successively, the chapter investigated on the strategies that are being implemented for making cities more sustainable. Even if a definite and universally accepted list of best practices for sustainabilizing cities does not exist, there seems to be consensus on certain guidelines that planning for sustainability should embody. These guiding principles mainly refer to the planning procedure and high level objectives pursued by sustainabilizing cities. With regards to the former, urban sustainability strategies need to be designed and selected according to an *ad hoc* analysis of the territory (identifying the physical and cultural legacy constraints and opportunities within the region) and should not be imposed by governmental authorities using a top-down approach. Considering the latter, the performed research brought to the recognition of six high-level goals pursued by sustainabilizing cities:

1. Reducing the consumption rate of natural resources to the level that equals their rate of self-regeneration;
2. Achieve a circular urban metabolism that reduces the quantity of waste disposed;
3. Reducing the consumption of non-renewable energy sources;
4. Reducing the environmental impact of the targeted urban sector;
5. Improving the economic performance of the city (e.g. competitiveness and ability of attracting human and financial capital)
6. Improving the living standards of citizens

The conceptual diagram presented in Figure 2.6 emphasized how these six high-level goals are interconnected, which means that they should be pursued contemporaneously.

The chapter concluded by presenting a planning framework for sustainable urbanization, *the sustainabilizing city cycle (*ref. page 61). The aim of this framework was to summarize the main findings on Sustainable Cities and sustainable urbanization, and to provide a tool for systematically evaluating certain "sustainabilizing urban strategies" (such as Intelligent City Programmes). This pragmatic policy-making methodology is characterized by an iterative cycle composed of the 10 activities which arise from the combination of the classic policy cycle (e.g. problem definition, agenda setting, policy development, implementation and policy evaluation) and the concept of to sustainabilize. These activities are:

1. Definition of a sustainable city vision;
2. Agreement on an "urban sustainability auditing" tool[1];
3. Transposition of the urban vision to the real system;
4. Identification of "sustainability gaps";
5. Definition of a "sustainabilizing agenda";
6. Recognition of physical and cultural legacy constraints and leverage points of the region;
7. Definition and evaluation of sustainabilizing strategies;

[1] A system for monitoring sustainabilizing cities is developed and proposed in the following chapter.

8. Possible formation of public-private partnerships;
9. Implementation of strategies and progress monitoring;
10. Periodic update of the sustainable city vision

Finally, some reflections on the proposed framework were discussed. In sum, these refer to:

- the higher suitability of the framework for mature cities undergoing processes of urban re-development and upgrade;
- the difficulties of implementing the policy-making cycle due to frame of urban projects which is in contrast with the short-term thinking of many politicians;
- the need of adopting different spatial scales of analysis and interventions, trying to focus on both the intra- and inter-urban dynamics of the cities sub-systems;
- the contrast between the simplicity and linearity with which the framework presents itself and the complexity of urban policy-making processes.

Looking for "the finger pointing at the moon"

A practical framework for evaluating the progress of sustainabilizing cities

Chapter 3

"Characterizing and measuring sustainability involves making choices about how to define and quantify what is being developed, what is being sustained and for how long."

Parris & Kates, 2003

Summary

Following from the principle that "you cannot achieve what you cannot measure", many researchers and public administrations are devoting much effort to the definition of Sustainable Development Indicators (SDI), with the aim of creating a monitoring system allowing the tangible assessment of strategies for sustainable development. Nonetheless, despite numerous attempts, there is a clear lack of consensus in the definition, selection and use of SDI. In the first part of this chapter, the reasons responsible for the abundance and heterogeneity of methods for measuring sustainability at the settlement level are presented. This is done by first introducing the importance of SDI, then by providing an overview of the different types of indicators, their features and selection criteria, and finally by studying some examples of assessment initiatives carried out by academicians and governments. The aim of this research activity is to gather knowledge necessary for designing a framework that articulates the main characteristics of sustainabilizing cities in a set of measurable indicators. This conceptual diagram, entitled *"the sustainabilizing city tree"*, represents the tool that will be used for assessing the contribution of Intelligent and Knowledge City Programmes to the achievement of sustainable urban systems. The route followed for its design is described in the second part of this chapter. It mainly consists of three steps: (i) transposing the working definition of "to sustainabilize" to urban systems; (ii) articulating the four identified pillars of sustainabilizing cities in specific parameters; and (iii) formulating them in a set of measurable indicators according to a set of guiding principles previously defined.

Keywords
Sustainable Development Indicators; Sustainable Cities; Monitoring Framework

Goal of Chapter 3

The goal of this chapter is to develop a practical framework for monitoring the progress of sustainabilizing cities. The conceptual model will help give rigor to the meaning of Sustainable Cities by providing a clear articulation of the concept in pillars, parameters and indicators. In addition, the framework will be functional to this project by providing a system for identifying the contribution of Intelligent and Knowledge City Programmes (ref. Chapter 4) to sustainabilizing cities. In pursuing this goal, this chapter will provide an answer to the following questions:

1. Why is it so important to define indicators of sustainable development?
2. What are the reasons determining the abundance and heterogeneity of methods for measuring sustainability at the settlement level?

3. How can we articulate the high-level objectives that characterize Sustainable Cities in a set of meaningful parameters?
4. How can we translate these parameters into a list of Sustainable Development Indicators (SDI)?
5. What are the guidelines that should be followed in defining these indicators?

3.1 “You cannot achieve what you cannot measure”

Policy and decision-makers are usually familiar with the saying “you cannot achieve what you cannot measure” or “what gets measured gets managed”. If you are not able of formulating a goal in terms of a set of qualitative or (preferably) quantitative indicators, then either it has not been defined in sufficient detail, or there is still a lack of consensus over its meaning, or it is close to something which is unachievable. In the case of sustainable development, researchers and public administrations are devoting much effort to the definition of Sustainable Development Indicators (SDI), with the aim of creating a monitoring system allowing the tangible assessment of sustainable development strategies. Nonetheless, despite numerous attempts, there is a clear lack of consensus in the definition, selection and use of SDIs (Tanguay, Rajaonson, Lefebvre, & Lanoie, 2010). Why is this so?

> *“Combining global, national, and local initiatives, there are literally hundreds of efforts to define appropriate indicators of sustainable development.”* (Kates, Parris, & Leiserowitz, 2005)

The aim of this section is to find an answer to this question by investigating on the reasons that make the definition of SDI such an arduous task. This will be done by first discussing the concept of SDI in general terms, identifying their characteristics and importance, and successively by presenting a selection of different methods for defining SDI, evidencing the strong and weak points of each measurement system. The knowledge gathered throughout this bibliographic research will support the process of developing a framework for identifying the contribution of the Intelligent and Knowledge city (ref. Chapter 5) to sustainabilizing cities.

3.1.1 The importance of defining indicators of sustainable development

Indicators as empirical indirect interpretations of reality are constantly being used in many management and policy analysis practices, especially in the field of urban planning (OECD, 1997). This is probably because managing cities implies dealing with complex phenomena, characterized by goals that require thinking in the long-term and affect different stakeholders in various ways. In these cases, the definition of a common tool for policy guidance becomes essential. Likewise, planning for sustainability is an action that strongly calls for a measuring system, as it reflects these characteristics in the following ways:

- It is a complex and highly debated concept;
- It is subject to different interpretations according to stakeholders’ perceptions and interests;

- It merges together economic, social and environmental objectives;
- It is a long-term arduous process, a structural transformation that does not imply a clear final state.

In light of these considerations, the need of translating sustainability in a set of coherent policy goals becomes evident. In pursuing an operational definition of sustainable development, SDI come through as indispensable for materializing the true meaning of the concept, for quantifying sustainability performance, and for measuring whether a system is truly becoming more sustainable. Thus, it should not surprise that in recent years there has been a proliferation of methods for evaluating sustainable development (Becker, 2004).

3.1.2 Typologies, features and selection criteria of indicators of sustainable development

For the reasons that will be later discussed, there is no single universally accepted set of indicators for measuring sustainable development. SDI differ under many aspects for their typology, features and selection criteria.

- **Typologies**

> *"Indicators summarize complex information of value to the observer. They are our link to the world. They condense its enormous complexity to a manageable amount of meaningful information, to a small subset of observations informing our decision and directing our actions."* (Bossel, 1999)

There are two main types of indicators: *descriptive* and *performance indicators*. The former are based on concrete physical measures and are used for describing the status of the environment or system. They are usually easier to establish and interpret because they are judged on the base of pre-defined benchmarks and thresholds (Mega & Pedersen, 1998). Descriptive indicators can in turn be ordered in the following sub-typologies: indicators corresponding to *states* (provide information of system states such as stocks or levels), rates (the speed by which a system state changes), and converters (information obtained by appropriate conversion of data on the state and rates of the system) (Bossel, 1999). Examples of the three types are respectively: Green House Gas emissions per urban sector, rate of deforestation, and average per capita food consumption computed from total food sales per month and the size of the population. On the other hand, performance indicators are based on policy principles and are used for assessing the effectiveness of implemented strategies for achieving pre-specified goals. In other words, they result from the comparison of a descriptive indicator with a reference value or a policy target for determining progress made towards a goal (Hardi, Barg, Hodge, & Pinter, 1997), which makes them meaningless in the absence of a policy framework, a description of the current state of the system and a desired direction of change (Mega & Pedersen, 1998).

In many ways, *indices* (or composite indicators) may be regarded as a third typology of indicators. In fact, indices derive from the aggregation of two or more indicators, so it is not totally a mistake to include them in the typology. In general, their purpose is to synthesize different information contained by a set of indicators in a single variable. The advantage of using indices instead of a set of indicators is that they facilitate the monitoring of a certain phenomenon or state by reducing the number of variables that need to be observed and evaluated simultaneously. Moreover, through different aggregation methods and weighting systems, indices allow giving different levels of importance to the indicators used for describing a complex phenomenon. Nonetheless, the risk of relying on indices is that they often make the evaluation of a state or process ambiguous to the eyes of the people who were not involved in its definition (Tanguay, Rajaonson, Lefebvre, & Lanoie, 2010). Consequently, if not well described and simple to understand, indices may lose effectiveness in the eyes of a skeptical audience. A typical example is provided by the Ecological Footprint Index, which is obtained by various calculations on material flow indicators for assessing human demand against available natural capital (Rees & Wackernagel, 1996).

- **Features**

Features of indicators mainly refer to the type of data considered and to the method of presentation. With regards to the type of information presented, indicators may be separated in two categories: *quantitative* and *qualitative* (Tanguay, Rajaonson, Lefebvre, & Lanoie, 2010). The former provide indications on the state of the system observed in the form of hard data (i.e. numbers) while the latter are based on soft data (i.e. qualitative judgments such as good, sufficient and bad). Considering the methods for presenting information, the value of indicators can be communicated in different ways according to the requirements of the targeted audience, the purpose of the assessment and the information available (Becker, 2004). These include different graphical representations (e.g. bar charts and time series), numerical tables or a single figure presented in the form of an *index*.

- **Selection criteria**

There are no bounding rules that determine how SDI should be selected, designed and used. These activities will be as varied as the purpose of the measurement system developed, its audience and the resources of data available (Becker, 2004).

Below are provided four different examples of how academicians and public institutes have attempted to define SDI.

- *The Bellagio Principles*

According to an international group of measurement practitioners and researchers (the Bellagio Panel), indicators of sustainable development should be defined according to five basic principles (interconnected as illustrated in Figure 3.1): visualization, assessment content, presentation, actualization and public participation (identified by the panel as the key component of the process)

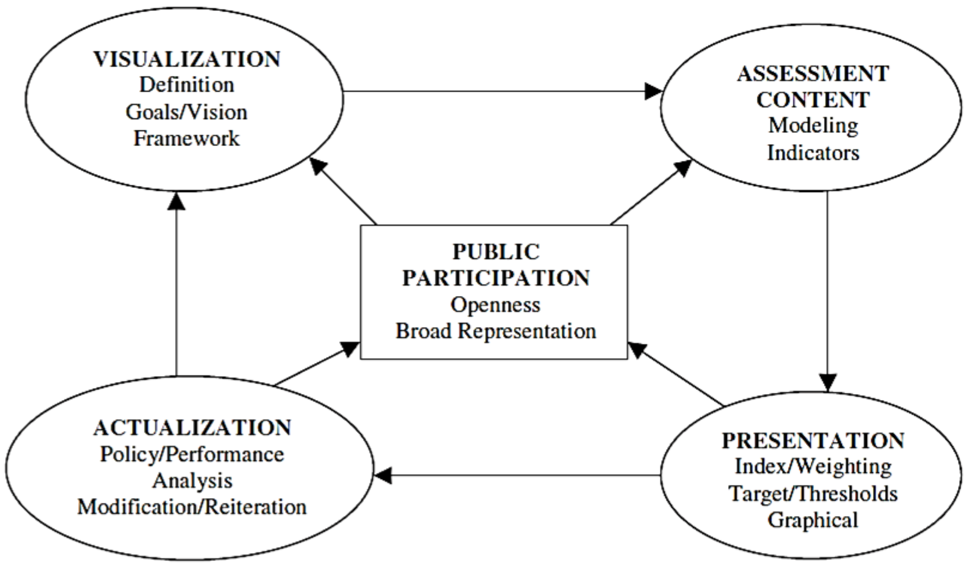


Figure 3.1: The conceptual model of the Bellagio principles.
Source: Becker, 2004.

- *SMART system*

A particularly widespread approach in social sciences is the so called *SMART system*. According to this principle, indicators should comply with the following characteristics: Specific (be clear and concise and avoid vague terms); Measurable (quantifiable indicators to measure progress); Achievable or Assignable (someone must be able to complete the objective); Relevant or Realistic (able to be interpreted within a certain budgert and time frame); and Time-related (completed by a certain date) (Tanguay, Rajaonson, Lefebvre, & Lanoie, 2010).

- *Framework of the European Charter of Sustainable Cities and Towns*

Another method for the selection of SDI, widely adopted within the European community, consists of assigning indicators *a priori* to selected policy themes (see Figure 3.2). Within each policy theme, a certain number of indicators are selected with the support of public participation. The question mark shown in Figure refers to the "unique sustainability index" which is supposed to aggregate the indicators pertaining to all identified policy themes. The complexity of the aggregation process mainly relies in deciding the level of contribution (i.e. weight) of each indicator to urban sustainability (the charter tried to solve this issue by measuring, through surveys, the theoretical degree of interest shown by citizens of a given city to particular aspects of urban sustainability).

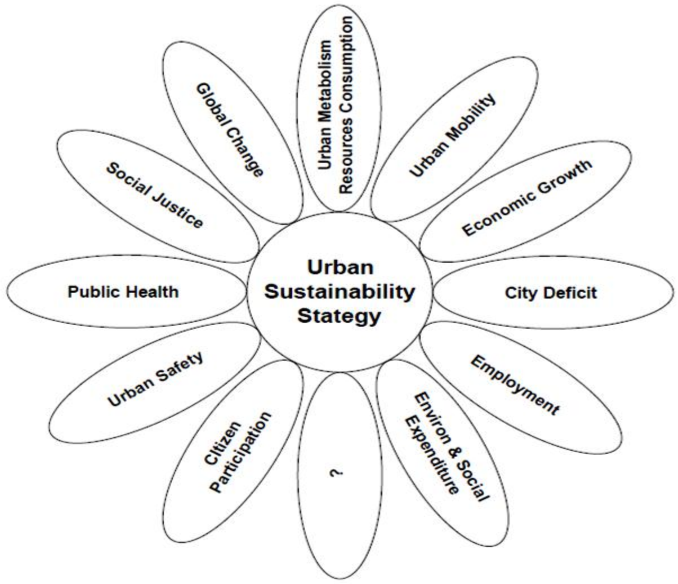


Figure 3.2: The policy theme framework adopted by the European Charter of Sustainable Cities and Towns for the development of SDI. Source: European Sustainable Cities and Towns Campaign, 1994.

- *Selection methodology adopted by Li et al. (2009) for the city of Jining (China)*

In the case study for measuring the urban sustainability of Jining (China), 52 SDI were selected based on the following criteria (Li, et al., 2009): *Maturity* (the indicator system should embody the social, economic, ecological, environmental, and institutional aspects of the city, with corresponding attention); *Objectivity* (the indicator system should objectively reflect the scientific consensus on sustainable development, and especially the social evenness and the needs of the children); *Interdependence* (the meanings of the indicators should be independent to avoid overlap and autocorrelation); *Measurability* (indicators should be measurable; it should be possible to quantify even qualitative indicators using appropriate quantification techniques); *Accessibility* (the difficulty of collecting and quantifying the data and indicators must be low enough to permit practical use of the indicator); *Dynamics* (indicators should be sensitive to temporal, spatial, or structural changes in the system to reflect the changes of the social, economic and environmental development); *Relative Stability* (indicators should capture long-term rather than short-term processes, but no indicators should exhibit absolute invariability, since the whole indicator system must respond to changes over time).

> *"Indicators may be weighted, aggregated or qualitative, but more does not necessarily mean better, while fewer risks loss of important detail."* (Becker, 2004)

- *Salience, Credibility, and Legitimacy*

According to a review of 12 major efforts for defining SDI, the authors identified three main attributes that characterize this process (Parris & Kates, 2003): *Salience* (refers to the relevance of the measurement system to decision makers); *Credibility* (refers to the scientific and technical adequacy of the measurement system); and *Legitimacy* (refers to the perception that the production of the measurement system is respectful of stakeholders' divergent values and beliefs, unbiased and fair in its treatment of opposing views and interests).

Table 3.1: Definition of indicators, indices and methods of aggregation.

Concept	Description
Indicator	A datum or variable that has an established and agreed role in the evaluation of a phenomenon (e.g. an increase in the number of unemployed is regarded as an indicator for expressing the negative economic performance of a given territory)
Indices	An index (or composite indicator) is a synthesis of indicators (e.g. the Human Development Index consists of three indices, each one synthesizing a set of indicators).
Methods of aggregation	Indicators may be aggregated according to spatial, temporal or thematic considerations
Weighting	A multiplying factor used for expressing the higher or lower value of an indicator over the others
Threshold	A scientifically demonstrated reference value which causes the phenomenon described to change status
Critical value	A recognized, generally arbitrary reference value

Source: based on Tanguay, Rajaonson, Lefebvre, & Lanoie, 2010.

3.1.3 Some examples of initiatives to measure sustainable development

In order to provide a more practical understanding of different typologies of SDI, several attempts to measure sustainability were reviewed. Four initiatives are provided below as an illustrative example of the efforts being made in measuring Sustainable Development.

- *The Ecological Footprint Index and the Driving Force, Pressure, State, Impact Response (DPSIR) selection framework*

R. Moles *et al.* (2008) defined their own system for measuring sustainable development from a review of more than 100 SDI. As selection criteria, they carried out tests of normality (Kolmogorov–Smirnov and Shapiro–Wilk statistical tests) and observed that all four dimensions of sustainable development (which according to the authors were: environmental, socio-economic, transport, quality of life and composite) were equally represented. This process resulted in a final list of 40 SDI (see Appendix 4), which were then divided among the four domains of sustainable development identified. For each of the domains, the values of the indicators were aggregated in four indexes, which were in turn combined to create a final measurement of the sustainability of an urban settlement (the sustainable development index).

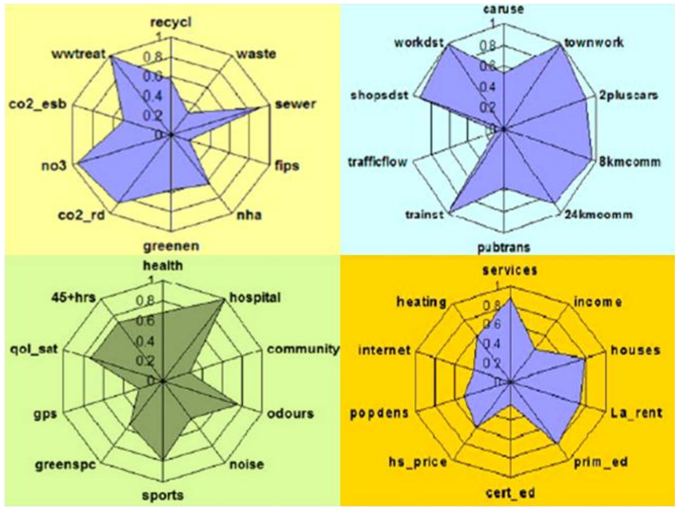


Figure 3.3: The four polygons of Sustainable Development with the relative indicators positioned on their vertexes calculated for a specific urban settlement. From the top left corner going clockwise: Environment, Transport, Quality of Life, Socio-Economic.
Source: Moles *et al.*, 2008.

- *The Full Permutation Polygon Synthetic Indicator method*

For measuring the urban sustainability of Jining (China), Li *et al.* (2009) applied the Full Permutation Polygon Synthetic Indicator method (FPPSI) to a list of 52 SDI. The method consists of creating thematic polygons (economic growth and efficiency; ecological and infrastructural construction; environmental protection; social and welfare progress; comprehensive evaluation of urban sustainability of Jining) over which the 52 indicators were divided. Finally, using theorems of geometrical calculation, the value of each indicator was used to calculate the entire area of the polygon, which was taken as final indicator of sustainability for a particular sustainability theme.

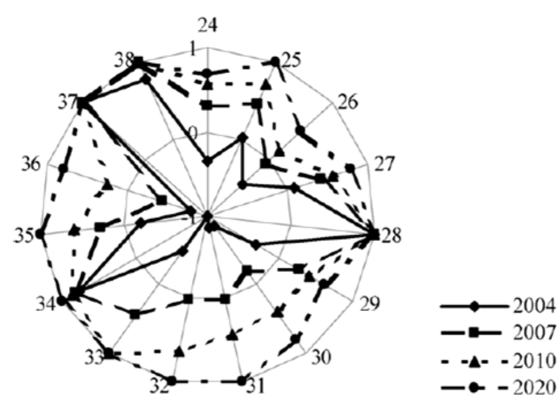


Figure 3.4: Example of the application of FPPI method for the sustainability domain "environmental protection". Each of the 15 vertexes of the polygon represents the SDIs relevant to the domain (e.g. vertex 34 represents indicator "proportion of industrial solid wastes that are treated and reused").
Source: Li *et al.,* 2009.

- *The Sustainable City Program of Santa Monica (California)*

In 1992, from an initiative sponsored by the Environmental Programs Division of Santa Monica, the municipality gave birth to a "Sustainable City Program" with the objective of establishing a result-oriented strategy for achieving improvements in the environment and quality of life. The program was mainly created in order to provide decision-making processes within the municipality with a framework for evaluating long-term, as opposed to short-term, impacts of implemented policies on the economy, environment and society (City of Santa Monica, Office of Sustainability and the Environment, 2011). In this sense, even if the program embodied basic principles of sustainable development, it did not aim at evaluating the progress made towards a state of sustainability (Brugmann, 1997). The office of Sustainability and the Environment identified a list of SDI divided among eight main policy areas: (i) resource conservation; (ii) environmental and public health; (iii) transportation; (iv) economic development; (v) open space and land use; (vi) housing; (vii) community education and civic participation; (viii) and human dignity.

Table 3.2: Selected goals, targets and indicators for one of the policy areas identified in the Sustainable City Program of Santa Monica.

Policy Area	Resource conservation
Goals	1. Promote the use of conservation technologies and practices that reduce the use of non-renewable resources; 2. Develop local, non-polluting, renewable energy, water and material resources, and expand recycling technologies in these areas.
Targets	• Reduce energy usage by 16% • Reduce potable water usage by 20% • Reduce solid waste volumes by at least 50% • Achieve a 50% avergae post-cosnumer recycled and/or tree-free conent in all city paper purchases • Convert 75% of the city vehicle fleet to reduced-emission fuels • Reduce wastewater flow by 15% • Increase total number of trees on public property by 350
Indicators	• Energy usage (non-mobile sources) (million Btu per year) • Water usage (million gallons per year) • Post-consumer recycled tree-free paper purchases (%) • Wasterwater flows (million gallons per year) • City fleet vehicles using reduced-emission fuels (%) • Trees planted in public space (tree units)

Source: Adapted from Santa Monica Sustainable City Plan, 2011.

- *The survey based selection strategy (SuBSelect) for SDI*

G. A. Tanguay *et al.* (2010) conducted a review of 17 initiatives for measuring sustainable development. Out of the 188 SDI examined, they came up with a final list of 29 indicators (see Appendix 5) by adopting the "survey based selection strategy" (SuBSelect). In brief, their selection criteria consisted in selecting (i) the most cited indicators in the reviewed cases, (ii) which cover all components of sustainable development, and (iii) were the simplest with regards to data collection, understanding and dissemination (Tanguay, Rajaonson, Lefebvre, & Lanoie, 2010).

3.1.4 Complications in defining indicators of sustainable development

The *Compendium of Sustainable Development Indicator Initiatives* list more than 500 different attempts by scientists and organizations to measure sustainability (International Institute for Sustainable Development, 2004). Such a large number of initiatives clearly evidence the lack of consensus on the methods pertaining to SDI practices (Tanguay, Rajaonson, Lefebvre, & Lanoie, 2010). From the bibliographic research performed, four main reasons have been recognized as responsible for this disagreement.

1. Different opinions regarding what is to be sustained, what is to be developed, and for how long (Parris & Kates, 2003).
2. The fact that sustainability is much of a process of discourse and effort as it is a state (Fricker, 1998).
3. The concept of sustainability addresses the ultimate question of the meaning of quality of life (Fricker, 1998).
4. The contingent nature of certain aspects of sustainable development, which allow for different interpretations of the concept according to stakeholders' interests, values and beliefs (Bossel, 1999; Fricker, 1998; Levett, 1998).

To sum up, the impossibility of finding agreement on a single system of SDI is essentially caused by the inherent malleability of the concept. For this reasons, many authors stress the importance of involving the community (through public participation) and main stakeholders of the urban system in the definition of what is to be sustained (with the given level of importance) and how we should measure it (Fricker, 1998; Maclaren, 1996; Mega & Pedersen, 1998).

3.2 Designing a conceptual framework for monitoring sustainabilizing cities

Following from the discussion on the obstacles and issues that characterize the process of translating sustainable development into practical terms, it becomes clear that "the struggle to find and use indicators of sustainable development is intimately bound up with the process of deciding what we mean by (the term) and what we should do about it" (Levett, 1998). In line with this statement, J. Becker (2004) concludes that "there is no single recipe for designing and conducting an evaluation of sustainable development". Nonetheless, for the scope of this research, it was necessary to translate the features that characterize sustainabilizing cities in a set of operational parameters. Only by branching the high-level goals and general features of urban sustainability will it be possible to assess the exact contribution and efficacy of Intelligent City Programmes. This was done by designing a conceptual framework, entitled "*the sustainabilizing city tree*".

In order to pursue this objective, the essence of "to sustainabilize" was transposed to the urban systems, resulting in the recognition of four pillars of sustainabilizing cities. Successively, these pillars were expanded in a set of parameters and finally, for each of these parameters, a set of SDI was created following four guiding principles defined from the performed bibliographic research. This entire process, which has been resumed in Figure 3.5, is described in the following sections.

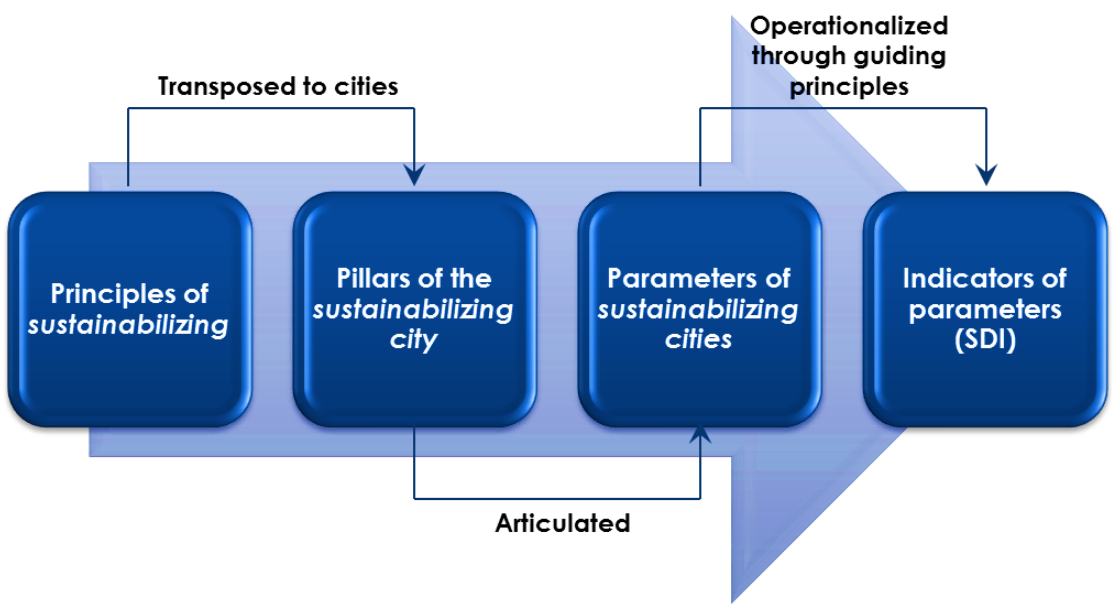


Figure 3.5: Diagram illustrating the process for articulating sustainable development within urban systems.

It should be noted that the developed set of SDI is not intended to represent an additional attempt for measuring urban sustainability. Rather, it will help narrow down the developed working definition of sustainabilizing cities, providing a clear articulation of the concept in pillars, parameters and indicators. The final purpose of this activity is twofold:

1. To provide this research with a tool for allowing the assessment of Intelligent and Knowledge City Programmes in light of urban sustainability.
2. To develop a methodology for systematically articulating the complexity of urban sustainability

3.2.1. Transposing the principles of sustainability to the city

In order to design the backbone of the *sustainabilizing city tree*, the working definition of sustainable development (ref. Chapter 1) was transposed to urban systems. This activity, which was performed in Chapter 2, brought to the formulation of the "sustainabilizing city" ideal. Successively, with the aim of further developing the new working definition, the link between the identified elements of sustainable development and sustainable cities was investigated. This activity revealed the existence of two main sets of sustainability principles:

- ***Sustainability 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.
- ***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.

Sustainability imperatives refer to the metabolism of urban systems, and represent the structural characteristics that cities should pursue in order to approach a state of sustainability. They relate to the flows of energy and resources that cities exchange with their hinterland (i.e. *input flows* and *output flows*) and to the impacts on the environment (both within and outside the urban boundaries) of how these flows are processed (i.e. *Impacts of urban activities*). In theory, they apply to all cities of the world, and represent a list of objective goals that need to be included in the sustainability agenda of every government.

"We recognize the diversification of actors and stakeholders engaged in the pursuit of sustainable development." (United Nations, 2012)

Turning to the second set of sustainability elements, these derive from the application of the concept to the three main sub-systems of cities: (1) environment, (2) economy, and (3) society. The elements that characterize a sustainable city from these three perspectives are equally important as the ones pertaining to the sustainability imperatives set. However, a universal definition of a sustainable society, economy, and environment cannot be reached as these three concepts are subject to the different interests, values, and system of beliefs of the actors pertaining to the urban community.

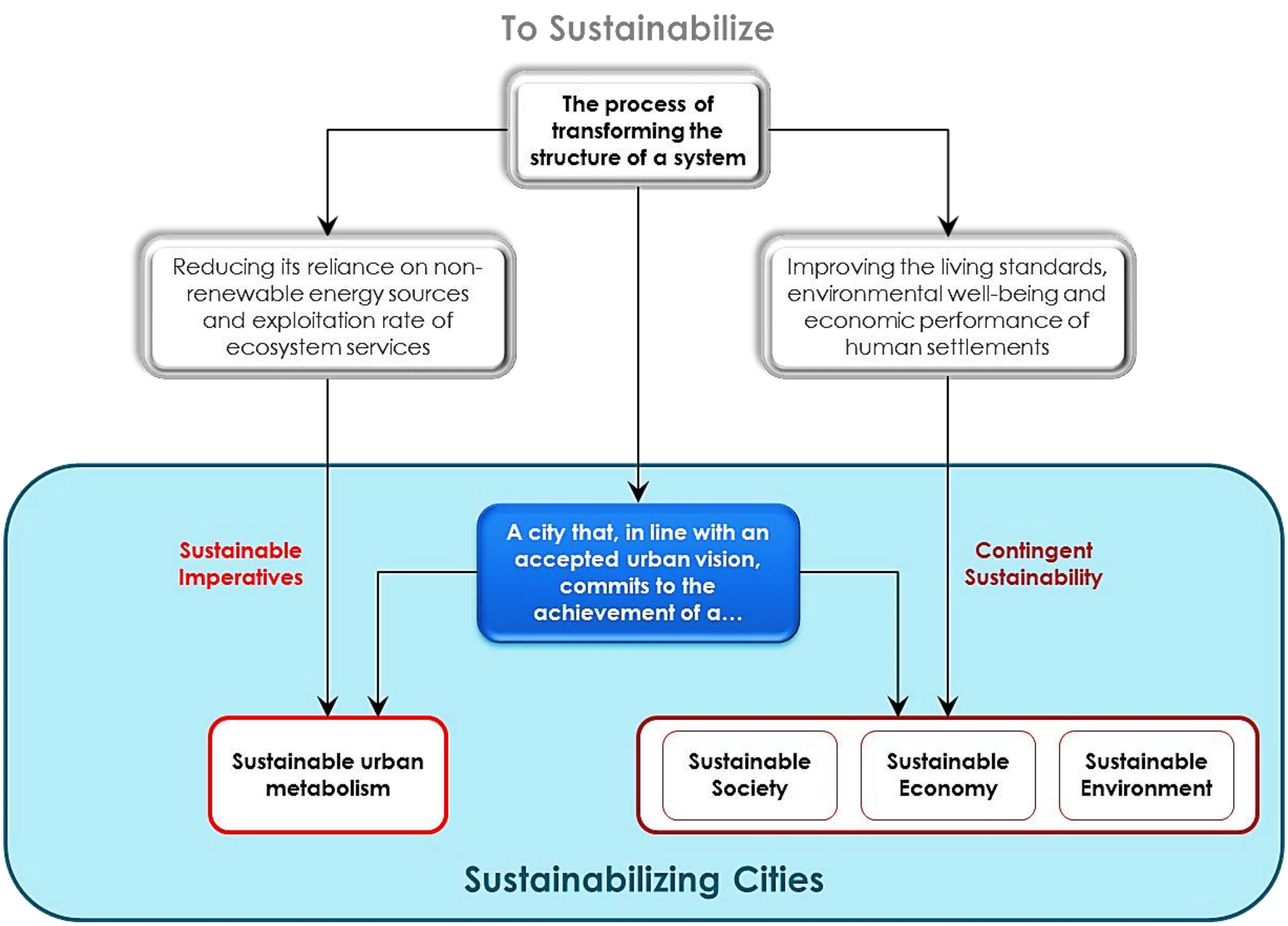


Figure 3.6: The backbone of *the sustainabilizing city tree*.

Keeping in mind the need of contextualizing and negotiating these three concepts, this research provides a proposal of what their definition could be:

- A city is **socially sustainable** when it is able to attract and retain population, and when it exhibits a symmetrical distribution of age groups.
- A city is **economically sustainable** when it is able to continuously improve the welfare of its society.
- A city is **environmentally sustainable** when it is able to satisfy the system's demand of ecosystem services, without running the risk that these are depleted or permanently damaged.

3.2.2 Articulating the pillars of urban sustainability in parameters

The following step carried out for the design of the conceptual framework consisted in articulating the four main pillars that characterize sustainabilizing cities (see Figure 3.5).

With regards to the parameters pertaining to the sustainability imperatives set, the following elements were recognized as forming the ideal of a sustainable urban metabolism[1]:

I. Sustainable Urban Metabolism

1. Input flows
   - (1.a) Reducing the consumption of non-renewable energy sources;
   - (1.b) Reducing the consumption rate of natural resources;
2. Output flows
   - (2.a) Reducing the quantity of waste produced and disposed
3. Environmental impact of urban sectors
   - (3.a) Reducing the environmental impact of urban sectors[2]

Turning to the contingent sustainability set, the concepts of a socially, economically and environmentally sustainable city were articulated in the following elements

II. Sustainable society

4. Quality of life within the city
   - (4.a) Satisfying the physiological/basic needs of citizens
   - (4.b) Improving urban safety
   - (4.c) Increasing individual freedom
   - (4.d) Improving social life
   - (4.e) Improving urban mobility
5. Attractiveness of the city
   - (5.a) Increasing the attractiveness of city to nonresidents and business activities
6. Distribution of age groups
   - (6.a) Balancing the age structure diagram of population

III. Sustainable Economy

7. Competitiveness of the city in the short-term

[1] For a graphical representation of urban metabolisms, refer to Figure 1.2 (Chapter 1).
[2] Sectors of urban systems include Water, Energy, Transportation, Solid Waste, Buildings and Ecosystems (ref. Appendix 6)

(7.a) Improving the market conditions and competitiveness of city's economic system

8. Competitiveness of the city in the long-term

(8.a) Higher capacity to foster innovation and stimulate a knowledge-based economy

IV. Sustainable Environment

9. Health of the three environmental compartments

(9.a) Preservation of the health of aquatic compartment
(9.b) Preservation of the health of terrestrial compartment
(9.c) Preservation of the health of atmospheric compartment

10. Biodiversity in the city's hinterland

(10.a) Preservation of biodiversity

3.2.3 Guiding principles for defining indicators of sustainabilizing cities

In order to complete the *sustainabilizing city tree*, the parameters pertaining to the two sets were articulated in the form of measurable indicators. Before carrying out this activity, a set of guiding principles were identified from the review of more than a dozen initiatives for measuring sustainable development at the settlement level. This review revealed the existence of some common elements among the different methodologies. These elements, combined with a personal understanding of urban sustainability (ref. Chapter 2) and re-framed according to the scope of this project, brought to the formulation of four guiding principles, which are discussed below.

I. The initiative should be embedded in a conceptual framework of sustainable development.

The general impression obtained from the appraisal of several systems for monitoring sustainable development is that often they are defined in the absence of an established working definition of sustainability. Consequently, it is difficult to evaluate the relevance and scope of some indicators in light of sustainability. Even if a universally accepted formulation of sustainable development does not (and probably will never) exist (ref. Chapter 1), it is recommended that SDI are to be defined within a conceptual framework of the principle which illustrates its main characterizing elements.

II. 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").

According to the developed working definition of sustainability, there are some objective elements of the concept that exist regardless of different perceptions that actors may have of it and interests involved. These are the *Sustainable Imperatives,* the *sine qua non* requirements that any system should possess in order to comply with the physical definition of sustainability. For example, indicators such as "% of energy produced from renewable resources" and "% of total waste recycled" should be present in every measurement system of sustainable development. On the other hand, there are aspects of sustainable development which are contingent to the specific city and actor. For example, higher "living standards" is an aspect of sustainability that needs to be defined *ad hoc* for a community. Identifying indicators for such elements necessarily has to involve a negotiation process with the participation of the public and main stakeholders of the urban system.

Unfortunately, due to time and resources constraints, the contingent SDI identified for this research project were not developed through public participation nor stakeholder negotiations. To reduce as much as possible the impacts of this limitation, these SDI were defined from the investigation of several statistical reports published by National and International Bureaus of Statistics (ref. Appendix 8).

III. Formulation of indicators in terms of rates of change

Most attempts to measure sustainable development focus on the achievement of target values (e.g. The Sustainable City Plan of Santa Monica, 2011) that refer to a desirable state of sustainability. However, working with absolute values of indicators in the case of sustainability is conceptually wrong if we agree that sustainable development is a dynamic process of structural transformation. For this reason, this research proposes the idea of formulating SDIs in terms of derivatives. This means that the attention is placed on how the indicator changes through time (i.e. the intensity with which values of the indicator increase or decrease).

$$\frac{\partial f}{\partial t} = \lim_{t \to 0} \left(\frac{f(t + \Delta t) - f(t)}{t} \right)$$

Mathematical definition of derivative according to Newton's difference quotient using time as variable of differentiation[1].

The advantages of this new approach for measuring sustainable development are many:

- Derivatives embody the concept of change/transformation over time[2], in line with the idea expressed by the definition of "to sustainabilize"
- Derivatives give information regarding the rate at which change occurs, which means that they can allow an objective assessment of the efficacy of policies and strategies for sustainable development;

[1] Using real data, it is obviously impossible to comply with the precise definition of derivatives. Strictly speaking, the developed indicators will be quotients with the denominator (Δt) to be determined according to the phenomenon observed and availability of data.
[2] If time is taken as the variable of differentiation.

- Derivatives overcome the need of negotiating target values amongst stakeholders. Minor efforts will only be needed for agreeing on the sign (i.e. negative or positive) of the derivatives.

IV. The measurement system should focus on the essence of sustainable development, following the "Keep It Simple Stupid" (KISS) principle.

"Paraphrasing Einstein, indicator sets should be as simple as possible, but not any simpler than that" (Bossel, 1999). Even if this statement might sound like a platitude, it is important to stress how measurement systems should always embrace the *KISS principle*. This is especially true when dealing with complex phenomena such as sustainability. Thus, in this attempt to operationalize sustainability, the number of indicators used will be kept as low as possible. This will be done by focusing on indicators that capture the essence of sustainability according to the definition provided in chapter 1. Furthermore, indices based on complex aggregation methods should be avoided in order to keep the measurement system as simple and direct as possible.

3.2.4 Operationalizing parameters of urban sustainability

For completing the *sustainabilizing city tree*, the parameters previously identified were further articulated in a set of measurable indicators, formulated according to the scale of cities (i.e. Metropolitan Regions[1]). The guiding principles previously presented were used throughout the entire activity. Moreover, the identified parameters were operationalized with the use of several reports published by the OECD, United Nations, Eurostat and other National Institutes of Statistics (ref. Appendix 8). The indicators which resulted from this research activity are presented in the following tables and discussed in the paragraphs below. A more detailed description, including examples of organizations making use of them is presented in Appendix 8.

I. Sustainable Urban Metabolism

Table 3.3 illustrates the indicators pertaining to the three parameters of the sustainability imperative set. The first two refer to the flows of material and energy entering and exiting the urban system. The essence of a sustainable urban metabolism is that all incoming flows derive from renewable sources (i.e. their rate of depletion is smaller or equal to their regeneration rate) and that all outflows are recycled (either from natural or artificial processes). Furthermore, the set of reactions that take place within the different sectors of a sustainable urban metabolism should have a reduced impact on the natural environment. Formulating this parameter in terms of measurable indicators was not as straightforward as the previous two, mainly because there are many ways for measuring the environmental impact of urban activities, and because the indicators of this set

[1] Ref. Chapter 2 for the definition of urban boundaries.

should not overlap with the ones of the sustainable environment one. The indicators that solved these two issues were found to be emissions of Green House Gases (GHG) and toxic substances deriving from all urban sectors except "ecosystems"[2]. Without going into further detail, toxic substances include chemicals that have adverse effects on the ecosystems (biotic and abiotic components) and/or on the health of humans. These are to be determined and measured by experts in the fields of toxicology and ecotoxicology.

Table 3.3: Identified SDI pertaining to the pillar "sustainable urban metabolism".

Sustainable Urban Metabolism	
Articulation of parameters in indicators	**Symbol & direction**
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) per urban sector "i"	$\Delta NR_i/\Delta t \leq 0$
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	$\Delta W_R/\Delta t \geq 0$
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)	$\Delta SP_i/\Delta t \leq 0$

Tables 3.4, 3.5 and 3.6 illustrate the indicators pertaining to the six parameters of the contingent sustainability set. **As previously stressed, due to the nature of these parameters it is essential that these indicators are to be defined through negotiations with representatives of the community and stakeholders of the city**. As the scope of this research was to design a general framework for evaluating sustainabilizing cities, the formulated indicators only represent a proposal. Moreover, they are presented in this instance also for providing the reader with a better understanding of the framework developed. The following paragraphs discuss in more detail the meaning of the contingent sustainability parameters, and illustrate the reasoning adopted behind their formulation (for a more detailed description, ref. Appendix 8).

II. Socially sustainable cities

According to the definition provided in this research, a city is socially sustainable when it is able to attract and retain population, and when it exhibits a symmetrical distribution of age groups. The basic behind this reasoning is that citizens represent both the consumers and resources of cities, and that an excessively ageing population is economically and socially unsustainable (e.g. higher expenditures in social security and health care, and unsustainability of pensions systems)[1]. Thus, stable (or increasing) demographic figures and a balanced aged structure diagram are the two requisites for cities to exist and survive. Pursuing these requisites implies that cities have to result attractive, offer high living standards to their population and adopt policies for tackling an ageing society. These concepts are all quite ambiguous and complex to measure, as they lack a and for operationalizing them this research drew information from several social and lifestyle statistics of different national census bureaus (ref. Appendix 8) and other scientific publications. According to this investigation, the variables for assessing the quality of life within cities were found to be: basic physiological needs of humans (ref. Appendix 7), urban safety, individual freedom, social life and urban mobility. With regards to the assessment of the attractiveness of a city, the indicators used were net immigration flows, variation in real-estate values and the number of mega-events[2] hosted. Finally, the median age was selected as variable for measuring the ageing of a population.

III. Economically sustainable cities

A city can be regarded as economically sustainable if it is able to continuously increase the welfare of its society. Pursuing this goal implies that the economy of the city should be competitive in current and future market conditions. The decision of separately considering urban competitiveness in the short- and long-term is justified by the fact that they are determined by dissimilar factors and imply different methods of measurement. Whereas in the short-term competitiveness can be assessed by observing indicators such

[1] http://www.un.org/esa/population/publications/worldageing19502050/

[2] Mega-events, also referred to as "hallmark" or "landmark" events, are large-scale events intended to renew investment in host cities, usually in the tourism sector, by projecting a positive image of the city (Greene, 2001)

as *net exports, employment rate* and *Gross Domestic Product per capita*, in the long-term it is usually associated to the capacity of a system to foster innovation. While measuring the former is relatively simple, the same does not hold for the latter. In fact, the complex nature of innovation is made evident by the existing quantity of assessment methodologies and theories regarding the main factors influencing the phenomenon[1]. In this instance, indicators measuring the capacity of a city to foster innovation were selected from various initiatives carried out by researchers of the OECD and National Institutes of Statistics. These mainly refer to the heterogeneity of the city's total labor force and business activities operating, the facility for entrepreneurs to start new commercial activities, the flexibility of labor contracts, the level of urban broadband, the degree of corruption in the city's public administration, the level of ubiquitous connectivity and physical interconnection of the city with other Metropolitan Areas of the world.

IV. Environmentally sustainable cities

Finally, a city can be praised for being environmentally sustainable when the population's demand for ecosystem services can be sustained (in the long-term) by the environment's capacity to re-generate them. It is generally acknowledged that pursuing this goal implies preserving the health of the three environmental compartments (aquatic, terrestrial and atmospheric) and biodiversity of the city's hinterland. While overall consensus exists on the definition and methods of assessment of biodiversity (i.e. *number of species living within the city and its hinterland*), measuring the "health" of an environmental compartment is more complicated. In fact, this activity requires a community to be specific about the meaning of a "healthy environment". Furthermore, the process needs to be designed according to the specific landscape features of the region within which the city is embedded[2]. For these two reasons it was decided to include parameters of environmental sustainability in the contingent set. Table 3.6 illustrates an example of a set of indicators for measuring the health of the three environmental compartments.

> *"We recognize the severity of the global loss of biodiversity and the degradation of ecosystems and emphasize that these undermine global development, affecting food security and nutrition, the provision of and access to water of the rural poor and of people worldwide, including present and future generations."* (United Nations, 2012)

In the following pages, Tables 3.4, 3.5 and 3.6 are presented, followed by the final diagram of the *sustainabilizing city tree* (Figure 3.7).

[1] See, for example, (Kleinknecht, van Montfort, & Brouwer, 2002); (Pavitt, 1984); (Greunz, 2004); (Werker & Athreye, 2004); (Feldman, 2003); (Jensen, Johnson, Lorenz, & Lundvall, 2007).
[2] As an example, consider the differences in the landscape, flora and fauna between an Arab city like Muscat and a Scandinavian one like Oslo.

Table 3.4: Identified SDI pertaining to the pillar "sustainable society".

Sustainable Society	
Articulation of parameters in indicators	**Symbol & direction**
4. Quality of life within the city	
a. Satisfying the physiological/basic needs of citizens	
i. *Concentration of air pollutants in the atmosphere (proxy for inferring the quality of air)*	$\Delta CP_A/\Delta t \leq 0$
ii. *Consumption per food type "i" (proxy for inferring the variety of food available)*	$\Delta F_i/\Delta t \geq 0$
iii. *Density of urban green (proxy for inferring the quality of outdoor spaces)*	$\Delta UG/\Delta t \geq 0$
iv. *Share of households with direct connection to piped water systems (proxy for inferring the state of development of the city's piped water systems)*	$\Delta H_{WS}/\Delta t \geq 0$
b. Improving urban safety	
i. *Average waiting time for hospital inpatients (proxy for inferring the efficiency of public health system)*	$\Delta HWT/\Delta t \leq 0$
ii. *Number of reported criminal code offences (proxy for inferring level of urban safety)*	$\Delta RC/\Delta t \leq 0$
c. Increasing individual freedom	
i. *Number of reported criminal code offences related to cultural/ethnical reasons (proxy for inferring individual freedom and respect for cultural/ethnical diversities)*	$\Delta RC_{C/E}/\Delta t \leq 0$
d. Improving social life	
i. *Provincial Gross Domestic Product by entertainment industry (proxy for inferring the development of the entertainment industry)*	$\Delta GDP_{ENT}/\Delta t \geq 0$
e. Improving urban mobility	
i. *Average commuting time of citizens (proxy for inferring level of urban mobility)*	$\Delta CT/\Delta t \leq 0$
ii. *Share of population regularly using public transportation means (proxy for inferring the level of urban mobility)*	$\Delta PT/\Delta t \geq 0$
iii. *Ratio of the length of roads within the city's administrative boundaries to the total territorial surface (proxy for inferring the level of urban mobility)*	$\Delta LR/\Delta t \geq 0$
iv. *Accessibility of public spaces to people holding physical handicaps (proxy for inferring the level of urban mobility)*	$\Delta A_H/\Delta t \geq 0$

(Continues)

Table 3.4 (continued): Identified SDI pertaining to the pillar "sustainable society".

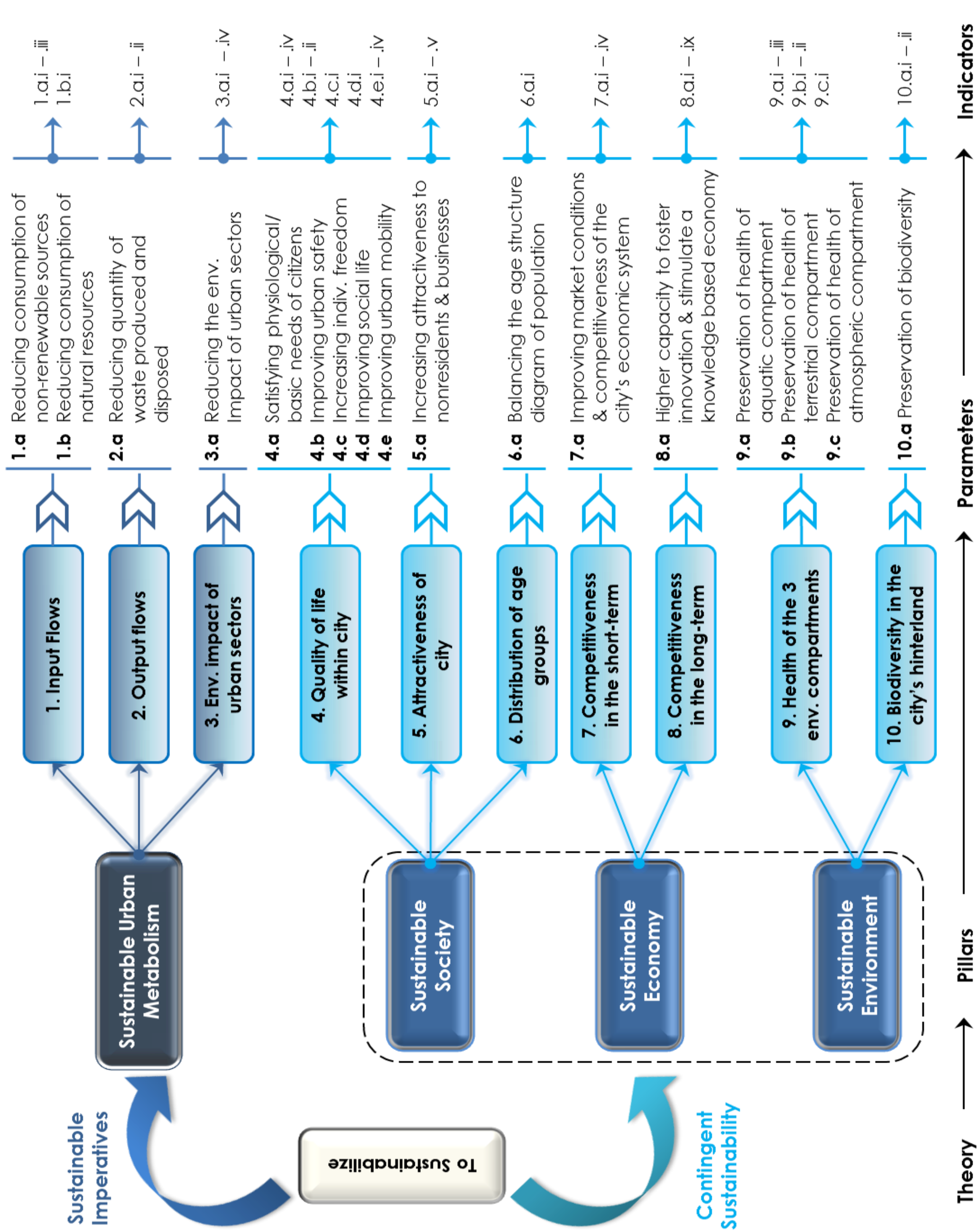
Sustainable Society	
Articulation of parameters in indicators	**Symbol & direction**
5. Attractiveness of city	
a. Increasing the attractiveness of city to nonresidents and business activities	
i. Net Immigration flow	$\Delta IM/\Delta t \geq 0$
ii. Number of Mega-Events hosted each year by the city	$\Delta ME/\Delta t \geq 0$
iii. Real-estate value range per neighborhood "i" and building typology "j"	$\Delta RE_{ij}/\Delta t \geq 0$
iv. Income tax of individuals and businesses	$\Delta TAX_{IND}/\Delta t \leq 0$
v. Corporate tax per commercial activity "i"	$\Delta CTAX_{i}/\Delta t \leq 0$
6. Distribution of age groups	
a. Balancing the age structure diagram of population	
i. Median age	$\Delta MA/\Delta t \leq 0$

Table 3.5: Identified SDI pertaining to the pillar "sustainable economy".

Sustainable Economy	
Articulation of parameters in indicators	**Symbol & direction**
7. Competitiveness of the city in the short-term	
a. Improving market conditions and competitiveness of city's economic system	
i. Net exports of the city	$\Delta NX/\Delta t \geq 0$
ii. Unemployment rate	$\Delta UE/\Delta t \leq 0$
iii. Gross Domestic Product of the city	$\Delta GDP/\Delta t \geq 0$
iv. Expenditures per Public Administration "i"	$\Delta EPA_i/\Delta t \leq 0$
8. Competitiveness of the city in the long-term	
a. Higher capacity to foster innovation and stimulate a knowledge-based economy	
i. Distribution of city's working population per educational qualification, per sector of specialization, and per working status (proxy for inferring the heterogeneity and conditions of labor force)	$\Delta H_{POP}/\Delta t \geq 0$
ii. Distribution of city's enterprises, annual gross profits, employed workforce and average payroll per sector (proxy for inferring the heterogeneity of the city's industry and development of each sector)	$\Delta H_{IND}/\Delta t \geq 0$
iii. Number of new start-ups per industrial sector "i" (proxy for inferring the facility to open new businesses)	$\Delta SUps_i/\Delta t \geq 0$
iv. Regional expenses on R&D activities per institutional sector "i" (proxy for inferring the level of Investments in innovation)	$\Delta R\&D_i/\Delta t \geq 0$
v. Index of Flexibility in Labor Relations Law	$\Delta FLR/\Delta t \geq 0$
vi. Share of households passed by an infrastructure that enables a cable modem Internet connection (proxy for inferring the level of Urban Broadband Connectivity)	$\Delta UBC_H/\Delta t \geq 0$
vii. Corruption Perception Index	$\Delta CP/\Delta t \leq 0$
viii. Share of population with 3G coverage of at least one operator (proxy for inferring level of Ubiquitous Connectivity)	$\Delta 3G/\Delta t \geq 0$
ix. Number of national/international Metropolitan Areas directly connected to the city (proxy for inferring the level of Urban Physical Interconnection)	$\Delta MA/\Delta t \geq 0$

Table 3.6: Identified SDI pertaining to the pillar "sustainable environment".

Sustainable Environment	
Articulation of parameters in indicators	**Symbol & direction**
9. Health of the three environmental compartments	
a. Preservation of the health of aquatic compartment	
i. *Biological and Chemical Oxygen Demand of closed water bodies and effluents (proxy for inferring the health of aquatic compartment)*	ΔB-COD/$\Delta t \leq 0$
ii. *Concentration of pollutants in closed water bodies and effluents (proxy for inferring the health of aquatic compartment)*	$\Delta CP_W/\Delta t \leq 0$
iii. *Coast and lake fish productivity (proxy for inferring the state of the fauna of aquatic compartment)*	$\Delta FP_W/\Delta t \geq 0$
b. Preservation of the health of terrestrial compartment	
i. *Concentration of soil pollutants (proxy for inferring the health of terrestrial compartment)*	$\Delta CP_T/\Delta t \leq 0$
ii. *Share of land sealed (proxy for inferring the health of terrestrial compartment)*	$\Delta LS_T/\Delta t \leq 0$
c. Preservation of the health of atmospheric compartment	
i. *Concentration of air pollutants (proxy for inferring the quality of air)*	$\Delta CP_A/\Delta t \leq 0$
10. Biodiversity in the city's hinterland	
a. Preservation of biodiversity	
i. *Share of the region's surface designated as natural protected areas*	$\Delta PA/\Delta t \geq 0$
ii. *Population index of common birds*	$\Delta PIB/\Delta t \geq 0$


Sustainable Imperatives
To Sustainabilize
Contingent Sustainability
Sustainable Urban Metabolism
Sustainable Society
Sustainable Economy
Sustainable Environment
1. Input Flows
2. Output flows
3. Env. impact of urban sectors
4. Quality of life within city
5. Attractiveness of city
6. Distribution of age groups
7. Competitiveness in the short-term
8. Competitiveness in the long-term
9. Health of the 3 env. compartments
10. Biodiversity in the city's hinterland
1.a Reducing consumption of non-renewable sources
1.b Reducing consumption of natural resources
2.a Reducing quantity of waste produced and disposed
3.a Reducing the env. Impact of urban sectors
4.a Satisfying physiological/ basic needs of citizens
4.b Improving urban safety
4.c Increasing indiv. freedom
4.d Improving social life
4.e Improving urban mobility
5.a Increasing attractiveness to nonresidents & businesses
6.a Balancing the age structure diagram of population
7.a Improving market conditions & competitiveness of the city's economic system
8.a Higher capacity to foster innovation & stimulate a knowledge based economy
9.a Preservation of health of aquatic compartment
9.b Preservation of health of terrestrial compartment
9.c Preservation of health of atmospheric compartment
10.a Preservation of biodiversity
1.a.i – .iii
1.b.i
2.a.i – .ii
3.a.i – .iv
4.a.i – .iv
4.b.i – .ii
4.c.i
4.d.i
4.e.i – .iv
5.a.i – .v
6.a.i
7.a.i – .iv
8.a.i – .ix
9.a.i – .iii
9.b.i – .ii
9.c.i
10.a.i – .ii
Theory
Pillars
Parameters
Indicators

Conclusions

Indicators as empirical indirect interpretations of reality are constantly being used in many management and policy analysis practices. This is especially true in the case of planning for sustainability, as this activity deals with a concept which is particularly complex, debated, interdisciplinary and malleable according to different interests and beliefs.

The same reasons that make Sustainable Development Indicators (SDI) so important are also the ones responsible for the abundance of different methodologies for assessing sustainability at the settlement level. In trying to justify, with the support of evidence, the lack of consensus over a method for measuring sustainable development, this chapter reviewed several initiatives carried out by academicians and governments. After discussing them, it was concluded that a universal methodology for measuring the progress made by cities in the direction of sustainability will never be reached as:

1. There are different opinions regarding what is to be sustained, what is to be developed, and for how long (Parris & Kates, 2003).
2. Sustainability is much of a process of discourse and effort as it is a state (Fricker, 1998).
3. The concept of sustainability addresses the ultimate question of the meaning of quality of life (Fricker, 1998).
4. Sustainable development possesses several features which are contingent by nature (i.e. they allow for different interpretations of the concept according to stakeholders' interests, values and beliefs) (Bossel, 1999; Fricker, 1998; Levett, 1998).

Facing the fact that sustainable development is inherently a malleable concept, this chapter tried to conceive a general method for assessing the contribution of urban policies (e.g. Intelligent and Knowledge City Programmes) to the achievement of sustainable cities. **The aim was to develop a framework (entitled *"the sustainabilizing city tree"*, ref. page 91), potentially suitable for every city, which shows how the essence of sustainable cities can be operationalized.** Besides representing a contribution to the methods for narrowing down and measuring the broad concept of urban sustainability, **the framework developed will serve as a tool for tracking the contribution of Intelligent and Knowledge City Programmes to specific aspects of the sustainabilizing city.**

The procedure followed for the design of the *sustainabilizing city tree* was illustrated in the second part of this chapter. The first step consisted in the transposition of the working definition of sustainable development (ref. Chapter 1) to the city. This activity revealed the existence of two main sets of sustainability principles:

- ***Sustainability 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.
- ***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.

Having made this important clear cut distinction, the second step consisted in identifying the elements pertaining to these two sets, which brought to the formulation of four pillars: (I) *the Sustainable Urban Metabolism*, (II) *the Sustainable Society*, (III) *the Sustainable Economy,* and (IV) *the Sustainable Environment pillar*. Following on, these pillars were articulated in a total of 10 parameters which are listed in Table 3.7.

Table 3.7: Sustainability sets, pillars and relative parameters

Sustainability sets and pillars	Parameters
Sustainability imperative	
I. Sustainable Urban Metabolism *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*	1. Input flows 2. Output flows 3. Environmental impact of urban sectors
Contingent sustainability	
II. Sustainable Society *A city is socially sustainable when it is able to attract and retain population within its urban boundaries*	4. Quality of life within the city 5. Attractiveness of the city 6. Distribution of age groups
III. Sustainable Economy *A city is economically sustainable when it is able to continuously improve the welfare of its society*	7. Competitiveness of the city in the short-term 8. Competitiveness of the city in the long-term
IV. Sustainable Environment *A city is environmentally sustainable when it is able to satisfy the system's demand of ecosystem services, without running the risk that these are depleted or permanently damaged*	9. Preservation of the health of the three environmental compartments 10. Preservation of biodiversity in the city's hinterland

The final step consisted of operationalizing the 10 defined parameters in a set of measurable indicators. However, before performing this activity, a set of guiding principles were defined. This was done by building on the knowledge obtained from the review of more than a dozen initiatives for measuring sustainable development at the urban level. The guideline developed consisted of the following four main points:

- The initiative should be embedded in a conceptual framework of sustainable development.
- 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").
- Formulation of indicators in terms of rates of change (i.e. derivatives with time as variable of differentiation)[1]
- The measurement system should focus on the essence of sustainable development, following the *Keep It Simple Stupid* (KISS) principle.

Following these four principles, a total of 49 indicators (10 for the sustainability imperatives set and 39 for the contingent sustainability one) were developed (ref. Table 3.3, 3.4, 3.5 and 3.6). It was underlined throughout the chapter that, due to the nature of the parameters pertaining to the Contingent sustainability set, a universal definition of the respective parameters and indicators cannot be achieved. In fact, it was concluded that the SDI pertaining to the *sustainable society, economy and environment pillars* need to be defined through negotiations with representatives of the urban community and stakeholders of the specific city. However, for the scope of this project, it was necessary to proceed with the formalization of these three aforementioned pillars, which was presented as a proposal and as an illustrative example for the reader. To support this activity, several documents deriving from International and National Institutes of Research and Statistics (e.g. OECD, Eurostat, Italian National Institute of Statistics) were used.

A detailed description of the 49 indicators, including the relative source of reference, is presented in Appendix 8.

[1] The advantages and utility of defining SDI in terms of rates of change for the scope of this research were discussed in detail in this chapter (ref. section 3.2.3).

Intelligent Cities

What happens when urban environments start thinking?

Chapter 4

"Intelligence is what you use when you don't know what to do."

Jean Piaget

Summary

The Intelligent City urban ideal is growing momentum since the 1990s, probably as a consequence of the awareness regarding the immense possibilities offered by modern Information and Communication Technologies. As Intelligent Cities start establishing themselves around the globe, high expectations are flourishing regarding their ability of making urban systems more sustainable. In order to determine whether these expectations are based on evidence or mere wishful thinking, it is necessary to start with a clear understanding of what "urban intelligence" really means. In other words, what happens when cities start thinking, and what does this mean? After introducing the reasons that have brought to the success of the Intelligent City label, Chapter 4 provides insights on the essence of intelligent urban environments. In doing so, it will initially demonstrate how the concept is characterized by two substantially different connotations: the Intelligent City as an innovation hub and the Intelligent City as an urban system that seeks operational excellence. Having made this distinction, the chapter will discuss these two different visions of the Intelligent City separately, highlighting their main features, the value added to urban systems and objectives pursued. Successively, the chapter investigates on the role of ICT for the creation of Intelligent and Knowledge Cities and discusses on the obstacles and policy challenges that these two urban visions will face in turning into a concrete reality. The chapter concludes by presenting a conceptual framework for systematically characterizing Intelligent and Knowledge City Programmes that will be used in the following parts of this research.

Keywords
Intelligent Cities: Knowledge Cities; Ubiquitous Cities; Urban Management; Innovation Systems; ICT

Goal of Chapter 4

The goal of this chapter is to investigate on the nature and main features of Intelligent and Knowledge Cities for providing the project with a solid body of knowledge on the concept of Intelligent Urban Environments. In line with this overall goal, Chapter 4 will attempt to find an answer to the following questions:

1. What is the essence of the "Intelligent and Knowledge City" and what are their characterizing elements?
2. What are the goals that Intelligent and Knowledge Cities are expected to achieve and how are they supposed to achieve them?
3. What is the role played by ICT in making urban systems more intelligent?

4. What are the obstacles that Intelligent and Knowledge Cities face?
5. What are the features that distinguish Intelligent and Knowledge City Programmes (ICPs and KCPs) from traditional urban (re-)development projects?
6. How can we identify and characterize ICPs and KCPs in a way that is functional to this project?

Special note

Given the scope and time frame of this project, it was not possible to go into much detail concerning the technical characteristics of Intelligent and Knowledge Cities. Besides, there are numerous different strategies for implementing intelligence within an urban environment and detailed information regarding the technical aspects of such projects was not found from the bibliographic research performed on the topic (the plan and technical details of these projects are not treated by scientific articles and newspaper publications). Thus, this chapter adopts a high level of analysis, focusing on the essence of Intelligent and Knowledge Cities and highlighting their main features and value added. More insights on ICPs and KCPS will be provided in Chapter 5 when assessing the selected case studies.

4.1 A window of opportunity for the digital city

In trying to shed light on the essence of Intelligent Cities, it would be wise to initially take one step back and focus on the reasons that have given birth to this concept which is growing momentum since the 1990s (Santinha & Castro, 2010). By understanding the factors that have brought to the birth of this urban ideal, its *raison d'être* together with its underlying features will stand out more clearly.

It is acknowledged that cities are the most important social, economic, cultural, and defensive structures that humankind has ever produced (Harrison, *et al.*, 2010). As cities grow in dimensions and complexity, there is always more the need to find new integrated methods to manage them, especially in light of the present economic and environmental crisis, concerns for sustainability and increasing global competition (Department of Foresight and Planning and International Affairs of Portugal, 2007). These innovative management methods need to consider entire more effective decision-making structures, able to cope with the increased dynamicity with which societies evolve. Above all, they need to find ways for integrating the physical, social and economics parts of the city in a sustainable and efficient manner (Yigitcanlar, 2008).

Urban planning is aware of these new challenges (ref. Chapter 2), and has dramatically evolved since the 1960s in order to cope with them. During this process of change, two dominating principles are arguably guiding the future of urban management (Department of Foresight and Planning and International Affairs of Portugal, 2007):

- **Sustainability:** urban management is called to find solutions that maximize the use of already urbanized spaces, reduces urban sprawl and improve the way cities function so that they result more sustainable.
- **Competitiveness:** cities have to find new ways for remaining competitive on the global stage, they need to retain talent, attract capital and above all foster innovation and new economic activities

Thus, cities are striving to find ways for increasing their attractiveness at a time when sustainability is becoming a major concern and differentiation factor (Harrison, *et al.*, 2010). Furthermore, this is occurring in a context characterized by the affirmation of a knowledge-driven economy, where organizational capacity, institutional leadership and creativity combined in order to produce innovation are the main drivers of competitiveness (Santinha & Castro, 2010). With regards to this last point, cities are increasingly aware of their entrance in the Information Economy, "where information is no longer an instrument for producing economic merchandise, but has itself become the chief merchandise" (Eco, 1986). In this new economic context, knowledge and information play a leading role in generating economic value and competitive advantages by supporting technological innovation (Santinha & Castro, 2010).

> *"Knowledge is the third factor of production, alongside labor and capital. In other words, knowledge is the 'Ingredient' underlying the competitiveness of nations, regions and firms."* (Romer, 1996)

How can cities achieve the goals of sustainability and competitiveness at a time of global economic crisis? How can they generate innovation, retain and attract talent, manage knowledge and stand out in a world of increasing competition? While governmental decision-makers are trying to find solutions to these pressing needs, Information and Communication Technologies have experienced an incredible development since the 1990s. Similarly to the effects that the first industrial revolution had on the spatial and social organization of cities, so is the current ICT revolution radically transforming the entire concept of urbanity (Hepworth, 1990). Today, the implementation of ICT in the structure of cities offers a whole new range of possibilities that no one could have ever imagined. Cities have the possibility to be *Ubiquitous*, to interact with its citizens through *Ubiquitous-infrastructure* and to provide them with *Ubiquitous-services* (Yigitcanlar, 2008). Thanks to extended and affordable broadband connectivity, the installation of sensors in different key points of the city and massive adoption of smart phones and devices among its citizens, cities can monitor their performance, keep track and store live data regarding its different sub-systems and all allow the flow and exchange of this information with its inhabitants.

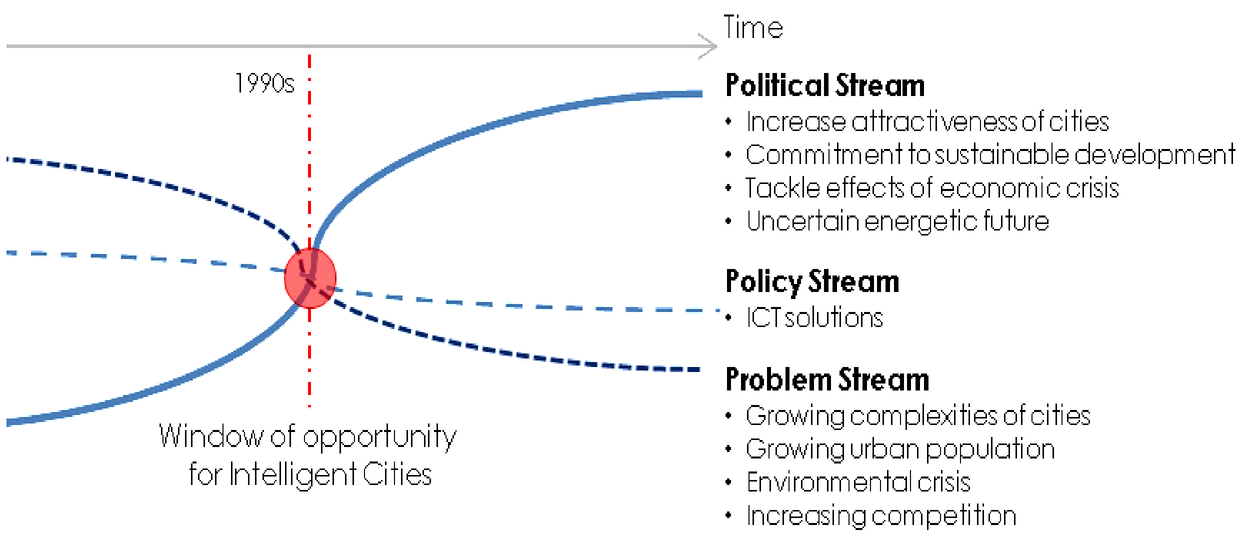


Figure 4.1: A window of opportunity for the digital city.
Source: Application of the Kingdon Model (Kingdon, 1995).

As it usually happens with many inventions, they require *policy windows* to open, opportunities that stand out in a given set of circumstances. According to J. W. Kingdon, this happens when the three *decision-making streams* (i.e. the policy, problem and political streams) meet (Kingdon, 1995). In many ways we could conclude that the digital city concept has grasped the policy window opened by the current environmental crisis and economic context (the problem and political streams). But above all, the combination of these two factors with the huge technological progress of the past two decades (the policy stream) has set the ground for the birth of the digital city ideal. In fact, the importance of digital technologies in improving the operational efficiency and quality of life in cities has long been acknowledged (Harrison, *et al.*, 2010), but there were various obstacles that limited their use and possibilities, mostly related to their high costs. Today, most of these obstacles have been overcome thanks to a growing competitive market that fosters innovation and price reductions, allowing telecommunication devices to become a basic component of everyone's life. Above all is the fact that sensors are becoming ever smaller, cheaper (in accordance with Moore's law) and able to detect the tiniest details of the environment (The Economist, 2010a).

Figure 4.2: The digital city giving rise to a new concept of urbanity.
Source: http://www.pikeresearch.com/research/smart-cities

The last, but not least important reason determining the popularity of digital cities as a solution to most of the problems that governments are facing is related to their costs and time of implementation, especially if compared with traditional urban planning solutions. Given the current strict budget constraints and the uncertainties related to the performance of different urban forms in terms of sustainability (Jabareen, 2006), governments favor investments in creating "smarter cities" in the *hope* that these will reveal more sustainable. In this optic, the digital city is regarded as the most cost-efficient solution for making cities more flexible, more efficient, more sustainable, more urban, more aesthetic and functional (Mega, 1996). There is little disagreement that Investing on efficient and modern management systems for achieving smarter cities is much more convenient than modifying the physical structure of cities (Harrison, *et al.*, 2010), but this does not, however, guarantee the success of these strategies in achieving more sustainable and competitive cities. This is especially true because at the present moment there are no clear instructions as for how should urban decision-making handle the huge quantity of information and data captured by smart sensors and monitoring systems, and because the relation between "urban intelligence and sustainability" is not clear. No one disagrees with the fact that smarter urban environments are highly desirable, and that enhancing their performance will improve the quality of life of its inhabitants. Nonetheless, the exact contribution of the digital city to the achievement of sustainability targets is often vague, left implicit and affected by wishful thinking. If this contribution can be supported by valid arguments and data, the popularity of the digital city will undoubtedly grow.

> *"Many countries have been spending large chunks of their stimulus packages on smart-infrastructure projects, and some have made smart systems a priority of industrial policy."*
> (The Economist, 2010a)

4.2 Digital cities fostering urban intelligence and knowledge

Since the 1990s, almost suddenly, every city wants to become “smart”. But of course, which city would not want to achieve this laudable etiquette, irrespective of its true meaning? In order to clearly distinguish between a truly smart city and one which is simply lauding a label (Hollands, 2008), we have to initially answer the following question: how does a digital city become “smart” and what are the characterizing features of smart cities?

4.2.1 Recognizing two different visions of the digital city: Intelligent and Knowledge Cities

The greatest difficulty in narrowing down the concept of digital cities is probably determined by the multiple names and meanings that it possesses and the vagueness of the terms they embrace. In fact, there are many different and overlapping urban ideals that stem from the concept of digital cities. Today we often hear of the “Digital City” (Yovanof & Hazapis, 2009), the “Smart City” (Eger, 1997), the “Intelligent City” (Kominos, 2006), the “Ubiquitous City” (Yigitcanlar, 2008), the “Creative City” (Landry, 2000) and the “Knowledge City” (Ergazakis, Metaxiotis, & Psarras, 2004). As the various definitions presented in Table 4.1 demonstrate, all of these urban ideals have in common digital infrastructure and state of the art ICT as their backbone. Nonetheless, it seems as though for each of these city archetypes, digital infrastructure and ICT constitute the means to different ends. We could, in fact, group these different overall goals in two main categories which are discussed separately in the two following paragraphs.

1. Improving the **operational efficiency** of the city

Data platforms exploiting modern ICT have the ability to improve the decision-making structure by mapping and monitoring the spatial location of different types of service enquiry. This allows the identification and investigation of persistent problems in the city’s infrastructure that negatively affect its performance, providing urban decision-makers with valuable policy relevant information (Kingston, Babicki, & Ravets, 2005). Such information is then integrated in a model that connects the physical infrastructure of the city to the virtual one, allowing the gathering, integration, analysis and optimization of operational data which results in better planning and management activities and consequently higher operational efficiency of urban systems (Harrison, et al., 2010).

2. Developing the city into an **innovation system** that encourages the nurturing of knowledge and creativity

The second objective for which intelligent urban environments are designed is encouraging the circulation of knowledge among its inhabitants (Edvinsson, 2002), transforming the city in an innovation hub where intensive flows and exchanges of information take place. This new vision of the city, also known as the Knowledge City, is growing stronger as knowledge is becoming progressively more an important factor of production and competition in today's economy (Ergazakis, Metaxiotis, & Psarras, 2004).

Table 4.1: Different names and definitions of the same concept?

The Intelligent City (Kominos, 2006)

The Intelligent City is an innovation system involving multiple agents, combining activities that are intensive in knowledge, institutional cooperation and communication tools, which maximize the capacity to solve problems under strong leadership, by structuring itself in three levels. In short, we may consider the Intelligent City as a knowledge city committed to technological innovation and the creativity of its inhabitants, endowed with a strong institutional leadership and organizational capacity, looking for solutions to increase its competitiveness and sustainability.

The Digital City (Yovanof & Hazapis, 2009)

The digital city involves a series of ICT applications that concept involves a series of information and communications technology applications that simplify public transactions, reduce telecommunication costs, and offer a wide range of end-user services that meet the everyday needs of residents of urban environments. The goal is to create an environment for information sharing, collaboration, interoperability and seamless for all its inhabitants anywhere in the city.

The Smart City (Harrison, et al., 2010)

The Smart City is the city that connects the physical infrastructure, the IT infrastructure, the social infrastructure, and the business infrastructure to leverage the collective intelligence of the city.

The Ubiquitous City (Yigitcanlar, 2008)

The Ubiquitous City is a city that provides ubiquitous infrastructure and ubiquitous services for their residents and visitors by utilizing a range of ubiquitous technologies.

The Smart Thinking City (The Climate Group, Arup, Accenture, Horizon, 2011)

An 'intelligent' or 'smart' city is one that meets its challenges through the strategic application of ICTs to provide new services to citizens or to manage its existing infrastructure. It is a city that uses data, information and communications technologies strategically to:

- Provide more efficient, new or enhanced services to citizens,
- Monitor and track government's progress toward policy outcomes, including meeting climate change mitigation and adaptation goals,
- Manage and optimize the existing infrastructure, and plan for new more effectively,
- Reduce organizational silos and employ new levels of cross-sector collaboration,
- Enable innovative business models for public and private sector service provision.

Various sources.

Table 4.1 (2): Different names and definitions of the same concept?

The Knowledge City (Ergazakis, Metaxiotis, & Psarras, 2004)
The Knowledge City is a city that aims at knowledge-based development, by encouraging the continuous creation, sharing, evaluation, renewal and update of knowledge which is achieved through the continuous interaction between its citizens and at the same time between them and cities' citizens. The cities' knowledge-sharing culture as well as IT networks and infrastructure support these interactions.

Various sources.

To sum up, the implementation of modern ICT in the city's structure represents a means to opposite ends: improving the operational efficiency of the city and/or transforming it into an innovation hub. Given these two distinct goals, it is wise to differentiate the *Intelligent City* (i.e. the city that seeks operational excellence) from the *Knowledge City* (i.e. the city that encourages and nurtures creativity and innovation amongst its inhabitants). This distinction will be adopted throughout the remaining part of this research.

Figure 4.3: Cities pursuing urban operational efficiency and cities as innovation hubs.

4.2.2 Characterizing Intelligent and Knowledge Cities in terms of their value added to urban systems

Having substantially two distinct goals, Intelligent and Knowledge Cities add different value to urban systems and to the life of their citizens. The value added by these two types of cities is illustrated in the following paragraphs.

➢ Value added by Intelligent Cities

1. Optimization of urban sectors and infrastructure

At the base of Intelligent Cities lies the concept of smart urban management systems (Yigitcanlar, 2008) and Intelligent Infrastructure, "an open, standardized and scalable platform that provides the interface between service supply and citizen demand"

(Accenture, 2011). In theory, these systems have the ability to significantly optimize the usage of the city's physical infrastructure. The effects of infrastructure usage optimization have been rapidly recognized in the transport sector. For example, in Singapore "smart toll systems" coupled with real-time dynamic pricing are significantly reducing congestion on the main expressways of the city. Furthermore, by regulating traffic lights on the flow and average speed of vehicles, travelling time has been significantly reduced on some roads of the city (The Economist, 2010b).

Optimizing a system implies that the inflows of energy and resources and the outflows of waste are minimized while maximizing the services and value produced by the system. Consequently, the optimization of urban sectors and infrastructure can be articulated in three goals: (i) reduced consumption of resources, (ii) reduced impacts on the environment, and (iii) better services offered to citizens.

i. Reduced consumption of resources (minimization of inflows)

Being operational efficiency the main objective pursued, Intelligent Cities add value to urban systems by reducing the quantity of resources needed to deliver the same or higher quality of services to its citizens. This is the main idea of efficiency, probably the oldest and most common objective pursued by humans. The general strategy adopted by Intelligent Cities for pursuing this objective is to identify major losses and inefficiencies in certain urban sectors trough a wide range of sensors and actuators. Said in the words of Adam Freed, Deputy Director of Long Term Planning and Sustainability of New York City, "we need the data, to show what could be saved, and then we can make it happen" (The Climate Group, Arup, Accenture, Horizon, 2011). For example, smart water management systems implemented in London have been able to significantly reduce leakages in the water pipelines (up to 670 million liters of treated water per day) by identifying critical points in the infrastructure that, once fixed, would yield the highest benefits to the overall system in terms of resource (and costs) savings (The Economist, 2010b).

> *"If the power grid in America alone were just 5% more efficient, it would save GHG emissions equivalent to 53m cars, calculates IBM. In 2007 its congested roads cost the country 4.2 billion working hours and 10.6 billion liters of wasted petrol, according to the Texas transportation Institute."* (The Economist, 2010a)

ii. Reduced environmental impact of urban sectors (minimization of output waste)

By combining principles of low carbon emissions and resource efficient development, Intelligent Cities aspire to the mitigation of their impact on the natural environment (Alusi, Eccles, Edmondson, & Zuzul, 2011). Higher urban operational efficiency means that the Intelligent City requires fewer resources to function. Under this hypothesis, the consequence of a more efficient city is that its ecological footprint, that is the direct and indirect biocapacity needed to support people's consumption patterns is reduced (Ewing, Reed, Galli, Kitze, & Wackernagel, 2010). An example of how an Intelligent City can achieve this objective is provided by the implementation of Smart Grids. As explained by Accenture, "smart grids can result in more optimal power delivery, two-way communication across the grid, lower energy costs, more reliable power, and reduced carbon emissions" (Accenture, 2011). Thus, by reducing greenhouse gas emissions, Intelligent Cities are capable of reducing the impact of urban systems on the environment.

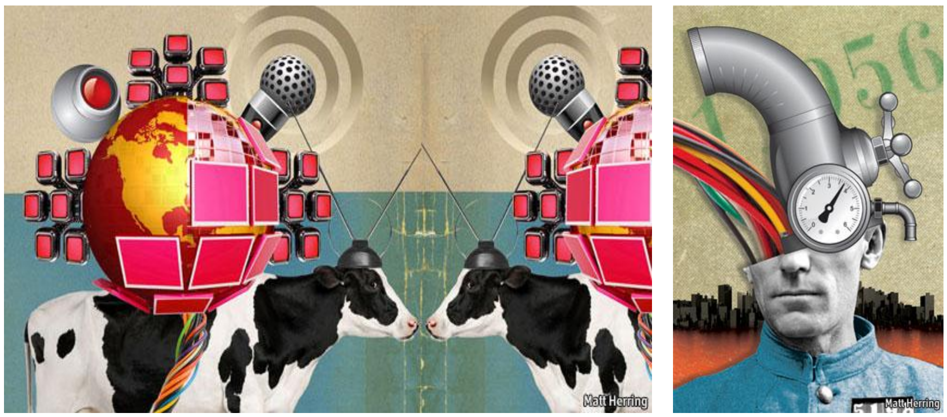


Figure 4.4: "It's a Smart World after all."
Source: The Economist, 2010a.

iii. Better services for higher living standards

Intelligent Cities are potentially capable of improving the quality of life within the metropolitan area by optimizing the physical infrastructure of the city and urban services while providing citizens with live information on specific aspects of the city. For example, the MIT Senseable Lab, in collaboration with Accenture, have developed a digital masterplan for the city of Singapore that allowed to optimize the distribution of taxis on the city's surface during peak times and extreme weather conditions (ref. Box 2.2). Always considering the transport sector, Intelligent Cities can help citizens take decisions on daily basis regarding the best routes and means of transportation for moving around the metropolitan area. Information on traffic congestion, waiting time at bus and metro stations, routes closed for accidents or maintenance activities can be delivered live through web community grid platforms[1] to citizens possessing smartphones. Intelligent Cities could also improve social equity by creating "Intelligent Enabling Environments, where disabled and aged people would be provided with user-friendly wearable computing devices, connected to a wireless, distributed and invisible two/multi-way data transmission system, allowing access 'on-the-go' of useful data related to buildings,

[1] For example, the city of Edinburgh investing on a pilot project for the creation of a web community grid platform (www.myedinburgh.com) through which citizens can have access to real time information on certain urban services, share knowledge and participate to decision-making processes related to urban planning and management.

urban infrastructure and services, and to transmit also user's personal data" (Macagnano, 2008). As a final example, Intelligent Cities can also increase public safety and security by installing video surveillance cameras in certain zones of the city (Yovanof & Hazapis, 2009).

2. Large scale monitoring of natural and urban environments

As technological progress is making sensors ever smaller, cheaper and capable of capturing the tiniest elements of their environment, their range of application has remarkably grown. In environmental monitoring and protection, sensors and actuators installed in strategic points of the urban environment can help localize major polluting sources, activities, and critical states of certain ecosystems. This information is extremely valuable for large scale environmental monitoring, which allows the Intelligent City to know exactly where major environmental criticalities occur within the region and take action for solving them more efficiently (Yovanof & Hazapis, 2009). For example, if a particular industrial activity is disposing toxic substances in a closed water body (e.g. a lake), a smart environmental management system will be able to detect this source of pollution and take action before the hypertrophication of the ecosystem is too advanced to reverse.

> *"In terms of time, effort and cost, there are numerous instances of efficiency and comfort achieved through IT. For instance, paying bills, shopping, booking concert tickets, reserving places at restaurants, browsing through the world's leading museums and art galleries, accessing videos and libraries, communicating with friends and family, (…)could all be done at unprecedented levels of comfort and efficiency."*
> (Mahizhnan, 1999)

➢ Value added by Knowledge Cities

1. Long-term competitiveness

The *raison d'être* of the Knowledge City is to create an innovation system having the mission of encouraging and nurturing "locally focused innovation, science and creativity within the context of an expanding knowledge economy and society" (Yigitcanlar, O'Connor, & Westerman, 2008). Thus, *Knowledge Based Urban Development* has the finality of adding long-term competitiveness to the city, making it stronger in a context of increasing global competition in which innovation is always more a key differentiator factor. Even if there are many and disputed strategies for encouraging innovation within a specific region, the Knowledge City mainly focuses on the creation of e-government and web community portals (i.e. web applications that offer citizens online services such as e-training, online libraries and e-commerce[2]) which make knowledge accessible to all citizens systematically and efficiently. In other words

[2] As an example, visit the e-government portal being developed in Melbourne (Australia) at the following address: www.agimo.gov.au/archive/seminars_and_events/2003/key_issues_mlb.html

"getting the right knowledge to the right people at the right time" is the scope of knowledge management activities (Ergazakis, Metaxiotis, & Psarras, 2004).

In supporting the development of a knowledge-based economy, Knowledge Cities bring value to urban systems by: (i) attracting high skilled, educated and talented citizens, and (ii) encouraging social and economic cohesion between human communities, the public and private sector.

i. Attract (and retain) talent and knowledge workers

The Knowledge City is in theory be able to create an environment which results attractive to highly skilled citizens in different domains (Ergazakis, Metaxiotis, & Psarras, 2004). Skilled workers are generally attracted by an environment of "collaborative innovation" where intellectual property rights are exchangeable and cooperation with R&D institutes is incentivized. This belief is supported by the general theory that knowledge attracts more knowledge, thus developing a positive feedback loop which becomes autonomous once initiated.

> *"In such a context of globalization, innovation emerges as a key factor for acquiring competitive advantages."* (Santinha & Castro, 2010)

ii. Encourage social and economic territorial cohesion

By facilitating information exchange and knowledge sharing through modern ICT networks, the Knowledge City aims at fostering social, economic and territorial cohesion (Santinha & Castro, 2010). Through extended broadband connectivity, people and organizations located in different points of the city can work together despite the physical distance separating them. A well-known example of how this phenomenon of cohesion takes place is provided by the increasing use of internet and dial-in conferencing calls (e.g. Office Communicator and Skype). Nonetheless, the strategy of promoting network communication systems could actually reveal a sword with two ends for the Knowledge City. If information and knowledge can be exchanged on the web, and if business and other social activities can be carried out regardless of the necessity to move over the territory, the core function of the city, that of physically concentrating economic and social activities, suddenly becomes questionable.

2. Improved governance of the city

Besides encouraging innovation, the Knowledge City brings value to urban systems in the form of improved governance systems (Santinha & Castro, 2010). Modern ICT combined with ubiquitous urban connectivity allow public administrations to enhance communication with citizens and the industrial sector. The goal of implementing e-governance systems (i.e. online gateways where information on the city is accessible to citizens and organizations) is to incentivize public participation and in urban policy-making processes and enable other principles of democracy and good governance in management of the city (Kominos, 2006).

Box 4.1: An attempt to measure and rank Smart Cities by the European Smart Cities Group

Among the various iniatives for defining and measuring Smart Cities, a meaningful attempt was carried out by a research group formed by the partnership of three European Universities (Delft, Ljubljana and Vienna). The project "Smart Cities – Ranking of European Medium Sized Cities" was set up with the objective of defining a methodology for classifying urban systems with a population between 100,000 and 500,000 inhabitants in terms of their "smartness". For the achievement of this goal, the researchers identified the following set of charactersitics and factors which define Smart Cities (European Smart Cities, 2007):

Characteristics and factors
1. Smart Economy (competitiveness) Innovative spirit; entrepreneurship; economic image & trademark; productivity; flexibility of labor market; international embeddedness; ability to transform
2. Smart People (human and social capital) Level of qualification; affinity to lifelong learning; social and ethnic plurality; flexibility; creativity; cosmopolitanism/open mindedness; participation in public life
3. Smart Governance (participation) Participation in decision-making; public and social services; transparent governance; political strategies and perspectives
4. Smart Mobility (transport and ICT) Local accessibility; (inter-)national accessibility; availability of ICT infrastructure; sustainable, innovative and safe transport system
5. Smart Environment (natural resources) Attractivity of natural conditions; pollution; environmental protection; sustainable resource management
6. Smart Living (quality of life) Cultural facilities; health conditions; individual safety; housing quality; education facilities; tourist attractivity; social cohesion

Source: European Smart Cities, 2007.

Another significant attempt to measure the level of maturity of Smart Cities was carried out by the Climate Group in collaboration with Accenture, Arup and Horizon. This is presented in Appendix 9.

4.3 ICT for Intelligent and Knowledge cities

Modern Information and Communication Technologies (abbreviated ICT) consist of Information Technologies (i.e. telephone lines and wireless signals, computers, middleware, software, storage and audio-visual systems)[3] which enable users to create, access, store, transmit and manipulate information[4]. The modalities through which ICT enables the creation of Intelligent and Knowledge Cities vary according to the specific service being provided. In general, these services and applications are based on some sort of "service platform" that connects data deriving from different sensors and information systems installed throughout the city (Nikayin & De Reuver, Submitted for review). Service providers then exploit these platforms in several ways in order to deliver and support innovative services offered to citizens (e.g. automated home solutions, buildings energy monitoring systems, remote e-health care, security monitoring systems, entertainment and communication applications, etc.). Without going into the technical characteristics of these platforms, the following sections discuss the modalities through which ICT enables the creation of Intelligent and Knowledge Cities

> *"ICT can strongly contribute to the process of making cities more intelligent by serving as a tool for improving the territorial governance system."* (Santinha & Castro, 2010)

4.3.1 ICT for creating Intelligent Cities

ICT can help cities achieve higher intelligence in the form of higher operational efficiency, by implementing the following three elements within the urban environment (Harrison, et al., 2010):

1. **Instrumentation**

Modern ICT instruments (e.g. sensors, kiosks, meters, personal devices telecommunication devices, video cameras, internet connection and other data-acquisition systems) that enable the measure and integration of live data deriving from different parts of the city. This data is then stored in an appropriately designed *virtual space*, the "digital layer" of the urban system where all policy-relevant information for urban planning is stored.

2. **Interconnection**

Through a Service-Oriented Architecture platform (SOA), information captured by ICT instrumentation is connected to the physical layer of the city, thus avoiding that *en masse* data remains isolated and unable to provide concrete indications on the state of

[3] http://en.wikipedia.org/wiki/Information_and_communications_technology
[4] http://foldoc.org/Information+and+Communication+Technology

different sectors of the city. In other words, digital data is combined and successively attached to the different sectors of the urban system, usually through the adoption of Geographic Information Systems (GIS).

3. Intelligence

By analyzing this interconnected information captured through ICT instrumentation, an intelligent system is able to model, optimize and visualize the performance of different urban sectors and services. All these operations significantly contribute to the enhancement of urban decision-making processes, which means higher operational efficiency of the city can be achieved. Smart systems are thus able to process huge quantities of information, saving decision-makers from drowning under such data.

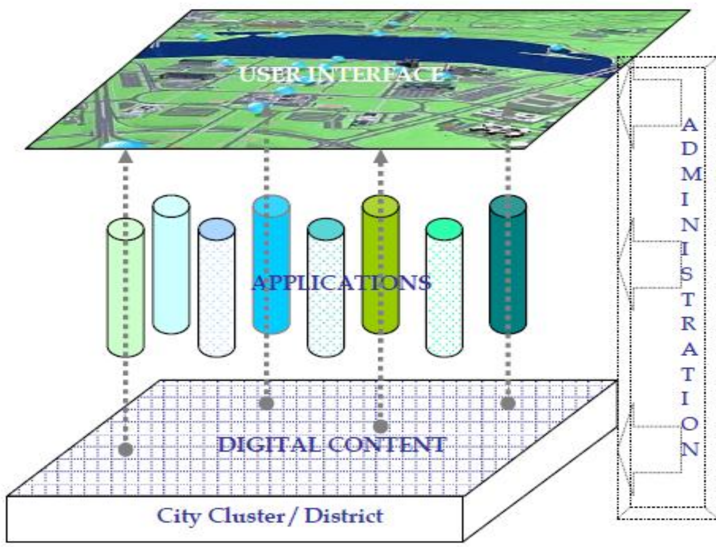


Figure 4.5: The interconnection between the digital and physical layers of the city. Source: Kominos, 2006.

It is worthwhile underlining how the characteristics of "intelligence" has been made possible thanks to the processing power and better connectivity of computing systems, which are now capable of storing and crunching the huge amounts of data produced by sensors and other devices located around the city's infrastructure (The Economist, 2010a). In fact, it is precisely because of the huge progresses in computer technologies that "supervisory control and data acquisition systems" have truly been able to become "smart". However, at the present moment there seems to be several obstacles designing interoperable platforms that can connect to the wide variety of sensors and information systems installed throughout the city (Nikayin & De Reuver, Submitted for review).

> *"Whether in water, power, transport or buildings, all are trying to turn their dumb infrastructure into something more like a central nervous system."* (The Economist, 2010b)

Box 4.2: Indicators of urban intelligence according to the Intelligent City Forum

The Intelligent City Forum (ICF) is a think tank that studies the economic and social development of the 21st Century community, with the objective of sharing the best practices of the world's Intelligent Communities in adapting to the demands of the Broadband Economy, in order to help communities everywhere find sustainable renewal and growth. In their research activities, the ICF has identified 5 indicators for measuring the level of "intelligence" of a community (The Intelligent Community Forum, 2012). These are:

- **Broadband connectivity** (measures the extension of broadband communication technologies over the urban community);
- **Knolwedge workforce** (measures the level of hihgly qualified/educated workers and skilled jobs of the community's economy);
- **Innovation** (measures the capacity of the community to foster innovation)
- **Digital inclusion** (measures the efforts made by the community in promoting access to digital technology and broadband to all its citizens);
- **Marketing and advocacy** (measures the capacity of a community to communicate and present its competitive advantages).

Source: http://www.intelligentcommunity.org/

4.3.2 ICT for creating Knowledge Cities

Within the Knowledge City, ICT is implemented in a different way than the one for developing intelligent urban management systems (Yigitcanlar, 2008). The goal of developing the IT infrastructure of a city is to encourage the exchange of knowledge and information between citizens and the central administration. This is done by developing the following four layers (Kominos, 2006):

1. The information storehouse, including all digital contents;
2. The applications level, which structure the digital content and provide online services (information, commercial and governmental);
3. The user interface, the web pages that citizens visit in order to get the services provided with the use of smartphones and mobile devices;
4. The administration, a tool for managing user rights to the applications and digital contents.

Thus, ICT in the Knowledge City is implemented in the form of extended internet connection and web applications that promote the interaction between citizens and other institutions so that knowledge and information is exchanged through digital platforms (i.e. *entertainment and communication service platforms*). Besides encouraging innovation and creativity within the city's population, this has also positive effects on territorial governance, as it promotes the participation of citizens in policy design and decision-making processes (Santinha & Castro, 2010).

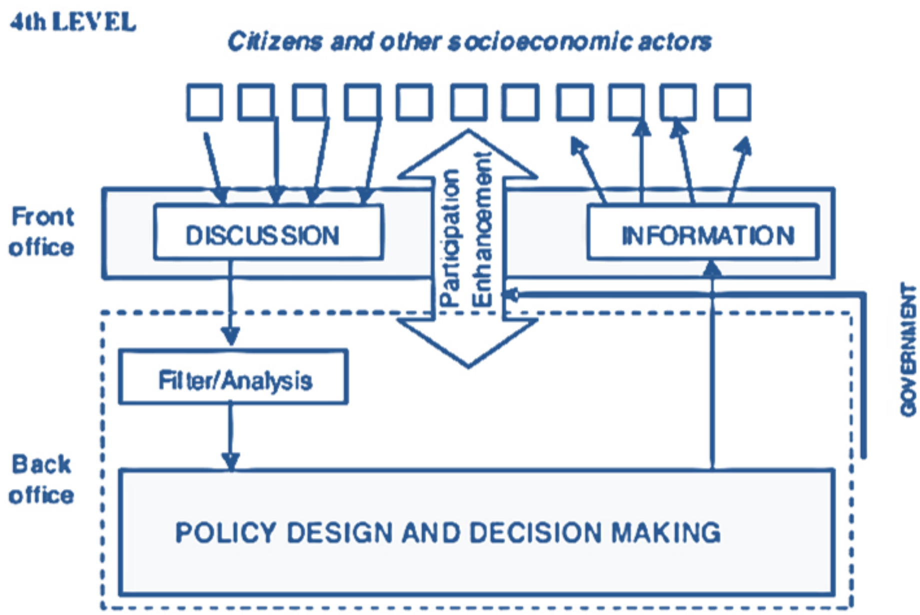


Figure 4.6: ICT devices and ubiquitous wireless networks for increasing the flow of information and knowledge amongst citizens and institutions.
Source: Santinha & Castro, 2010.

Table 4.2: ICT components of the Intelligent and Knowledge City.

Components	Intelligent City	Knowledge City
• Ubiquitous urban connectivity	✓	✓
• Extended use of Smartphones and wireless technologies	✓	✓
• Sensors and actuators for measuring data and monitoring natural/urban sectors	✓	
• Digital layer of the city	✓	
• Service platforms	✓	✓
• Intelligent Urban Management Systems (SOA)	✓	
• Web community grid platforms and knowledge management services		✓
• E-governance systems (e.g. U-life portals)		✓

4.3.3 Obstacles in creating Intelligent and Knowledge Cities

Take modern ICT, invest in internet wireless and broadband connectivity networks, locate sensors and actuators on the city's territory, design software and applications that can store and compute all the acquired data from the urban system, launch e-portals and community grid platforms for managing knowledge and information, and there you have it. Creating an Intelligent or Knowledge city is a simple as digitalizing its structure. Or is it not?

Unfortunately, the path towards making cities smarter seems hampered with obstacles and policy challenges. Intelligent and Knowledge Cities make use of networked infrastructure to enable social, economic and cultural development, but believing that installing ICT in the structure of cities is enough to make them "smart" is pure wishful thinking (Hollands, 2008). To overcome these obstacles, the participation and commitment of all actors of the urban system is a crucial ingredient (Santinha & Castro, 2010). After all, a city will never become smart if its citizens are not committed to doing their homework.

> *"As with nuclear energy, IT can be a force for good or evil. The smart community should be smart enough to make the right choice."*
> (Mahizhnan, 1999)

In this section, the main challenges that the Intelligent and Knowledge city need to deal with are discussed.

- **Controlling the use of internet in respect of local culture**

As the number of internet users is rapidly growing and as the content on the web expands, controlling this immense flow of information in the respect of local culture, ethos, ways of organization and governance becomes almost impossible. As A. Mahizhnan argues in his case study of how Singapore is converting into a "smart city", many countries are deeply concerned that "new technologies, most of which are flowing from the West, bring in their wake trends and influences that challenge and subvert long established traditions and beliefs of the recipient countries" (Mahizhnan, 1999). In this sense, we should recognize that like all other technologies, "IT is a double-edged sword as well" (Mahizhnan, 1999) which needs to be handled with care.

- ***No smartphone, no party***

There are several fears that a more digitalized society might actually lead to a decrease in social equity. Those that have the possibility to purchase a smartphone, or a portable computer with access to smart systems, will be much better informed than those who do not have such possibilities, giving them an "unfair advantage" (The Economist, 2010c). N. Kominos manifests similar concerns in asking the question whether "digital inclusion" actually means "digital exclusion" (Kominos, 2006). Form these considerations we also arrive to the conclusion that, in order to create Intelligent and Knowledge Cities, the population needs to have been previously educated to the use of ICT. Implementing a costly ICT infrastructure in a community where people are not able to take advantage of its benefits is completely useless (Deakin & Al Waer, 2011). With regards to this point, the Information for Development Program group has evaluated the effects on poverty and development of several *ICT-for-development projects* carried out in African states (Information for Development Program, 2003). The aim was to provide policy guidelines for implementing ICT in communities that had little or no education towards the use of these new computer technologies.

- **The *Big Brother syndrome*: the risk of violating privacy and personal freedom**

An "Ubiquitous-city" is virtually everywhere. Sensors, cameras and actuators can potentially allow governmental authorities to know where you are, where you have been, what have you done, which items have you purchased and which ones are you likely to buy, and a whole load of other personal information. If all this data is used in respect of privacy policies and for a good cause, then there should not be much to worry about. But a malevolent government could significantly take advantage of all this information, and with today's technologies and developed IT infrastructure, Winston Smith, the hero of George Orwell's book "1984", would be facing much bigger difficulties in trying to find a space to hide from "the big brother" (The Economist, 2010c).

> *"(…) much still remains to be done to demonstrate the economic impact and social acceptance of e-government systems."* (Kingston, Babicki, & Ravets, 2005)

- **Issues related to the management of radio spectrum**

There are several concerns related to radio spectrum management and the internet address system. Because of the dramatic increase in demand for internet-protocol addresses (IP), a number used as a unique identifier needed for a computer to connect to the internet network, these numbers could soon run out (The Economist, 2010c). There are also concerns related to radio spectrum management as the number of wireless devices and sensors is rapidly increasing.

- **Issues with the management of service platforms**

Despite the potential benefits offered by Smart Living Services, their presence on the market is still limited (Nikayin & De Reuver, Submitted for review). The reason underlying the restricted success of these services is being attributed to the "closed nature" of these service platforms: they are not interoperable with the sensors and information systems of the city despite the efforts made in standardizing technologies, and they remain inaccessible to third party service providers that could significantly expand the range of benefits deriving from these platforms (Nikayin & De Reuver, Submitted for review). Governments are currently working to solve this problem, trying to find policies that encourage cooperation between platform and service providers in order to fully leverage the benefits of these systems.

- **It's not just about collecting data and information**

Developing a monitoring system able of capturing the smallest detail on the state of the urban environment is not sufficient for making a city smart. The real challenge relies in how to design effective smart management systems able to process such immense quantity of data for really improving decision-making processes. For example, smart meters can significantly improve the intelligence of the electricity network only if operated in conjunction with the necessary management systems utilizing the data collected (Accenture, 2009). Besides the difficulties in designing smart management systems, "getting the city's islands of bureaucracy to work together" is not a piece of cake (The Economist, 2010c). Effective urban management requires different governmental departments of the city to share information and cooperate, avoiding the typical "turf, ego and power" behavior. Cities with a more hierarchical governmental structure and sometimes less democratic (e.g. Singapore) will have significant advantages in overcoming the barriers of bureaucracy.

Figure 4.7: e-Platforms as innovative knowledge sharing systems.

- **Difficulty of designing clear and effective implementation strategies**

Despite the numerous smart city technologies (e.g. smart grids, smart meters, real-time transportation systems) included in many pilot programmes implemented around the world, up to date there are no examples of cities launching fully-integrated, strategically-designed, smart city development programmes (The Climate Group, Arup, Accenture, Horizon, 2011). The reason seems to be that dialogues over smart city development are too much technology-led rather than needs and value-led, the value of digital infrastructure is not clearly demonstrated to the main stakeholders of the urban sector and the difficulty of aligning decision-making processes between multiple departments of the municipality with the sales cycle of companies (The Climate Group, Arup, Accenture, Horizon, 2011).

- **A smart city project could be outdated even before starting the implementation phase**

Probably one of the biggest challenges that cities desirous of becoming smart are facing is not so much in how to implement intelligent infrastructure as it is in how to stay smart in the future. The problem arises from the speed with which the computing power of microprocessors increases[5], and the time needed for planning and implementing urban projects. The substantial disparity between these two tempos implies that by the time that a city has gone through the design and execution stage of an intelligent infrastructure development project, the technology implemented could well be outdated. The questions of how to synchronize hard and digital infrastructure and how to keep the latter up to date with the speed of technological progress are yet to be answered (The Economist, 2010a).

[5] The processing power of sensors and computer chips roughly doubles each 18 months according to Moore's law.

4.4 A framework for identifying Intelligent and Knowledge City Programmes

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. Thus, for the scope of this project, it was necessary to define a framework for establishing whether a particular urban project/programme fulfills the definition of Intelligent or Knowledge City adopted in this research. In other words, the objective was to identify the features that differentiate Intelligent and Knowledge City Programmes (ICPs and KCPs) from each other and from traditional urban (re-) development projects. These features were sorted in four groups: (1) *the technological foundation,* (2) *the enablers of intelligence*, (3) *the type of intelligence supported and,* (4) *the value added by the project/programme.*

1. Technological foundation

On the basis of the bibliographic research performed and presented in this chapter, 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 Information and Communication Technologies[6] to enhance the management of the different urban sectors and environmental compartments of the city. Consequently, in order to label an urban project as an ICP or KCP, it should possess a *technological foundation* in the form of state of the art ICT and data platforms.

2. Enablers of intelligence

The next step for characterizing ICPs and KCPs was to focus on the technological means that arise from the ICT implemented by these two groups of programmes. From the knowledge gathered throughout this research, it was observed that ICPs and KCPs introduce ICT within urban and natural environments with the scope of providing them with three main systems:

- *Data acquisition systems*: 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.
- *Data processing systems*: hardware and/or software processing units that format, re-format, translate or convert raw input data in a final form of output information

[6] Ref. Section 4.3 for a definition of Information and Communication Technologies (ICT).

- *Knowledge sharing systems*: 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 (e.g. e-portals, e-governance systems, online training programmes).

It should be noted that data acquisition and processing systems, even if conceptually different, actually represent the two sides of the same medal. In fact, the two are strongly connected and generally always come together. Therefore, for simplicity reasons, these two systems were merged in a single block in the conceptual diagram of Figure 4.8. Moreover, because in some cases knowledge sharing systems are used for communicating information on the natural and urban environment, a dotted line connecting *knowledge* with *data acquisition and processing systems* was drawn in the diagram of Figure 4.8. This is the case, for example, of Smart Transport Systems that collect data on traffic congestion and communicate it through smartphone applications to drivers.

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.

As a final comment on the type of intelligence implemented by ICPs and KCPs, it should be noted that while artificial intelligence is dependent on data acquisition and processing systems based on digital technologies, this is not true for human and collective intelligence. In fact, the two latter do not require state of the art ICT nor digital technologies and have existed ever since. However, modern data acquisition, processing and knowledge sharing systems have significantly enhanced the capacity of humans to make decision and to co-operate as a community. Thus, the technological means implemented by ICPs and KCPs can be seen as enhancers of these two forms of intelligence.

> *Intelligence is the capacity of an agent (human or artificial) to transform complexity into simplicity.*

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:

- Improved management of environmental compartments (i.e. aquatic, terrestrial and atmospheric);
- Improved management of urban sectors and infrastructure (i.e. transport, water, energy, waste, buildings, public administrations);
- Behavior changes;
- Development of a knowledge-based economy;
- Better governance.

Depending on which the five values is brought by an ICP or KCP, it is possible to specify whether a programme is part of the former or latter group of initiatives: the first two types of value added result from ICPs, while the last two from KCPs. "Behavior changes" can belong to ICPs or KCPs depending on the final goal. If a programme aims at changing the conduct of humans (taken individually or as a collectivity) for optimization purposes, it will be considered an ICP. If the final aim is to educate citizens towards more eco-responsible and sustainable lifestyles, the programme belongs to the group of KCPs

The first two categories of value added are brought to the city by ICPs. Generally speaking, artificial and enhanced human/collective intelligence allow an upgrade in the management of the city's natural and urban environment. The objective of enhancing management practices is to optimize[7] ecosystem services and urban sectors so that services are delivered more efficiently and effectively to citizens. It should be noted that while artificial intelligence directly achieves the optimization of a system (e.g. automated lighting management systems that optimize illumination within buildings based on the detection of humans), human and collective intelligence can achieve this goal also through "behavior changes" (this connection has been labeled "indirect" in the framework presented in Figure 4.8). For example, energy monitoring devices implemented in Smart Building Programmes support households (human intelligence) in changing their energy consumption behaviors in order to optimize electricity usage. Considering behavior changes deriving from collective intelligence, an example is provided by traffic mobile applications, knowledge sharing systems through which drivers communicate information on traffic conditions.

Human intelligence is used directly for optimization purposes when urban managers use *data acquisition and processing systems* for improving decision-making processes, either by integrating data across different sectors of the city or by using a more detailed image of natural and urban sectors. In other words, ICPs that enhance the human intelligence

[7] In this instance, **optimization** of an urban sector or ecosystem refers to three goals: minimization of input resources (inflows of energy and materials), minimization of output waste, and maximization of the services delivered (ref. Section 4.2.2).

of urban-decision makers allow them to "turn inefficiencies into value by understanding the city as a system, breaking down silos and reducing fragmentation" (The Climate Group, Arup, Accenture, Horizon, 2011). As an example, consider "secure city technologies". These are cameras located in strategic points of the city that allow managers of the law enforcement department take decisions regarding the distribution of police officers over the territory (e.g. in case of unexpected crowds forming in certain areas of the city).

Table 4.3: Examples of ICPs and KCPs and their added value to the city.

Value added	Programme	Example
Improved mgmt. of building sector	**Intelligent Buildings**	London's Buildings Energy Efficiency Programme launched for reducing energy consumption and CO_2 emissions of public buildings
Improved mgmt. of water infrastr.	**Intelligent Water Systems**	Tokyo's water management programme launched to reduce leakages in the delivery of safe-to-drink water
Improved mgmt. of transport infrastr.	**Intelligent Transport Systems**	*SMART programme* launched in Singapore to optimize the distribution of taxis during peak hours and based on weather conditions
Improved mgmt. of public health	**Intelligent Healthcare System**	Taiwan's Telehealth Pilot Project for making health resources available close to patients' homes
Development of a knowledge based economy, better governance	**Gateways to online information storehouses**	Dublin is examining the effects of the programme Innovative Cities for Next Generation which is intended to make communities interact with the infrastructure to access services offered by the administration and information-based services
Improved mgmt. of public safety	**Secure City Technology**	Canada's Secure City Technology Alliance aimed at delivering integrated video, messaging and sensor networks to urban and regional emergency operations
Behavior changes	**Public Education systems**	Melbourne established frameworks by which federal state and local governments cooperatively work with local citizens to address sustainability challenges

Source: Accenture, 2011.

The last two categories of value added result from the implementation of KCPs. These programmes, by significantly enhancing the intelligence of the collectivity, have the goal of enabling a better governance of the city and the development of a knowledge-based economy. As an example of the former objective, consider e-governance portals, online gateways used by public administrations as a two ways channel of communication with citizens and/or as a tool for supporting public participation and other democratic principles in urban decision-making processes. An example of the latter objective is provided by online knowledge sharing platforms, virtual environments where citizens, public administrations, research institutes and industries cooperate for innovation-based activities.

Finally, programmes that drive behavior changes among citizens for educational purposes can be considered as KCPs. As an example, consider educational campaigns and online discussion forums where citizens share knowledge on topics such as sustainable development, climate changes and environmental degradation.

The reasoning delineated above for identifying ICPs and KCPs is summarized in Figure 4.8.

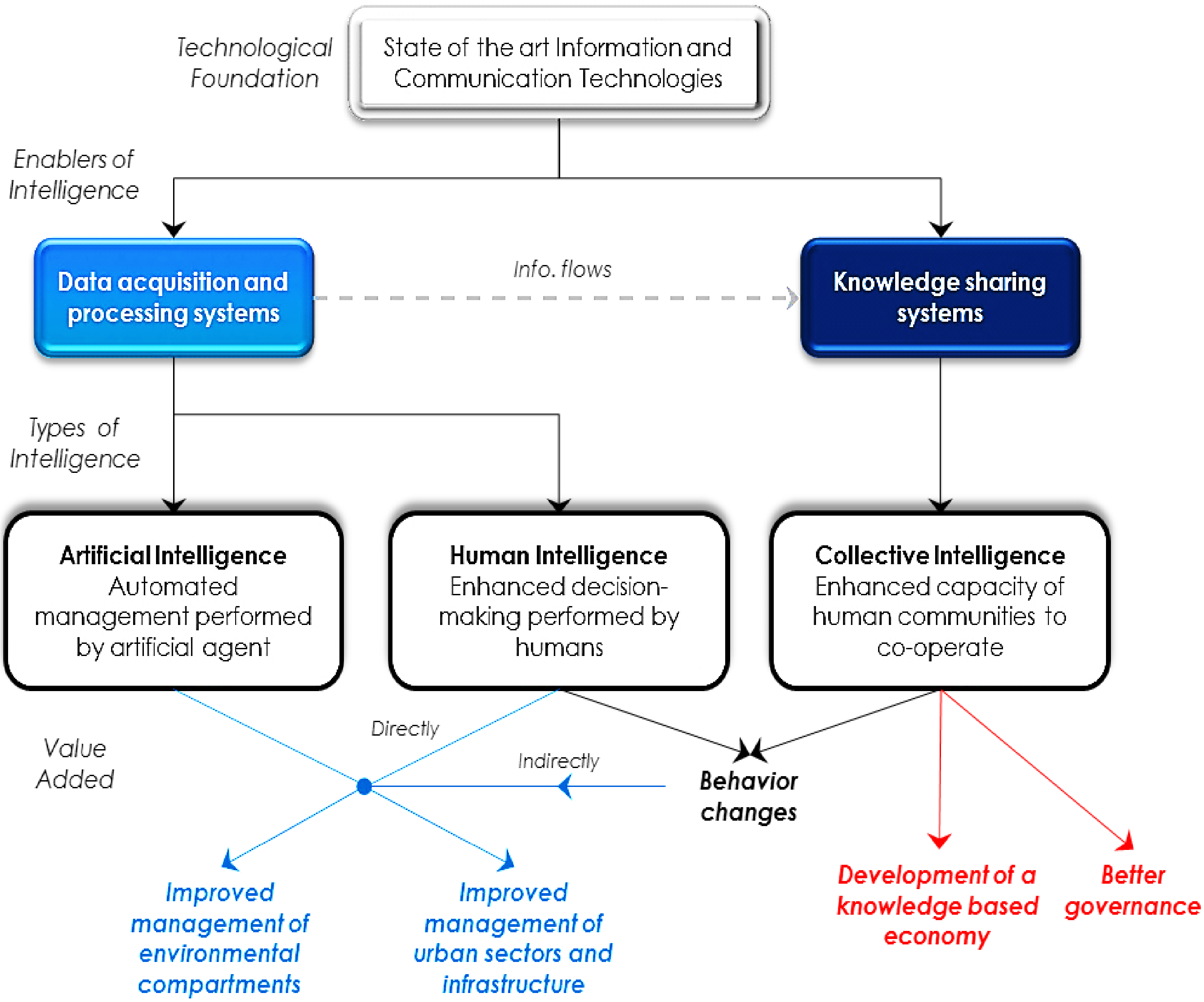


Figure 4.8: A framework for identifying and characterizing Intelligent and Knowledge City Programmes (ICPs & KCPs).

It comes without saying that the conceptual model developed is a simplification of reality, and characterizing ICPs and KCPs is not a simple as it seems. However, in spite of the limitations of the model and the definitions provided in this chapter, the framework fulfills its objective, which is threefold:

1. to provide the research with a systematic approach for characterizing ICPs and KCPs;
2. to define a methodology for selecting case studies for assessing the contribution of Intelligent and Knowledge City initiatives to sustainabilizing cities;
3. to provide the research project with a tool for connecting sustainable and intelligent cities (ref. Chapter 5).

Table 4.4 represents the labeling system that will be used in the following parts of this project to synthetically describe the selected ICPs and KCPs. Element "E: Additional requisites and/or assumptions" refers to the other components that the programme requires in order to deliver its potential added value to the city.

Table 4.4: Labeling system for ICPs and KCPs.

Elements of ICP/KCP	Description
A. Physical scale of programmes	-
B. Technological foundation	-
C. Implemented enabler(s) of Intelligence	-
D. Types of intelligence empowered	-
E. Additional requisites and/or assumptions	-
F. Finality of programme and value added to city	-

Conclusions

During the first years of the 1990s, the digital cities ideal began growing momentum as the result of the opening of a *policy window*, which occurred with the collision of three *decision-making streams*:

1. The *problem stream*, characterized by the difficulty in managing the growing complexity of urban systems, their continuous expansion, the effects on the environment of unsustainable urban metabolisms and the growing competition between cities on global scale;
2. The *political stream*, defined by the interest of governmental decision-makers in increasing the attractiveness and sustainability of their cities, tackling the current economic crisis and securing a stable energetic future;
3. The *policy stream,* represented by the potential benefits that modern ICT and IT infrastructure can deliver to urban management practices, especially now that their costs have radically decreased and that huge technological progress has been made in the processing power and connectivity of computers.

Since the opening of the window of opportunity, cities have progressively started investing in digitalizing their urban structure. These huge efforts are the result of the belief that making cities "smarter" is the most cost-efficient and effective strategy for achieving a form of sustainable development.

An investigation on the essence of "urban intelligence" has brought to the identification of diverse "city labels" and definitions of the concept. While digital infrastructure is the underlying feature shared by these different urban ideals, they substantially differ for their *raison d'être*. Two main urban archetypes stood out from the panorama of definitions characterizing digitalized urban environments:

- **The Intelligent City:** the city that exploits modern ICT for pursuing urban operational excellence through improved management of the city's sectors and infrastructure, resulting in better services provided to citizens, more efficiently and effectively.
- **The Knowledge City:** The city that exploits modern ICT for turning into an innovation hub that nurtures knowledge, creativity and technological innovation and for improving territorial governance systems.

The goals pursued by these two distinct urban ideals are substantially different, and so is the value added to urban systems (see Table 4.5 below).

Digging into the nature of these two different urban archetypes, the role played by ICT in creating Intelligent and Knowledge Cities was investigated. In sum, ICT within the Intelligent City is adopted for delivering three fundamental elements to the urban system:

1. *Instrumentation:* a whole set of digital monitoring devices (i.e. sensors and actuators) that collect live and detailed data on the functioning and state of different urban sectors
2. *Interconnectedness:* digital computing systems able to integrate and process the quantity of captured data, connecting it to the physical layers of the city through a *Service-Oriented Architecture platform* (SOA), or *Digital Masterplans*.
3. *Intelligence:* Innovative urban management systems and *service platforms* that exploit ICT for optimizing existing infrastructure and identifying the most effective ways for increasing the efficiency of the urban metabolism.

With regards to the process of developing cities into innovation systems, ICT and digital infrastructure are used for encouraging the exchange of knowledge and information between citizens and the central administration. This is done by developing the following four layers:

1. The information storehouse, including all digital contents;
2. The applications level, which structure the digital content and provide online services (information, commercial and governmental);
3. The user interface, the web pages that citizens visit in order to get the services provided with the use of smartphones;
4. The administration, a tool for managing user rights to the applications and digital contents.

The chapter included a brief discussion on the obstacles and policy challenges that governmental decision-makers are likely to face in the process of digitalizing their cities. These issues mainly refer to: (i) the difficulties in controlling the content of web information in respect of local culture; (ii) the risk of violating privacy and personal freedom (the diffusion of the *Big Brother Syndrome*); (iii) the challenge that digital inclusion will not turn into *digital exclusion*, affecting social equity by favoring those having the possibility of using computers and smartphones; (iv) finding ways for effectively processing and sharing data among the different governmental departments, bypassing inefficient bureaucracy; (v) designing policies that encourage co-operation between platform and service providers in order to fully leverage the value added of these systems, (vi) the management of radio spectrum as the number of wireless devices and sensors is rapidly growing; (vii) the difficulty of designing clear and effective strategies for the implementation of fully-integrated Smart City development programmes; and (viii) the substantial disparity between the tempos of technological progress and urban infrastructure development projects.

Finally, the chapter concluded with a framework for identifying and describing Intelligent and Knowledge City Programmes (ICPs and KCPs). In sum, the framework developed focused on four aspects of these projects: (1) the *technological foundation* of the programme/project, (2) the implemented *enablers of intelligence*, (3) the *type of* *intelligence* empowered, and (4) the *value added to the city* (ref. Section 4.4). The aim of the conceptual model was threefold:

1. to provide the research with a systematic approach for characterizing ICPs and KCPs;
2. to define a methodology for selecting case studies for assessing the contribution of Intelligent and Knowledge City initiatives to sustainabilizing cities;
3. to provide the research project with a tool for connecting sustainable and intelligent cities (developed in Chapter 5).

Table 4.5: Value added to urban systems by Intelligent and Knowledge cities

<table>
<tr><th>Intelligent Cities</th><th>Knowledge Cities</th></tr>
<tr><td>• Optimization of urban sectors and infrastructure
- Reduced consumption of resources (minimization of inflows)
- Reduced environmental impact of urban sectors (minimization of output waste)
- Better services for higher living standards
• Large scale monitoring of the natural and urban environment</td><td>• Long-term competitiveness
- Attracts (and retains) talent and knowledge workers
- Encourages social and economic territorial cohesion
• Improved governance systems</td></tr>
</table>

Intelligent and Knowledge City Programmes for urban sustainability

Assessing the contribution

Chapter 5

"The whole problem with the world is that fools are always so certain of themselves, but intelligent people so full of doubts."

Bertrand Russell

Summary

On the base of the frameworks and concepts developed throughout this research, in Chapter 5 a methodology for assessing the modalities through which ICPs and KCPs contribute to the achievement of urban sustainability is developed. Furthermore, this methodology is applied to the information gathered on ICPs and KCPs (ref. Chapter 4) and four case studies for achieving two objectives: (i) formulating a central hypothesis regarding the role played by these two types of programmes in enabling the "sustainabilizing" transition of cities, and (ii) improving the developed assessment methodology. Before presenting the case studies, the selection criteria and approach adopted for their assessment are discussed. Please note that even if presented as a linear sequence, these three activities (i.e. developing an assessment methodology; formulating a central hypothesis; assessing case studies) were performed in a cycle (ref. Figure C, page 6) which was repeated several times before presenting the final results of this research.

Keywords
Sustainable Cities; Intelligent and Knowledge City Programmes; Assessment Methodology

Goal of Chapter 5

The goal of this chapter is to shed light on the contribution of Intelligent and Knowledge City projects/programmes (ICPs and KCPs) to the achievement of urban sustainability. In order to reach this goal, a methodology for assessing the contribution is developed based on the knowledge gathered throughout this research and the assessment of four case studies provided by Accenture. Altogether, this chapter will attempt to answer the following set of questions:

1. How can we systematically assess the contribution of ICPs and KCPs to the achievement of urban sustainability?
2. What is the theoretical contribution of ICPs and KCPs to the pursuit of more sustainable urban environments?
3. What are the strong and weak points of ICPs and KCPs?

Special note

For a more complete evaluation of the hypothesis formulated regarding the contribution of ICPs and KCPs to the achievement of urban sustainability, it would be preferable to apply a significant number of IC and KC initiatives deriving from different organizations and regions of the world. Even if this research focuses on ICPs and KCPs implemented by Accenture, it does to a certain extent satisfy these requisites. In fact, Accenture has worked in collaboration with many different organizations and governments of all over the world, providing either strategic and management consultancy and/or technological solutions. With regards to the size of the sample used for testing the formulated hypothesis, this thesis had to deal with strict time constraints. The majority of the 6 month period dedicated to this project focused on the design of a methodology for evaluating ICPs and KCPs in light of urban sustainability. Thus, this chapter is not intended to provide an exhaustive application of the methodology, but to illustrate the approach to future research initiatives. Further investigation is required to verify the developed empirical model and formulated hypothesis (ref. Chapter 6, section 6.2).

As a final premise, please consider that in applying the developed methodology to the case studies selected, some assumptions needed to be made when assessing the contribution of an ICP or KCP to the parameters of sustainabilizing cities. This is because in most cases not all the required data for applying the methodology was retrievable, as most of the programmes were still in the implementation phase or represented pilots for testing the effectiveness of certain technologies. Moreover, as the majority of these initiatives involve innovative technologies that often require changes in the consumption behavior of citizens, predicting their outcomes in terms of numerical figures was not always possible with an acceptable level of reliability. Therefore, the contributions of ICPs and KCPs to certain parameters of the framework developed were defined according to the qualitative description of the objectives included in the project's plan and personal assumptions. These have been underlined throughout the entire chapter.

5.1 Combining concepts: how are ICPs and KCPs enabling the "sustainabilizing transition" of cities

The bibliographic research performed in the previous chapters resulted in the design of two conceptual frameworks that describe the essence of sustainabilizing cities and Intelligent/Knowledge City Programmes (ICPs and KCPs). Their final purpose was to develop a conceptual model for assessing the modalities and extent of the contribution of ICPs and KCPs to the achievement of sustainable urban environments. This framework was successively adopted for formulating a central hypothesis concerning the role played by ICPs and KCPs in sustainable urbanization.

In the following sections, the reasoning adopted for the development of the aforementioned methodology and hypothesis are presented.

5.1.1 Formulation of the central hypothesis: linking ICP and KCP value drivers to indicators of sustainabilizing cities

The framework developed for identifying and describing ICPs/KCPs evidenced the link between the ICT employed by these two types of programmes and their value drivers. This list of values was successively used for assessing the contribution of ICPs/KCPs to the achievement of urban sustainability. This was done by constructing a table with the values added by ICPs/KCPs on the first column and the parameters of sustainabilizing cities on the top row (see Table 5.1). Successively, based on the knowledge and evidence gathered throughout this research, the cells of the table where the value added by an ICP/KCP would contribute to parameters of sustainabilizing cities were colored in yellow (specifying the indicator of the parameter affected). All of these contributions are discussed in the following points.

Please note that for reasons of simplicity, in the table designed the value "behavior changes" was considered as the ultimate goal of a KCP and not also as a means for the value "improved management of urban sectors and infrastructure" (ref. Chapter 4, section 4.4 for further explanations). As a final remark, please note that the specific indicators affected by ICPs and KCPs are not entirely relevant. In this instance, the main focus was placed on the 10 parameters of sustainabilizing cities. The indicators defined for each parameter only represent a proposal (ref. Chapter 3, section 3.2).

- **1.a – Contributing to lowering the consumption levels of non-renewable energy**

ICPs do not necessarily include the installation of renewable energy technologies, so in this sense they are not directly leading to an increase in the share of renewable electricity in the gross final electricity consumption of the city (1.a.i). However, by optimizing the performance of the urban infrastructure, sectors and services (either directly or indirectly through behavior changes), they reduce the total quantity of energy consumed by cities (1.a.ii and 1.a.iii). But the greatest contribution to this parameter was observed in their capacity to change the electric network grid allowing the accommodation of decentralized energy production units fueled by renewable sources. In the words of Mr. Jeremy Rifkin, Smart Grids enable the development of distributed energy systems, where each building becomes both a consumer and supplier of electricity, transforming the energy network from a top-down structural organization to a multilateral system similar to the Internet (Rifkin, 2012). Turning to KCPs, these also contribute to this parameter by incentivizing more eco-responsible and sustainable lifestyles among citizens.

> *"The energy transition required for the Third Industrial Revolution to occur will have to transform the energy network from a top-down structure to a multi-lateral distributed system, just like the way internet functions."*
> (Rifkin, 2012)

- **1.b – Contributing to lowering the consumption levels of natural resources**

Besides reducing the energy consumption of the city's metabolism, optimization also translates in lower consumption levels of natural resources (e.g. reduction of water leakages in aqueducts) (1.b.i). Depending on the natural resource considered, in general the minimization of material inflows in the water, transport, energy and building sectors contributes to this parameter. An improved management of the environmental compartments does not directly lead to lower consumption levels of natural resources by the city, so this contribution was not considered. However, it can be argued that an improved management of ecosystems could help the formulation of policies for the preservation of these environments. KCPs could positively contribute to this parameter by incentivizing lifestyles that are less resource demanding. Moreover, these programmes could reach this goal as a secondary effect of shifting the city's economic structure from an industrial- to a knowledge-based system.

- **2.a – Contributing to lowering the quantity of waste produced and disposed**

Smart Waste Management Systems have the objective of optimizing the collection and transportation of urban waste, but they do not aim directly at reducing the city's production of garbage or at increasing the capacity of installed recycling plants. Up to now, waste management systems have adopted ICT and digital technologies basically for improving the logistics and transport of waste collection and disposal, so in this sense they do not directly affect the level of waste recycled by households and industries (Accenture, 2011). Technologies that improve the separation of waste in different categories (i.e. recyclable and non-recyclable materials) can increase the share of recycled waste, but these do not fit in the definition of ICPs provided in this research.

KCPs could positively contribute to this parameter by incentivizing behavior changes of citizens that result in less production of domestic waste and more attention in separating recyclable from non-recyclable materials (2.a.i and 2.a.ii). Moreover, similarly to the previous parameter, it can be assumed that a city with an economic system more specialized in knowledge-based activities produces, as a consequence, less urban waste than one which is mostly characterized by industrial activities.

- **3.a – Contributing to lowering the impact on the environment of urban sectors**

Optimizing the building, energy and transport sectors implies that ICPs can reduce the inflow of resources and the outflow of excess materials and substances. Consequently, optimizing these three sectors translates into lower consumption levels of fossil fuels, which means that emissions of GHG, air pollutants and heavy metals are reduced (3.a.i, 3.a.ii, and 3.a.iv). Even in this case, KCPs that incentivize eco-responsible behaviors within the community and ICPs that help citizens in making decisions that lead to a more efficient usage of energy (in the building and transport sector) can positively affect this parameter.

- **4.a – Contributing to the satisfaction of basic needs of citizens**

It seems that ICPs and KCPs do not have a direct impact on the basic/physiological needs of citizens. In this sense, they come through as sophisticated programmes more appropriate for “upgrading” the structure and functioning of mature cities. The key elements needed for satisfying the basic and physiological needs of citizens are traditionally delivered by urban development plans. However, a small contribution to a better quality of air within the city’s region (4.a.i) can be seen in ICPs enabling an improved management of the atmospheric compartment (though the implementation of air monitoring systems).

- **4.b – Contributing to urban safety**

Modern data acquisition systems are very useful enablers of a better control of the territory, thus helping law enforcement departments reduce criminality within the city’s boundaries (4.b.ii). Moreover, better governance systems made possible by KCPs that enhance communication channels between public administrations and citizens, together with the optimization of the health care system (e.g. through the implementation of “telehealth technologies”) also contribute to increased levels of urban safety (4.b.i).

- **4.c – Contributing to higher individual freedom of citizens**

No evidence was observed regarding the positive effect of ICPs and KCPs on the level of individual freedom of citizens. However, it can be argued that a knowledge-based society is potentially more open to cultural and ethnical differences and thus implicitly contributes to higher individual freedom of its citizens (4.c.i). Moreover, in the same way that KCPs support collective intelligence for producing behavior changes among human communities that are more respectful for the environment, the same can be done with regards to tolerance for cultural and ethnical diversities.

- **4.d – Contributing to higher quality of social life**

No evidence regarding the positive effect of ICPs on the social life within a city was observed. With regards to KCPs that stimulate the development of a knowledge-based economy, it can be assumed that the entertainment industry is generally more developed in societies where high skilled and educated people live (4.d.i).

- **4.e – Contributing to urban mobility**

The positive effects that ICPs deliver in terms of improved urban mobility have been observed from several projects (ref. Chapter 4). These are obtained from the optimization of transport infrastructure and mass transit systems (4.e.i, and 4.e.ii). Even in this case, it can be assumed that KCPs also contribute to this parameter by encouraging behavior changes in the community that favor mass transit systems. Moreover, it was observed how KCPs enabling better governance systems can provide disabled citizens with accurate information on the accessibility of public spaces (Macagnano, 2008).

- **5.a – Contributing to the attractiveness of the city**

A city offering efficient infrastructure and services is certainly more appealing than one which lacks these two features. Consequently, as urban infrastructure and services are made more efficient and effective or upgraded by ICPs, it can be stated that these programmes positively contribute to the attractiveness of a city, which is reflected in the net immigration flows, real-estate values, and the number of Mega-Events hosted each year (5.a.i, 5.a.ii and 5.a.iii). With regards to KCPs supporting the development of a knowledge-based economy, the attractiveness of a city is increased but only for a certain segment of the population. In fact, a rise in the demand for housing in a city (which translates into higher real-estate values) contributes to the expulsion of the poorest segment of the population and admittance of the wealthier citizens (a phenomenon known as *Gentrification*). It can also be assumed that KCPs improve the attractiveness of a city by equipping municipalities with enhanced governance systems.

- **6.a – Contributing to a balanced distribution of age groups**

No evidence regarding the effect of ICPs and KCPs on a more symmetrical distribution of age groups was observed.

- **7.a – Contributing to the competitiveness of the city in the short-term**

No evidence regarding the effects of ICPs on the short-term economic competitiveness of cities was observed. However, as the optimization of urban infrastructure, sectors and services also leads to a more efficient use of economic resources (mainly through savings), it can be argued that ICPs indirectly contribute to the competitiveness of the city by reducing expenditures of public utility service providers (7.a.iv).

- **8.a – Contributing to the competitiveness of the city in the long-term**

The *raison d'être* of KCPs is to create regional systems that encourage and nurture innovation. As innovation is considered to be one of the fundamental requisite for cities and organizations to be competitive in the long-term, KCPs contribute to the achievement of this goal by attracting talent workers of different sectors of specialization, supporting a heterogeneous industry and incentivizing R&D activities (8.a.i, 8.a.ii, 8a.iii and 8.a.iv). Moreover, KCPs contribute to the consolidation of the city's digital infrastructure and usually include investments in ICT necessary for connecting people and sharing information (8.a.vi and 8.a.viii).

- **9.a/b/c – Contributing to the preservation of environmental compartments**

ICPs can contribute to the preservation of the health of the biosphere by enabling improved management systems of environmental compartments. More accurate and sophisticated monitoring systems allow decision-makers of the environmental protection department to solve eventual criticalities (e.g. unexpected emissions of pollutants in water bodies) more quickly and effectively. However, the main contribution of ICPs to these parameters 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. Concerning KCPs, similarly to the case of parameters 1, 2 and 3, it can be assumed that these programmes contribute to this parameter by incentivizing behaviors that are more respectful of the environment, which might lead in the long-term to lower concentrations of pollutants in the three environmental compartments.

- **10.a – Contributing to the preservation of biodiversity**

No evidence regarding the direct effects of ICPs and KCPs to the preservation of biodiversity was observed.

5.1.2 Summing up

Table 5.1 summarizes the contribution of ICPs and KCPs to the achievement of urban sustainability by connecting their value added to the parameters of sustainabilizing cities. The pattern that stands out from the table leads to the following conclusions:

I. 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.

Achieving a sustainable urban metabolism represents the "sustainable imperative" of all cities, the *sine qua non* condition without which the structure of a city cannot accommodate the principles of a sustainable economy, society and environment (ref. Chapter 3, section 3.2). From the research performed it appears that both ICPs and KCPs are able of supporting cities in making their metabolisms more sustainable by adopting two different strategies: the former focus on optimizing the performance of the urban system (i.e. minimizing input flows and the environmental impact of urban sectors while maximizing services delivered to citizens), while the latter targets the lifestyles and daily consumption habits (i.e. incentivizing behavior changes within the community that are more eco-responsible and less resource demanding). It was also argued that, to some extent, KCPs enabling the development of a knowledge-based economy could also contribute to this goal. In fact, it can be assumed that a secondary effect of shifting the city's economic structure from an industrial- to a knowledge-based system results in lower consumption levels of natural resources.

Finally, an interesting finding was that ICPs seem not to impact directly on the quantity of urban waste produced and recycled by the city. The possible explanation of this result is that the level of waste produced and recycled by a city mainly depends on the lifestyles of its citizens and on their commitment to separate and recycle their garbage. In this sense, KCPs incentivizing behavior changes come through as the main levers for minimizing the output flows of waste produced by the city.

II. 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 (improved quality of life and attractiveness of the city).

According to this project's definition of a sustainable society (ref. Chapter 3, section 3.2), the research performed suggests that both ICPs and KCPs can contribute to parameters 4 and 5 of sustainabilizing cities (i.e. quality of life and attractiveness of the city). "Secure city technologies" and Smart Transport systems implemented by ICPs were observed to significantly enhance urban safety and mobility. Furthermore, ICPs increase the attractiveness and value of the city by making services more efficient and effective, thus resulting more appealing to potential immigrants. KCPs enabling better governance systems were also assumed to positively influence the quality of life and attractiveness of the city (only to certain segments of the population, namely high-skilled educated professionals).

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

According to this project's definition of a sustainable economy (ref. Chapter 3, section 3.2), gathered information suggested that both ICPs and KCPs are functional to parameters 7 and 8 of sustainabilizing cities. More specifically, the former contribute to the short-term competitiveness of the city optimizing urban sectors and infrastructure. This translates in reduced public expenditures for the provision of high quality city-services, which lead to higher competitiveness. Turning to KCPs, these focus on increasing the long-term competitiveness of the city by implementing knowledge sharing systems that encourage co-operation among citizens, research institutes, private and public organization in innovation-based activities. In this sense, the KCPs mainly contribute to the sustainable economy pillar of cities.

IV. 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. KCPs also contribute to this goal by promoting behavior changes within the community which are more eco-compatible.

In compliance with the definition of a sustainable environment provided in this project (ref. Chapter 3, section 3.2), ICPs implementing systems for monitoring environmental compartments can facilitate the preservation of ecosystems. This is true under the assumption that a better control of the city's natural environment results in effective actions on behalf of the local environmental protection agencies for preserving the state and quality of water bodies, air, green areas 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 (e.g. Smart Traffic Systems reducing congestion and stimulating mass transit means). Concerning KCPs, these were observed to contribute to the achievement of a sustainable environment in the moment that they succeed in making citizens more aware of the importance of preserving the environment and biodiversity, promoting lifestyles that are more eco-responsible and sustainable. No direct contribution was observed for both ICPs and KCPs for the preservation of biodiversity in the city's hinterland.

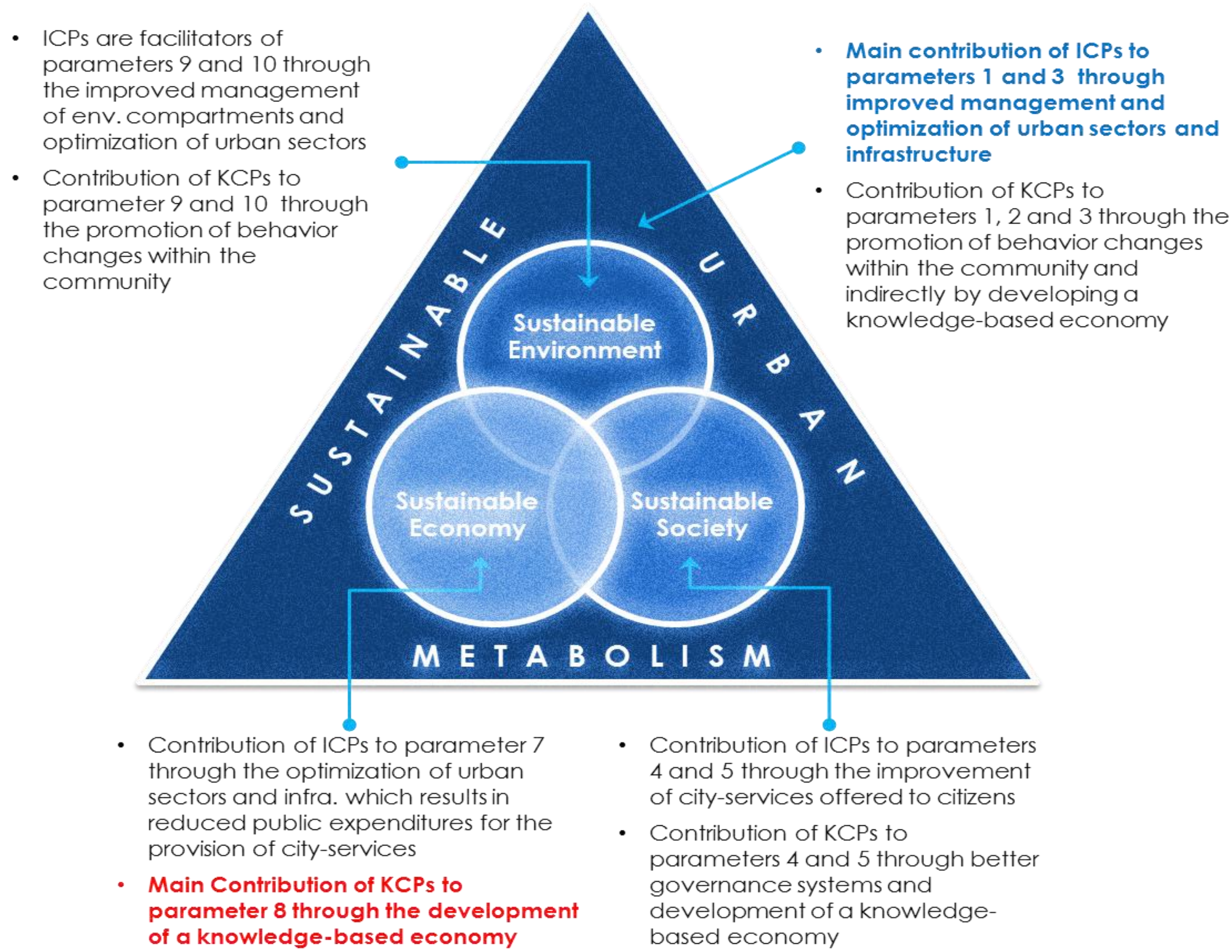


Figure 5,1: The contribution of ICPs and KCPs to the 4 pillars of sustainabilizing cities

To sum up, theory suggests that ICPs and KCPs can, to different extents, potentially contribute to all (except for parameter 6 and 10) **of the parameters pertaining to the four pillars of sustainabilizing cities.** The extent of the contribution obviously depends on the specific scope and dimensions of the programme, and can be determined based on the rate of change of the indicator affected. However, **it can be stated that ICPs are primarily enablers of a sustainable urban metabolism, while KCPs leverage their value mainly in the sustainable economy pillar.**

As a final remark, it is important to evidence how, for several ICPs and KCPs, the success of these programmes highly depends on the extent to which humans (both individually and collectively) really become "intelligent". Leaving aside *artificial intelligence*, most ICPs and KCPs are designed for supporting humans in making better decisions (*human* *and collective intelligence*), but it is up to them to finally take the right actions that make cities more sustainable. **In sum, intelligent urban environments are indeed more sustainable, especially if citizens and urban decision-makers are willing to do their "homework".**

5.1.3 Applying the methodology to selected case studies

The formulated statement regarding the theoretical contribution of ICPs and KCPs to the achievement of sustainable cities was confronted with a selection of case studies implemented by Accenture. From the company's Intelligent City projects portfolio (ref. section 5.2), four case studies where selected based on:

- The compliance of the project with the working definition of ICPs and KCPs developed in this research (ref. Chapter 4);
- The availability of sufficient data for applying the designed assessment methodology (i.e. *The Intelligent-Sustainable Assessment Table*).

With regards to the second point, a number of interviews were given to the people of the company responsible of the various Intelligent City projects. More information regarding the structure and questions of the interviews is provided in Section 5.2.2 and Appendix 1.

The procedure for assessing the selected cases is structured as follows:

1. Collect information on the project which has been labeled as a Smart/Intelligent/Knowledge city initiative;
2. Apply the framework developed in Chapter 4 (section 4.4) for assessing the compliance of the project with the definition of ICPs and KCPs formulated by this research;
3. If the programme is recognized as an ICP or KCP, describe it in terms of the technological foundation, the enablers of intelligence, the type of intelligence supported and the value added to the city using the labeling system defined in Chapter 4;
4. Collect data (empirical or forecasted) for measuring the value added by the programme;
5. Insert the retrieved data in the *Intelligent-Sustainability Table* in the cells corresponding to the parameter of sustainabilizing cities affected, based on the nature of the ICP/KCP considered;
6. If an ICP/KCP contributes to one of the 10 parameters of sustainabilizing cities, but does not affect any of the identified SDI, mark the contribution with the symbol "O".

The aim of this activity was twofold:

I. to confront the formulated hypothesis with practical cases in order to identify possible improvements and further support the conclusions reached by this research;
II. to refine the developed methodology for assessing the contribution of ICPs and KCPs to urban sustainability.

Please note that the outcomes of this assessment activity represent preliminary conclusions that require future research efforts (ref. Chapter 6, Section 6.2.2). Definite conclusions could not have been formulated in this instance due to the following reasons:

- most of the projects analyzed were either in the implementation phase or had just been executed, which meant that data regarding their outcomes and value brought to the city were not available;
- given the novelty of most of the technologies adopted by the assessed ICPs and KCPs, forecasts regarding their expected outcomes were often missing;
- some of the projects assessed were protected by intellectual property rights, which meant that a detailed analysis of the ICPs/KCPs implemented was not possible;
- the time frame and scope of this thesis did not leave space for investigating the case studies on site.

For these reasons, when assessing an ICP or KCP using the *Intelligent-Sustainability Table,* the contributions of the programme to the 10 parameters of sustainabilizing cities were marked using superscript numbering:

$^{\mathbf{1}}$ = contributions identified on the base of retrieved data
$^{\mathbf{2}}$ = contributions formulated from the project's plan and/or stated objectives
$^{\mathbf{3}}$ = contributions formulated on the basis of personal assumptions

Table 5.1: *The Intelligent-Sustainable Assessment Table*

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

N.B. Cells of the table where the value added by an ICP/KCP would contribute to parameters of sustainabilizing cities are colored in yellow.
For information on the parameters of Sustainabilizing Cities, ref. Chapter 3, Section 3.2.4.

5.2 Accenture and sustainability

Accenture is a global management consulting, technology services and outsourcing company, with approximately 211,000 people serving clients in more than 120 countries. Recently, the company has launched a whole new set of offerings under the label of *Sustainability Services,* sending out the message that Sustainable Development is to be seen as a unique opportunity for organizations to gain competitive advantage, improve efficiencies and reduce costs while striving for a positive economic, environmental and social impact (Accenture, 2011). In sum, Accenture's *Sustainability Services* is committed to helping forward-thinking organizations position sustainability as a key lever to long-term success.

5.2.1 Overview of Accenture's Intelligent Cities Offerings

Accenture's Sustainability Services spread across four groups of offerings, namely:

1. *Sustainability Regulation and Strategy* – support clients develop their sustainability visions and comply with sustainability regulations;
2. *Operational Excellence* – working with clients to build sustainability focused efficiencies in their core operations;
3. *Emissions Management* – helping clients reduce energy consumption, waste production and emissions;
4. *Sustainable Infrastructure* – helping clients increase energy efficiencies and emission reductions through large infrastructure and urban projects.

The latter is where the company's Intelligent Cities offerings are positioned, and are articulated as illustrated in the following diagram (Figure 5.2). Accenture's Intelligent Cities is the company's response to the new challenges faced by the cities of our era, which include the unprecedented pace and scale of urbanization, the ever so growing need for resource efficiency and the increasing competitiveness for human and financial capital between cities. The aim of the solutions offered is to tackle these challenges, while making cities more attractive to business and citizens within a context of growing importance of sustainable development. As illustrated in Figure 5.2, these solutions are subdivided among three main groups:

- **City Growth & Strategy Management**

The ability to shape and drive complex urban development programs across multiple priorities, stakeholders, and infrastructure layers, including defining a city's vision, value proposition, financing, governance and operating models. Offerings pertaining to this group are intended to help city leaders answer the following strategic questions:

- *How do I grow my city in a sustainable way?*
- *How do I engage my citizens to get their buy-in and feedback?*
- *How do I use technology to provide better services?*

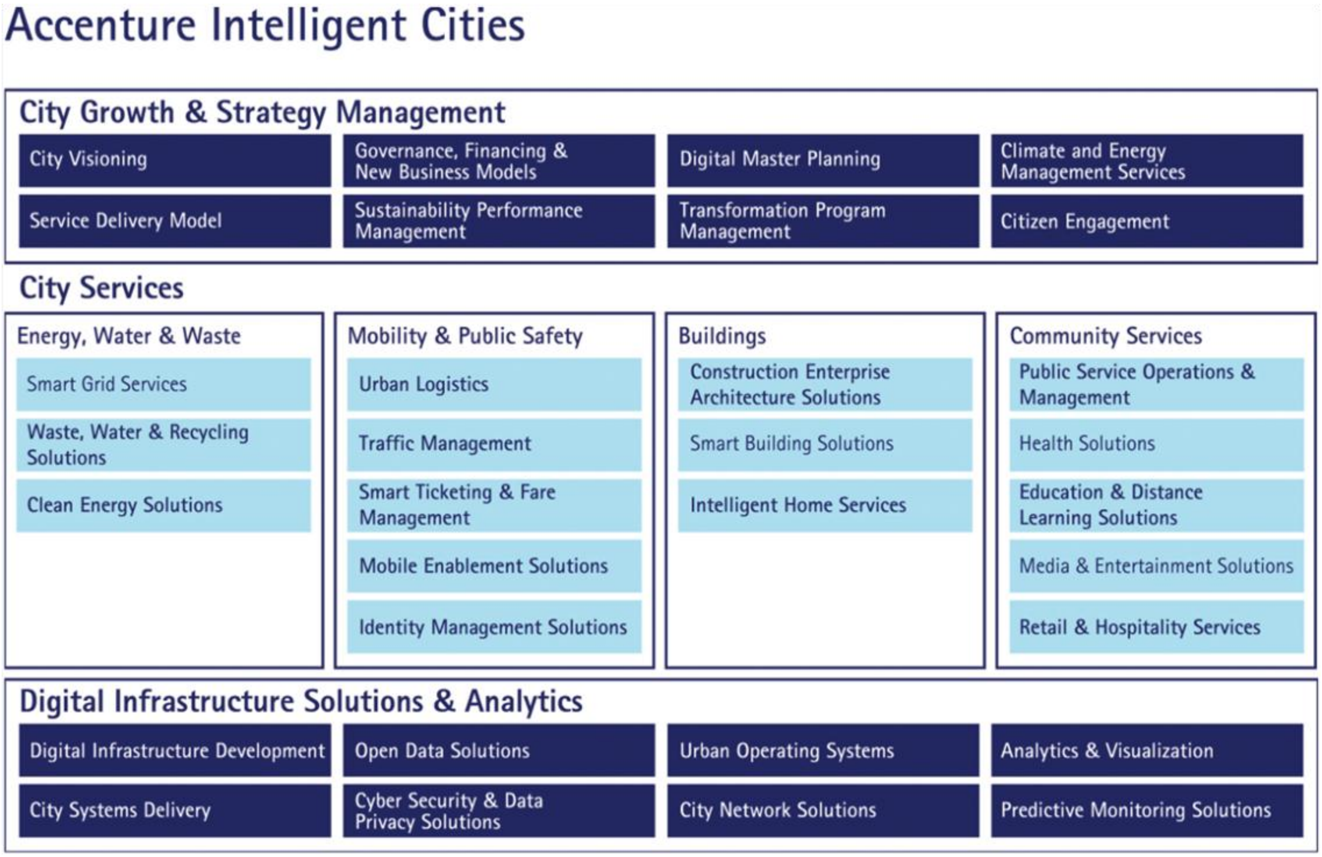


Figure 5.2: Accenture's Intelligent Cities Portfolio.
Source: Accenture, 2011.

➢ **City Services**

A holistic suite of services which are resource-efficient and customer-centric, including: energy, water, waste, mobility, public safety, buildings and community services. City services have the main objective to help governmental decision-makers solve the following questions:

- *What are the right investments for my city?*
- *How can I access funding from the private sector?*
- *How can I work effectively with my partners?*

➢ **Digital Infrastructure Solutions & Analytics**

The technology and communications infrastructure to enable integration across city departments and services, including widespread, high speed data infrastructure, service delivery platforms, and open application architecture. The technology solutions offered by Accenture help clients solve the following set of questions:

– *How can I use data more effectively to run my city?*
– *How can I reduce costs across different departments?*
– *How can I articulate the benefits of infrastructure investments?*

5.2.2 Selected case studies

Accenture's Intelligent City offerings have been implemented both in "Brownfield" (or retrofit) and "Greenfield" development projects all around the world. Below is presented a map with the location of all the Intelligent City projects implemented up to now by the organization (Figure 5.3). The process by which case studies were selected from the list of projects was based on two main criteria:

- The compliance of the project with the working definition of ICPs and KCPs developed in this research (ref. Chapter 4);
- The availability of sufficient data for applying the designed assessment methodology (i.e. *The Intelligent-Sustainable Assessment Table*).

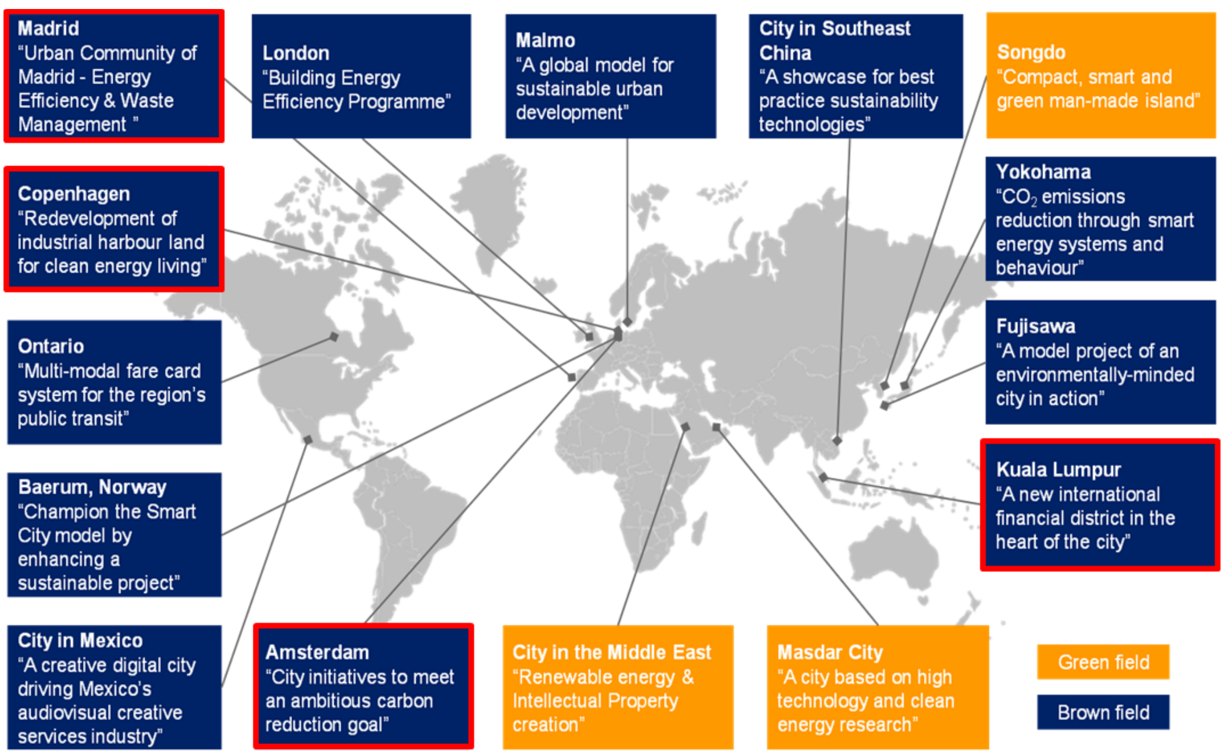


Figure 5.3: Location of Accenture's implemented Intelligent City Offerings.
The projects that have been examined in this research are outlined in red color.

In order to determine whether an ICP or KCP implemented by Accenture would comply with the scope and frame of this project, data on these projects was initially gathered by contacting (by email or phone) the people of the company that took part in their design or execution phase. The selected candidates were asked to answer a set of questions regarding the plan of the project and the benefits delivered (or expected to deliver) to the city (ref. Appendix 1). These questions, which varied according to the nature of the project and the role played by Accenture in its implementation, can be resumed in the following groups:

- An executive summary providing an overview of the project and on the role played by Accenture in its design and implementation phase.
- A description of the implemented Intelligent Cities offerings.
- The adopted methodology for measuring the (expected) benefits of the implemented ICPs and collected data
- The final outcome of the project (measured or forecasted)

Once this information was retrieved, the compliance of the ICP and KCP with the overall scheme of this project was assessed using the developed framework for characterizing these two types of programmes. The assessment process of each selected project, presented in the following sections, was structured as follows:

1. First, an overview of Accenture's implemented ICP or KCP is provided, including a description of the project's plan, the problem tackled and the benefits delivered to the city;
2. Second, the project is positioned within the developed framework for evaluating ICPs and KCPs;
3. Third, the project's contribution to the achievement of urban sustainability is evaluated by means of the developed framework for sustainabilizing cities.

5.3 Amsterdam Smart City

5.3.1 Project overview

A. Client Issue

Amsterdam has set ambitious sustainable energy and carbon reduction goals. The municipality is committed to reduce the energy consumption and CO_2 emissions deriving from all urban sectors. To meet these goals, the key challenge is bringing the parties together that are required to deliver energy initiatives. *Alliander* (a local electricity grid operator) and the *Amsterdam Innovation Motor* (AIM) recognized this challenge and asked Accenture to be a strategic partner in the development of a program to address this: Amsterdam Smart City (ASC).

Logo of the project.
Source: www.amsterdamsmartcity.com

B. Project scope

According to the Amsterdam Smart City Steering Committee, the project represents a unique partnership between the citizens of Amsterdam, businesses, knowledge institutions and local authorities with the scope of implementing a set of pilot projects (with an average duration of two years) that can demonstrate "how it is possible to save energy now and in the future" (Amsterdam Smart City, 2011). The aim of these pilots was to test the viability and effectiveness of new Smart Technologies (i.e. Smart Meters, Smart Plugs, Remote Energy Control and Metering, Energy Management Systems, Smart LED-Lighting, Smart Grids, Smart Electrical Charging Boxes, etc.) and use the results and lessons learnt to extrapolate the outcome (in terms of energy savings and reductions in CO_2 emissions) of these initiatives in case of large-scale implementation.

C. Project plan

The project consisted in the implementation of 16 pilot-programmes in the areas of Working, Living, Mobility and Public Space. In total, 36 Smart technologies were tested and 71 partners were involved in the process. At the end of this period of time, the pilots were assessed in terms of the reduction in energy consumptions and CO_2 emissions. The results obtained were finally used for estimating the benefits gained from their large-scale adoption. Table 5.2 provides an overview of 14 of the implemented solutions together with a brief description of their objectives and adopted Smart Technologies.

Table 5.2: Overview of the solutions included in the project ASC.

Project Name, Overview and Goals	Sector	Technology
Neighbourly Living in Geuzenveld; eManagement Haarlem; West Orange Installation of Smart Meters in 541 households in the neighborhood of Geuzenveld, 250 in Haarlem and 500 other households spread across Amsterdam • Stimulate awareness among citizens on their energy consumption patterns (in order to incentivize optimal electricity consumption behaviors) • Testing different innovative energy management systems	Buildings	Smart Meters; Smart Plugs; Energy Displays and Monitoring Systems
Our Energy A business model offered to 8,000 households for the collective financing of 7 windmills • Incentivize use of renewable energy sources by breaking the barriers of high investment costs for consumers wishing to generate their own energy	Energy	Windmills; Collective Financing Models
ITO Office Tower Building Installation of Smart Meters and LED-lighting systems in the ITO office building • Testing the effectiveness of energy management systems in the context of office buildings, for optimizing energy consumption patterns	Buildings	Smart Meters; Smart Plugs; LED-Lighting; Energy Monitoring Systems
Decentralized Generation Installation of a fuel cell in "De Groen Bocht" Building for decentral generation of electricity • Test the efficiency of decentralized energy production through Fuel Cell Technology	Energy	Fuel Cell Technology; Remote Control and Metering
Zuidas Solar Challenge Installation of 3,000 solar panels on the roofs at the Zuidas business district • Demonstrate the viability of large-scale solar power generation	Energy	Solar Panels
Ship to Grid Installation of 73 ship-to-grid electricity points (supplied by renewable energy producers) in the Port of Amsterdam • Reduce noise, air pollution and CO_2 emissions by replacing the old diesel generators of the harbours of Amsterdam	Port Infrastructure	Remote metering
Online Monitoring Municipal Buildings Connecting 10 municipal buildings of Amsterdam to an energy monitor system that allows managers to view energy use online • Test effectiveness of the online energy monitoring system in helping managers enhance the energy saving performance of their buildings	Buildings	Online Energy Monitoring Systems

Table 5.2 (continued): Overview of the solutions included in the project ASC.

Project Name, Overview and Goals	Sector	Technology
Ship to Grid Installation of 73 ship-to-grid electricity points (supplied by renewable energy producers) in the Port of Amsterdam • Reduce noise, air pollution and CO_2 emissions by replacing the old diesel generators of the harbors of Amsterdam	Port Infrastructure	Remote metering
Moet je Watt Installation of 50 electric vehicle charging points • Test the effectiveness of technology in rapidly charging EVs without overloading the electric grid • Test the user-friendliness of the appliance	Energy; Infrastructure	Smart Meters and Electrical Charging Boxes
Climate street Physical and logistic initiatives in busy commercial streets of the city, involving smart waste management solutions, LED-lighting systems and energy management systems • Stimulate user behavior changes • Help entrepreneurs of SMEs reduce energy consumptions • Increase attractiveness of commercial streets	Public Space; Buildings; Infrastructure	Smart Waste Solutions; Energy Displays; Smart Meters; LED-lighting
Smart School Contest A contest between 6 primary school to determine who can save the biggest amount of energy • Educate young population to energy saving behaviors • Test efficacy of energy management systems	Buildings	Smart Meters; Online Energy Monitoring Systems
ZonSpot Installation of outdoor workstations enabled by solar power and WiFi Internet connection • Incentivize solar energy by making its benefits visible to the public • Assess the success of a "new working concept" aimed at stimulating interaction and improving the quality of the urban environment	Public space; Energy	Solar panels; Wi-Fi Connection

Source: Amsterdam Smart City, 2011.

D. Accenture's role

Accenture was called to take part as a strategic partner by *Alliander* and the *AIM*, the two main promoters of the Amsterdam Smart City Project. More specifically, Accenture supported its clients in the following ways:

1. Visioning and Strategy – develop the city's vision & strategy; define business cases, principles and the technical architecture required; determine an implementation approach.

2. Concept Development – pre-select initiatives based on feasibility, costs and CO_2 reduction potential; contact and organize partners; develop plan of the project and a legal framework for implementation (including a governance model).
3. Value Delivery – develop projects and communicate plans and business cases to partners; secure funding from partners; exchange learning and knowledge between projects; monitor the realization of business casa.
4. Execution – Evaluate and select successful initiatives and partners; communicate results; Support (tenders for) full scale implementation and leverage with other offerings (i.e. Smart Meters, Energy Displays, Energy Management Systems, Smart (LED) Lighting, Electric Vehicles and recharging stations).

E. Outcomes

The outcomes of each of the 16 projects were expressed in terms of the observed (for the two year pilots) and extrapolated[1] (from the theoretical implementation of the initiatives to the entire city) reduction in energy use and CO_2 emissions compared to previously defined benchmarks. These outcomes are presented in Table 5.3.

Table 5.3: Results of 14 of the 16 initiatives included in the project ASC.

Project Name	Observed from Pilot		Extrapolated to city
	Energy Savings	**Tot. CO_2 Reductions**	**Realistic Scenario**
	% per household	*Tons CO_2 per year*	*Tons CO_2 per year*
Geuzenveld	3.9	153	17,271
West Orange	7.8	249	72,274
eManagement Harleem	3-12	17	2,895
Our Energy	-	1,364	11,254
ITO tower office	30	31	12,120
Monumental Buildings	28.1	9	2,262
Decentalized Generation	-	4	24,570
Zuidas Solar Challenge	-	168	560
Online Monitorning M.B.	10	16	326
Ship to Grid	-	9,314	9,773
Moet je Watt	-	-	-
Climate Street	9-36	661	3,292
Smart School Contest	10	24	143

[1] For details on the assumptions made for the extrapolation of data, see Amsterdam Smart City, 2011: p. 121-122.

Table 5.3 (continued): Results of 14 of the 16 initiatives included in the project ASC.

Project Name	Observed from Pilot		Extrapolated to city
	Energy Savings	**Tot. CO_2 Reductions**	**Realistic Scenario**
	% per household	*Tons CO_2 per year*	*Tons CO_2 per year*
ZonSpot	-	-	-
Total		**12,010**	

Source: Amsterdam Smart City, 2011.

5.3.2 Positioning the project in the ICP/KCP framework

On the whole of the 16 pilots pertaining to the Amsterdam Smarty City project, a total of 36 Smart City Technologies were employed. Out of the total number of pilots implemented, 11 possessed a technological foundation[1] and other characteristics that allowed them to be considered as ICPs of KCPs according to the definitions provided by this project. The ICP/KCP framework and labeling system was applied to these 11 projects in order to characterize them in more detail (ref. Appendix 10). Table 5.4 is presented below as an example of how the evaluation was performed.

Table 5.4: Example of the application of the ICP/KCP labeling system to project ASC.

Project: Geuzenveld; eManagement Haarlem; West Orange	
Elements of ICP	**Description**
A. Physical scale of programme	District level (potentially expandable to settlement scale)
B. Technological foundation	Smart Meters; Smart Plugs; Energy monitoring systems
C. Implemented enabler(s) of Intelligence	*Data acquisition/processing systems*
D. Type of intelligence empowered	*Human Intelligence*: incentivize behavior changes that optimize energy consumption in buildings
E. Additional requisites/hyp.	Users voluntarily optimize personal energy consumption patterns
F. Finality of programme and value added to city	Live monitoring of the consumption behavior of households for encouraging energy saving and optimization ✓ Improved management of buildings

[1] Windmills and solar panels are not considered as technologies pertaining to ICPs and KCPs as they do not employ ICT or other digital components.

5.3.3 Assessing the contribution to urban sustainability

The assessment of the Amsterdam Smart City Project was performed using the *intelligent-sustainable table* presented at the beginning of this chapter (ref. Tab. 5.5, page 150). This was done following the approach illustrated in section 5.1.3 and using the information and data contained in the documents of the project accessible to the public (i.e. Amsterdam Smart City, 2011).

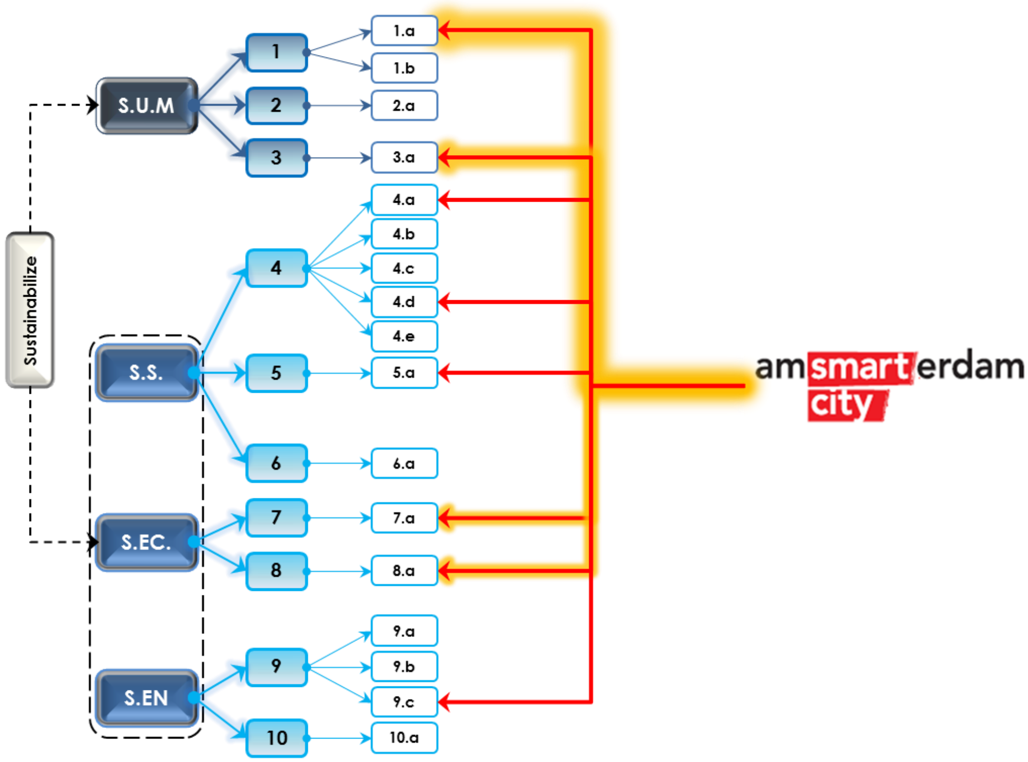


Figure 5.4: Tracking the contribution of project ASC to sustainabilizing cities.

According to the assessment framework developed, the Amsterdam Smart City project has focused fundamentally on one of the four pillars of sustainable cities, namely "sustainable urban metabolism". The large majority of the "smart initiatives", by enhancing the management of the electricity grid, improving the management of public buildings and incentivizing behavior changes among households for optimizing energy consumption patterns, have contributed to parameters 1 and 3 of sustainabilizing cities. More specifically, the share of renewable electricity in the city's grid (1.a.i) was increased by the "ship-to-grid" and "zonspots" projects, which also reduced the emissions of CO_2 and air pollutants deriving from the combustion of fossil fuels (3.a.i and 3.a.ii). These two objectives were also achieved by incentivizing the use of Electric Vehicles (which also contributed to indicator 1.a.iii), and above all by encouraging behavior changes among the population for reducing energy consumption of households (which also positively influenced indicator 1.a.ii). It should be noted that the majority of the initiatives implemented for optimizing the building sector highly depend on the extent to which citizens use the information provided by energy monitoring systems to voluntarily change their consumption habits.

> *"It was found that up to 16% of households' energy bills are spent on devices left on standby and that domestic energy use accounts for more than a quarter of the nation's CO_2 emissions."* (BBC, 2012)

Even if the project's contribution to a sustainable urban metabolism seemed significant, the other three pillars of sustainabilizing cities have not been addressed with the same level of intensity. In fact, besides improving the quality of air by optimizing the energy infrastructure and incentivizing electric mobility (4.a.i), the ASC does not directly contribute to parameter 4. A minor contribution to parameter 5 is supposable in the moment that equipping buildings with smart energy systems and decentralized energy production units increases their value and thus the attractiveness of the city's districts (5.a.iii). More explicit is instead the contribution of the "zonspot" project to the improvement of the quality of life within the city. In fact, by equipping public outdoor spaces with facilities that incentivize interaction between people (both physically and on the web through Wi-Fi access points), it can be assumed that the project improves the social life within the city of Amsterdam (4.d).

With regards to the achievement of a sustainable economy, the project was observed to improve the short-term competitiveness of the city mainly in the form of reduced public expenditures in buildings of the municipality and state-owned electricity production plants (7.a.iv), but no data was retrieved to support this statements. Moreover, a minor contribution to the city's competitiveness in the long-term was provided by the implementation of public Wi-Fi spots in outdoor spaces which increase the city's level of ubiquitous connectivity (8.a.viii).

Finally, the contribution to the achievement of a sustainable environment was supposed for the smart school context project. The project implemented a virtual energy portal where children could learn about their energy consumption behaviors and the relative consequences on the environment. This can be interpreted as a step in the direction of educating the community to lower energy consumption lifestyles, which result in reduced emissions of air pollutants in case that energy is produced from fossil fuels (9.c.i). Furthermore, the preservation of the health of the atmospheric compartment is achieved by reducing the consumption of fossil fuels in the buildings, energy and transport sectors.

Table 5.5: Application of the Intelligent-Sustainable Assessment Table to project ASC.

Value Added by ICPs and KCPs		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
ICPs	Improved mgmt. of env. compartments																	
	• Aquatic																	
	• Atmospheric																	
	• Terrestrial																	
	Improved mgmt. of urban sectors & infra.	i[1]											iv[2]					
	• Buildings	ii[2]			i[1]/ii[2]						iii[3]						i[2]	
	• Energy				i[1]/ii[2]												i[2]	
	• Public administ.																	
	• Transport	iii[2]			i[1]/ii[2]	i[2]											i[2]	
	• Waste																	
	• Water																	
KCPs	Behavior changes	o[2]/ ii[2]			i[1]/ii[2]												i[2]	
	Development of a Knowledge Based Ec.								o[2]					viii[1]				
	Better governance																	

[1] = based of retrieved data; [2] = based on project's plan and/or stated objectives; [3] = based on personal assumptions; o = contribution to parameter but not specifically to any of its indicators. Cells colored in yellow derive from the central hypothesis formulated in section 5.1.1

5.4 Nordhavn Intelligent District Development

5.4.1 Project overview

A. Client Issue

The City of Copenhagen has defined a number of "smart city initiatives" having the ambitious objective of turning it into one of the most environmental cities in the world. Among these initiatives is the one to redevelop the industrial harbor of Nordhavn (close to the center of the city) into a sustainable city district by installing and integrating different renewable energy generation plants in the district's electricity network.

Logo of the project.
Source: Municipality of Copenhagen, 2009.

B. Project scope

The Nordhavn Intelligent District Development (NIDD) involved several projects targeting specific urban sectors, namely heating, electricity and transportation, from the energy consumption perspective (Sustainable Cities, 2009). Among these, the scope of the project in which Accenture supported the Municipality of Copenhagen was the design of a "district energy system" that would allow the accommodation of intermittent sources of renewable energy in Nordhavn, and help utility service companies manage more efficiently the production capacity of their plants. The aim of the energy system was also to optimize and reduce the total energy consumption in the district, mainly by informing consumers on energy consumption patterns and saving benefits.

C. Project plan

The Nordhavn Energy Partnership (formed by the Municipality of Copenhagen, Dong Energy and the Danish Energy Authority) was in charge of carrying out the project plan, which consisted in the design of an *open energy data platform* to collate and share energy data between the utilities involved in the generation of renewable energy for the district. The objective of this data system was to collect, integrate, inform and utilize the information regarding the supply and demand of electricity in order to make the energy distribution network of the district more responsive.

D. Accenture's role

Accenture was called by the Nordhavn Energy Partnership to support the process of designing the open data platform needed for improving the responsiveness of the district's energy distribution network. More specifically, Accenture supported the project design and execution phases in the following ways:

1. Visioning and Value Case Definition – Define the vision and value case for the data platform that resonated with all of the data-sharing participants; this included input from 30+ stakeholders and benchmarking of existing local and international open data initiatives;
2. Organization and Technical Design – Design of the high level organisation structure and technical requirements to set-up the platform;
3. Service Identification – Identify services that could be provided using the shared energy data and the prerequisites for successful commercialization the data and services;
4. Citizen Engagement – Design of the mechanisms to encourage citizens to use the platform and adapt their energy consumption.

E. Outcomes

The outcomes of the project could not be measured as it is still in the design and development phase. Quantitative estimates of the benefits that the project will deliver were not found.

5.4.2 Positioning the project in the ICP/KCP Framework

The energy system developed for the district of Nordhavn was considered "smart" for its ability of making the energy distribution network more responsive to supply and demand, thus allowing the accommodation of several sources of renewable energy in utility network (heating and electricity) and transport sector (electric mobility). This was done mainly through the installation of sensors and smart meters for acquiring data on the energy consumption of different sectors, and successively integrating this information in an open data platform accessible to utility suppliers and citizens. Combined with common governance and standards for exchanging and collecting data, the platform will allow utility suppliers to adjust energy production based on the actual demand. Furthermore, the collected data will be available on online knowledge sharing forums[1] acting as a foundation for growth and innovation, where entrepreneurs and companies have a greater knowledge on the accessible data, thus making it easier to develop and test new energy and urban solutions. Consequently, the project was considered as a

[1] www.digitaliser.dk

combination of ICPs and KCPs, as it embodies characteristics of both typologies of programmes.

Table 5.6: Application of the ICP/KCP labeling system project NIDD.

Project: Nordhavn Intelligent District Development – Open Energy Data Platform	
Elements of ICP-KCP	**Description**
A. Physical scale of programme	District level
B. Technological foundation	Smart Meters; Energy monitoring systems; Data Platforms
C. Implemented enabler(s) of Intelligence	*Data acquisition/processing systems* combined with *Knowledge sharing systems*
D. Type of intelligence empowered	*Human Intelligence:* incentivize behavior changes that optimize energy consumption in buildings; enhanced decision-making performed by managers of energy utility organizations *Collective Intelligence:* Collaboration between public and private utility companies and citizens for identifying innovative energy solutions; behavior changes within the community
E. Additional requisites/hyp.	Users voluntarily optimize personal energy consumption patterns
F. Finality of programme and value added to city	Accommodate intermittent sources of renewable energy in the utility network and reduce inefficiencies of the system ✓ Improved management of energy infrastructure ✓ Behavior changes ✓ Development of a knowledge-based economy

5.4.3 Assessing the contribution to urban sustainability

The assessment of the Nordhavn Intelligent District Development Project was performed using the *intelligent-sustainable table* presented at the beginning of this chapter (ref. Table 5.7, page 156). This was done following the approach illustrated in section 5.1.3 and using the information and data contained in the documents of the project accessible to the public (Nordhavnen, 2011) and provided by Accenture.

According to the assessment framework developed, the Nordhavn Intelligent District Project touches all four pillars of sustainabilizing cities to different extents. The main contribution observed is in supporting Copenhagen achieve a sustainable urban metabolism by helping accommodate renewable energy generation plants in the district's utility distribution network. This will directly support the district of Nordhavn increase the share of electricity and heat produced from renewable energies (1.a.i) and consequently reducing the emissions of CO_2 and air pollutants deriving from the combustion of fossil fuels (3.a.i and 3.a.ii). An indirect contribution to the three parameters pertaining to the sustainable urban metabolism pillar was also observed relative to the public energy data platform developed. In fact, it can be assumed that the energy knowledge sharing system will incentivize behavioral changes within the community that result in a reduction of the energy input flows absorbed by the district.

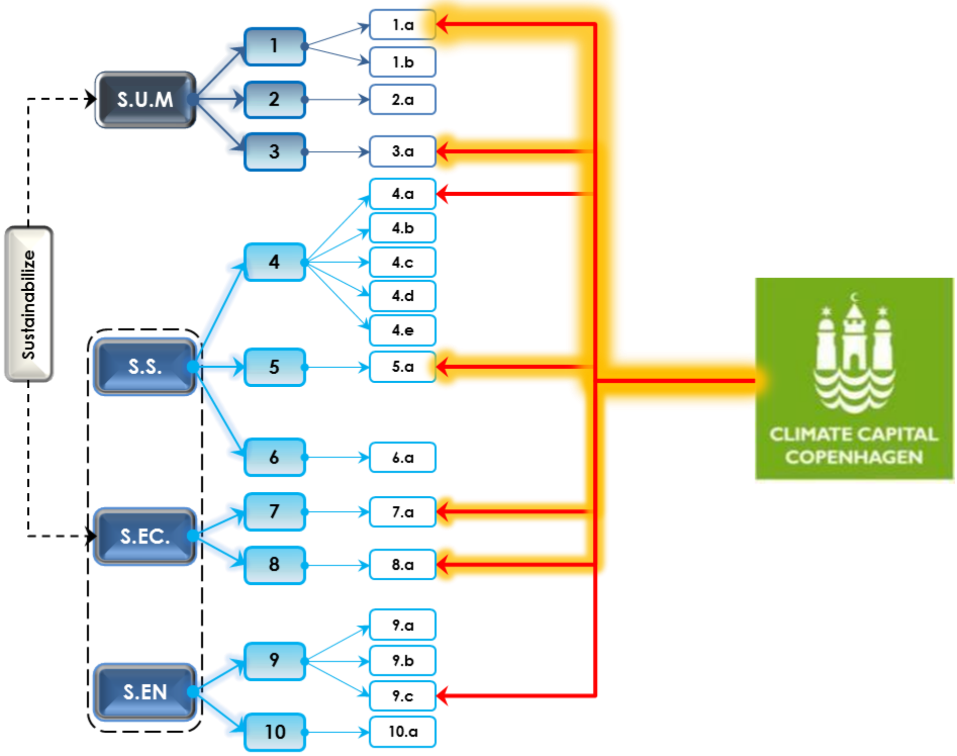


Figure 5.5: Tracking the contribution of project NIDD to sustainabilizing cities.

In pursuing a sustainable society, the project's contribution to the parameter "attractiveness of the city" was observed. Assuming that consumers favor living in cities that are more eco-compatible and self-reliant, the programme will contribute to an increase in the attractiveness of the district for these citizens (5.a.i and 5.a.iii).

The project was also observed to contribute to the achievement of a sustainable economy by increasing both the short-term and long-term competitiveness of the city. Short-term competitiveness is directly pursued in the form of reduced expenditures in the public sectors, more specifically in the utility companies owned by the Municipality (7.a.iv). A contribution to long-term competitiveness of the city was also observed, as one of the objectives of sharing data on energy demand and supply is to come up with innovative ideas for accommodating more efficiently and effectively renewable sources in the city's energy network (8.a.iii and 8.a.iv).

Finally, the project's contribution to the achievement of a sustainable environment was observed for the atmospheric compartment. According to the project's description and scope, the implemented initiatives help preserving the quality of air in the region by reducing the emissions of air pollutants deriving from the combustion of fossil fuels.

Table 5.7 : Application of the Intelligent-Sustainable Assessment Table to project NIDD.

Value Added by ICPs and KCPs		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
ICPs	Improved mgmt. of env. compartments																	
	• Aquatic																	
	• Atmospheric																	
	• Terrestrial																	
	Improved mgmt. of urban sectors & infra.																	
	• Buildings																	
	• Energy	i[2]/iii[2]			i[2]/ii[2]						i[3]/iii[3]		iv[2]				i[2]	
	• Public administ.																	
	• Transport																	
	• Waste																	
	• Water																	
KCPs	Behavior changes	o[2]			i[2]/ii[2]													
	Development of a Knowledge Based Ec.													iii[2]/ iv[2]				
	Better governance																	

[1] = based of retrieved data; [2] = based on project's plan and/or stated objectives; [3] = based on personal assumptions; o = contribution to parameter but not specifically to any of its indicators. Cells colored in yellow derive from the central hypothesis formulated in section 5.1.1

5.5 Bilbao Global City of Knowledge

5.5.1 Project overview

A. Client Issue

The Municipality of Bilbao is committed to developing the city in a knowledge-based economy given its belief that knowledge is a fundamental competitive factor for attracting talent and financial resources and for improving the quality of life of citizens. Furthermore, the Municipality is intentioned to achieve this goal while significantly reducing CO_2 emissions. In the words of José Antonio Garrido, chairman of the Association for the Revitalization of Bilbao (i.e. *Bilbao-Metropoli 30*), "the objective here is to turn metropolitan Bilbao into a node which is a reference point for the world-wide network of knowledge generation and management for the development of high added-value business activities" (Bilbao-Metropoli 30, 2010).

Logo of the project.
Source: www.bm30.es

B. Project scope

The scope of the project was to increase the city's level of maturity from the perspective of urban intelligence, thus developing Bilbao in a global city with a knowledge-based economy. In fact, the Municipality of Bilbao had already implemented several projects in the sectors of water, energy, transportation, *soft infrastructure* (i.e. education and social life in the community) and *hard infrastructure* (i.e. the utility distribution networks and physical infrastructure of the city), positioning the city at the second level of the framework[1] developed by The Climate Group, Accenture, Arup and Horizon for measuring the degree of urban intelligence of a city. Thus, the scope of the project *Bilbao-Metropoli 30* was to leverage the city's intelligent infrastructure to transform it into a global city of knowledge. This high-level goal can be articulated in following objectives (Bilbao-Metropoli 30, 2010):

- Creating new investment opportunities in high value added business initiatives;

[1] For a view of the "framework for a Smarter City", ref. Appendix 9.

- Designing mechanisms for training, keeping and attracting high skilled professionals;
- Stimulating innovation;
- Creating new working opportunities to reduce unemployment;
- Improving the level of integration of citizens in the social community of Bilbao

C. Project plan

For the achievement of a knowledge-based economy, the *Bilbao-Metropoli 30* defined a strategic plan for the implementation of different initiatives with different levels of priority. In sum, constructing a Knowledge Platform for Bilbao required the execution of the following two activities:

1. Designing a partnership model for the municipality of Bilbao and the main public and private parties involved (i.e. companies and research institutes)
2. Designing an innovation ecosystem model (a system of collaboration between the municipality, private organizations, research institutes and citizens). This also includes the definition of a governance system that supports spin-offs and joint ventures

The developed Knowledge Platform will allow creating new solutions of urban intelligence by combining the portfolios of existing products/services with new innovative elements developed by the city. The platform will exploit the city's internet infrastructure (fiber optic cable connection) and cloud computing systems to create knowledge sharing systems between companies, research institutes and citizens.

D. Accenture's role

Accenture was asked by the Association *Bilbao-Metropoli 30* to be a strategic partner in the design and implementation of the project. More specifically, Accenture was in charge of the following activities:

1. Selection of Initiatives – assessing the value added of proposed initiatives in the context of urban intelligence, selecting the best performing ones in terms of stimulating a dynamic and knowledge-based economy
2. Evaluation of Present Conditions – benchmarking the current situation of the city according to the framework developed by Accenture in collaboration with the Climate Group, Arup and Horizon;
3. Definition of a Road Map – designing a common strategic plan for all partners, including the project's trade-offs and the guidelines for achieving a smarter use of energy by citizens, enterprises and local authorities, for stimulating innovation and integrating the city's intelligent urban infrastructure.

E. Outcomes

The outcomes of the Knowledge Platform in terms of numerical estimates were not computed. The reasons are to be found in the difficulty of quantifying the effects of the programme, especially because it deals with human behavior changes and the actual impacts on innovation.

5.5.2 Positioning the project in the ICP/KCP framework

The *Bilbao-Metropoli 30* represents one of the many programmes included in the overall project of turning Bilbao into an Intelligent City (ref. Appendix 11). It was approved by the municipality of the city as the initiative conformed to the vision of urban intelligence that Bilbao is committed to achieve. Strictly speaking, it is more correct to treat the *Bilbao-Metropoli 30* project as a KCP, as its main focus is to foster collaboration and communication among the four main groups of actors of the city (i.e. public administrations, private companies, research institutes and citizens). However, according to the description of the project's plan, the programme will also serve as a tool for leveraging the potential of the intelligence infrastructure already implemented in the city. More specifically, the knowledge platform has been developed for integrating the various urban intelligence initiatives implemented in the sectors of energy, water, transport, soft and hard infrastructure. It will, in other words, consolidate the previously executed ICPs.

For these reasons, it was decided to consider the *Bilbao-Metropoli 30* project as both an ICP and KCP. Table 5.8 shows how the *Bilbao-Metropoli 30* project fits in the framework for characterizing ICPs and KCPs.

Table 5.8: Application of the ICP/KCP labeling system to project Bilbao-Metropoli 30.

Project: Bilbao-Metropoli 30	
Elements of ICP-KCP	**Description**
A. Physical scale of programme	Urban scale
B. Technological foundation	Digital infrastructure supporting high speed internet connection (fiber optic cable network) and cloud computing systems, live video surveillance/monitoring devices, energy monitoring systems, sensors in water aqueducts,
C. Implemented enabler(s) of Intelligence	*Data acquisition/processing systems* combined with *knowledge sharing systems*

Table 5.8 (continued): Application of the ICP/KCP labeling system to project Bilbao-Metropoli 30.

Project: Bilbao-Metropoli 30	
Elements of ICP-KCP	**Description**
D. Type of intelligence empowered	*Artificial Intelligence:* automated management of traffic lights *Human Intelligence:* enhanced decision-making performed by managers of transport, water and law enforcement departments; incentivize behavior changes that optimize transport infrastructure *Collective Intelligence:* collaboration between public administrations, private companies, research institutes and citizens for innovation based activities and better governance; behavior changes within the community
E. Additional requisites/hyp.	Users collaborate in the optimization of transport infrastructure; all four groups of actors engage and co-operate in innovation-based activities
F. Finality of programme and value added to city	Develop an e-platform where private companies, research institutes and citizens collaborate to find innovative solutions for the city and new products/services for the market, and for leveraging the potential of the intelligent infrastructure previously implemented ✓ Improved management of law enforcement department, buildings, transport and water infrastructure ✓ Behavior changes within the community ✓ Better governance systems ✓ Development of a knowledge based economy

5.5.3 Assessing the contribution to urban sustainability

The assessment of the *Bilbao-Metropoli 30* programme was performed using the *intelligent-sustainable table* presented at the beginning of this chapter (ref. Table 5.9, page 163). This was done following the approach illustrated in section 5.1.3 and using the information and data contained in the documents of the project accessible to the public (Bilbao-Metropoli 30, 2010) and provided by Accenture.

According to the assessment framework developed, the *Bilbao-Metropoli 30* programme is positively contributing to all four pillars of sustainabilizing cities to different extents. With regards to achievement of a sustainable urban metabolism, the contribution is remarkable if the programme fulfills its promises. In fact, the Knowledge Platform developed is expected to integrate and leverage the previously implemented intelligent infrastructure in the sectors of water, transport, and buildings for optimizing resource consumption. This will positively influence the consumption levels of non-renewable energies (1.a.ii and 1.a.iii) and natural resources (1.b.i), and the environmental impact of the building and transport sectors (3.a.i and 3.a.ii). A contribution to all three parameters of the first pillar of sustainabilizing cities was also observed relative to the online public educational campaigns launched by the municipality. Taking advantage of enhanced communication channels (i.e. installed high speed internet infrastructure), the Municipality of Bilbao is willing to incentivize behavior changes within the community that lead to more eco-responsible and sustainable lifestyles. Finally, it was assumed that the development of a knowledge-based economy would contribute to a reduction in the consumption of natural resources and production of waste on behalf of the city's economic system (1.b.i and 2.a.i).

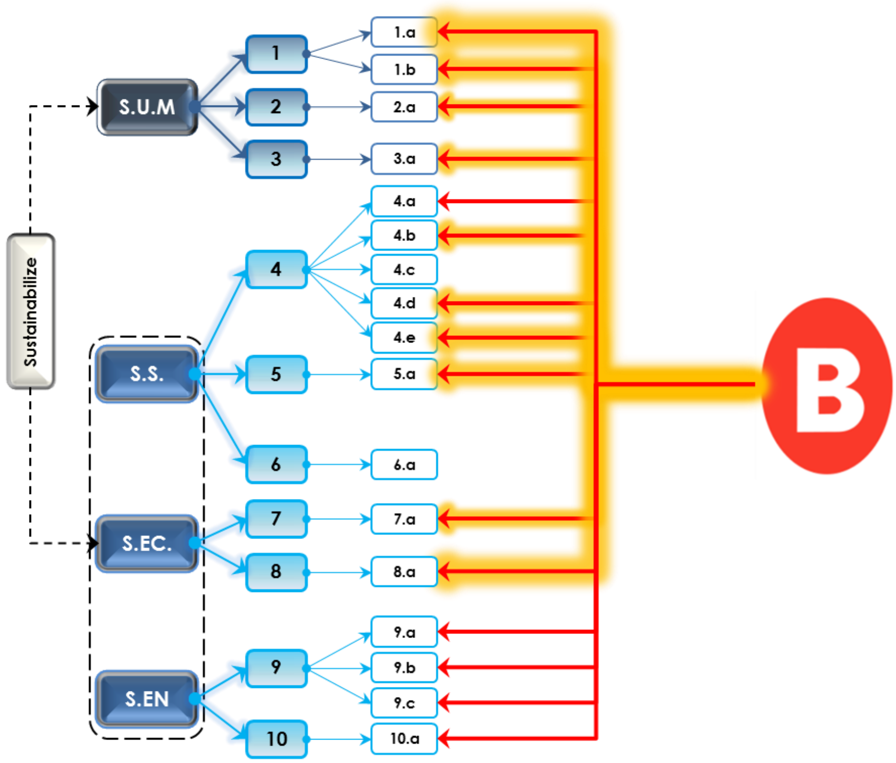


Figure 5.6: Tracking the contribution of project *Bilbao-Metropoli 30* to sustainabilizing cities.

The project was predicted to contribute to the pillar "sustainable society" by increasing the quality of life within the city and improving its attractiveness to talent workers and high income social groups. More specifically, the project is expected to improve the quality of air (4.a.i) by reducing traffic congestion and consequently the combustion of fossil fuels from vehicles, improve urban safety (4.b.ii) by installing video surveillance systems in public transport means (4.e.ii) and strategic points of the city; improve social life (4.d.i) through the implementation of better governance systems; and improve the level of urban mobility (4.e.i and 4.e.ii) by optimizing transport infrastructure and mass transit services. The programme was also predicted to increase the attractiveness of the city mainly by improving transport infrastructure, and by developing a knowledge-based economy. This will have positive effects on the net immigration flows of the city (5.a.i), and can be assumed to increase the city's probability of winning bids for hosting Mega-Events and real-estate values (5.a.ii and 5.a.iii).

Considering the third pillar of sustainabilizing cities, the programme was assessed to contribute to the achievement of a sustainable economy by improving both the short- and, especially, long-term competitiveness of Bilbao. The former will be achieved in the form of reduced public expenditures for the provision of services and maintenance of infrastructure, mainly in the water and transport sectors (7.a.iv). The latter represents the main objective of the KCP, that is to attract talent workers (8.a.i), increase the flow of knowledge among citizens, companies and research institutes by developing collaborative platforms that take advantage of the previously installed digital infrastructure (8.a.vi and 8.a.viii), and finally to stimulate innovation in the city's economy by supporting start-ups in all sectors (8.a.ii, 8.a.iii and 8.a.iv).

With regards to the fourth pillar of sustainabilizing cities, the contribution of the programme derives from the improved management of urban sectors and from the promotion of more eco-responsible and sustainable behavior changes. While the former contribute to a reduction in the pollutants in the aquatic and atmospheric compartments (9.b.ii and 9.c.i), the latter is expected to contribute to all four parameters.

Table 5.9: Application of the Intelligent-Sustainable Assessment Table to project Bilbao-Metropoli 30.

Value Added by ICPs and KCPs		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
ICPs	Improved mgmt. of env. compartments																	
	• Aquatic																	
	• Atmospheric																	
	• Terrestrial																	
	Improved mgmt. of urban sectors & infra.						ii^2											
	• Buildings	o^2			i^2/ii^2								iv^2				i^2	
	• Energy																	
	• Public administ.																	
	• Transport	iii^2			i^2/ii^2	i^2				i^2/ii^2	i^2		iv^2				i^2	
	• Waste																	
	• Water		i^2		iii^3								iv^2			ii^2		
KCPs	Behavior changes	o^2	i^2	i^2/ii^2	i^2/ii^2										ii^2	i^2	i^2	ii^2
	Development of a Knowledge Based Ec.		i^3	i^3							i^2/iii^3			$i\text{-}iv^2/vi^1/viii^1$				
	Better governance								o^2		i^2							

^{1} = based of retrieved data ; ^{2} = based on project's plan and/or stated objectives ; ^{3} = based on personal assumptions ; o = contribution to parameter but not specifically to any of its indicators. Cells colored in yellow derive from the central hypothesis formulated in section 5.1.1

5.6 Kuala Lumpur New International Financial District

5.6.1 Project overview

A. Client Issue

1Malayasia Development Berhad (1MDB) is a strategic development company wholly owned by the Government of Malaysia (1Malaysia Development Berhad, 2012). The Sovereign Wealth Fund is committed to the development of an entirely new financial district in the southern region of Kuala Lumpur, more specifically on an area of 75 acres located between Jalan Tun Razak, Jalan Sultan Ismail and the Putrajaya elevated highway (1MDB, 2010). The Kuala Lumpur International Financial District intends to be the destination of choice for high-value financial services and a global hub for innovation-based activities. To achieve this ambitious goal, the client required help in identifying and planning the digital infrastructure, facilities and services to integrate in the physical layout of the district.

Logo of the project.
Source: http://www.1mdb.com.my/klifd/klifd-greater-kuala-lumpur

B. Project scope

The KLIFD is part of the national project for turning the Greater Kuala Lumpur/Klang Valley (Greater KL) into a National Key Economic Area by 2020. More specifically, KLIFD was conceived to support the capital of Malaysia in becoming a global city, the preferred location of high-value businesses, talent workers and knowledge institutions.

C. Project plan

Given the dimensions of the project and its actual state, this research could only focus on the scheme of the district's masterplan. The element of innovation that differentiated the planning of the district from traditional urban development projects was the role played by digital infrastructure and ICT in the process. Right from the beginning, 1MDB envisioned a district that would accommodate smart city technologies in order to provide world-class facilities and infrastructure to the area. The idea of a *Digital Masterplan* was thus embraced by the team in charge of the planning phase. The instrument was conceived for merging together two distinct planning activities: (1) the design of the district's physical layout and (2) the blueprint of the ICT and digital infrastructure required for enabling state of the art urban connectivity and smart city technologies.

Unfortunately, a comprehensive view of the digital masterplan was not available to the public, so the description of the ICPs and KCPs planned for the KLIFD could not have been carried out in detail. However, with the collaboration of the members of Accenture's local delivery team (ref. Appendix 1), it was possible to retrieve an executive summary containing a brief description of the smart technologies that were included in the district's Digital Masterplan. These are illustrated in the following table.

Table 5.10: Overview of Smart City Technologies planned for KLIFD.

Smart City technologies planned for KLIFD	Sector
Intelligent City Management The KLIFD will be equipped with an urban operating system that integrates the different sectors of the city in a unique management tool. This data platform is expected to significantly enhance decision-making processes at the district's scale	Urban Mgmt.
Digital Retail Inter-connected monitors through ICT that allow new more effective advirtising systems, mobile marketing, retail analytics and interactive sidewalks	Commercial
Digital Mobility Traffic control systems for managing road capacity, mass transit, parking areas (parking sensors connected to parking mobile apps), controlling drivers behavior and movements (automatic plate recognition cameras) and supporting the adoption of Electric Vehicles (EVs)	Transport
High-speed Ubiquitous Connectivity Fibre optic cables supporting high speed internet installed in all the buildings of the district, including the development of a wireless and mobile backbone for the entire area	ICT
Smart Buildings Installation of smart meters for measuring energy and water consumption of buildings and waste production, in order to optimize the utilities network	Buildings
E-Governance "One Stop Centre Portal" for providing continuous communication channels between the citizens and public administration	Public Admin.
Digital Urban Security Installation of biometric access devices in buildings, video surveillance and analytics throughout the district and Pre/Post-emergency response systems	Security

D. Accenture's role

Accenture was called to take part in the development of KLIFD by assisting the client in the development of a Digital Masterplan, a scheme of the digital infrastructure that will be accommodated in the district's structure for allowing the implementation of a series of Smart City Technologies (ref. Table 5.10). More specifically, Accenture was in charge of the following activities:

1. Set Strategic Direction: Accenture conducted a benchmarking study to identify critical success factors of international financial centres and smart cities as well as defining the potential digital services offerings.
2. Define the business model: Accenture determined various business model options that considered the financial feasibility, environmental and social impact.
3. Develop Digital Master Plan: Accenture defined the design guidelines for the interface between physical and digital master plan and the ICT implementation roadmap with timelines and key performance indicators.
4. Implementation Plan: Accenture recommended the operating considerations for service groups including a digital lifecycle cost assessment and roadmap / implementation plan

E. Outcomes

Given the duration of the implementation phase, the outcomes of the project will not be available for the next 10 years (estimated time for the completion of the project). Moreover, quantitative forecasts were not computed given the complexity and dimensions of the project

5.6.2 Positioning the project in the ICP/KCP framework

The KLIFD is expected to accommodate several Smart City Technologies that will make the financial district come through as one of the most technologically advanced urban systems of the world. These technologies target different sectors of the district, ranging from the management of buildings and utility networks to enhanced government systems and digital advertising panels.

The developed framework for identifying and characterizing ICPs and KCPs was applied to these Smart City Technologies (ref. Appendix 12). Table 8 is presented below as an example.

Table 5.11: Example of Application of the ICP/KCP labeling system to project KLIFD.

Project: Digital mobility in KLIFD	
Elements of ICP	**Description**
A. Physical scale of programme	Urban scale (75 acres)
B. Technological foundation	Traffic and parking sensors, parking mobile applications
C. Implemented enabler(s) of Intelligence	*Data acquisition/processing systems* combined with *knowledge sharing system*

Table 5.11 (continued): Example of Application of the ICP/KCP labeling system to project KLIFD.

Project: Digital mobility in KLIFD	
Elements of ICP	**Description**
D. Type of intelligence empowered	*Human Intelligence:* enhanced decision-making performed by managers of transport department; *Collective Intelligence:* incentivize behavior changes within the community that optimize transport infrastructure
E. Additional requisites/hyp.	Drivers rationally process and follow information shared from traffic management department
F. Finality of programme and value added to city	Optimize transport infrastructure within the district and offer better services to its inhabitants ✓ Improved management of transport infrastructure

5.6.3 Assessing the contribution to urban sustainability

The assessment of the Smart City Technologies pertaining to the KLIFD project and that complied with the definition of ICPs/KCPs provided in this research was performed using the *intelligent-sustainable table* presented at the beginning of this chapter (ref. Table 5.12, page 169). This was done following the approach illustrated in section 5.1.3 and using the information and data contained in the documents of the project accessible to the public (1MDB, 2010) and provided by Accenture.

According to the assessment framework developed, the urban intelligence that will characterize the new financial district of Kuala Lumpur will positively contribute to all four pillars of sustainabilizing cities to different extents. Starting with the contribution of the project to the first pillar of sustainabilizing cities, the Digital Mobility and Smart Building technologies planned for implementation will help the district consume less energy and resources in these two urban sectors. As the district will be powered mainly by non-renewable energy production plants, an improved management of these two sectors will result in reduced emissions of CO_2 and air pollutants. It should be noted that energy savings in the building sector depend on the extent to which the inhabitants of the district change their consumption habits.

Through the improved management of transport infrastructure, and a better control of the territory on behalf of the law enforcement department, Digital Mobility and Digital Urban Security systems are expected to contribute to the achievement of a sustainable society. In detail, these ICPs will improve the quality of life within the district and increase its attractiveness (4.a.i, 4.a.ii, 4.e.i, 5.a.i and 5.a.ii). It is important to point out that the technologies implemented by these ICPs have the main goal of attracting high-value business companies, so the desirability of the district is intended to specifically satisfy the needs of these organizations. Finally, the E-governance system planned for the district could also contribute to the second pillar of sustainabilizing cities. The KCP, by enabling better governance systems through collective intelligence, is expected to offer higher living standards to the inhabitants of the district and increase its attractiveness.

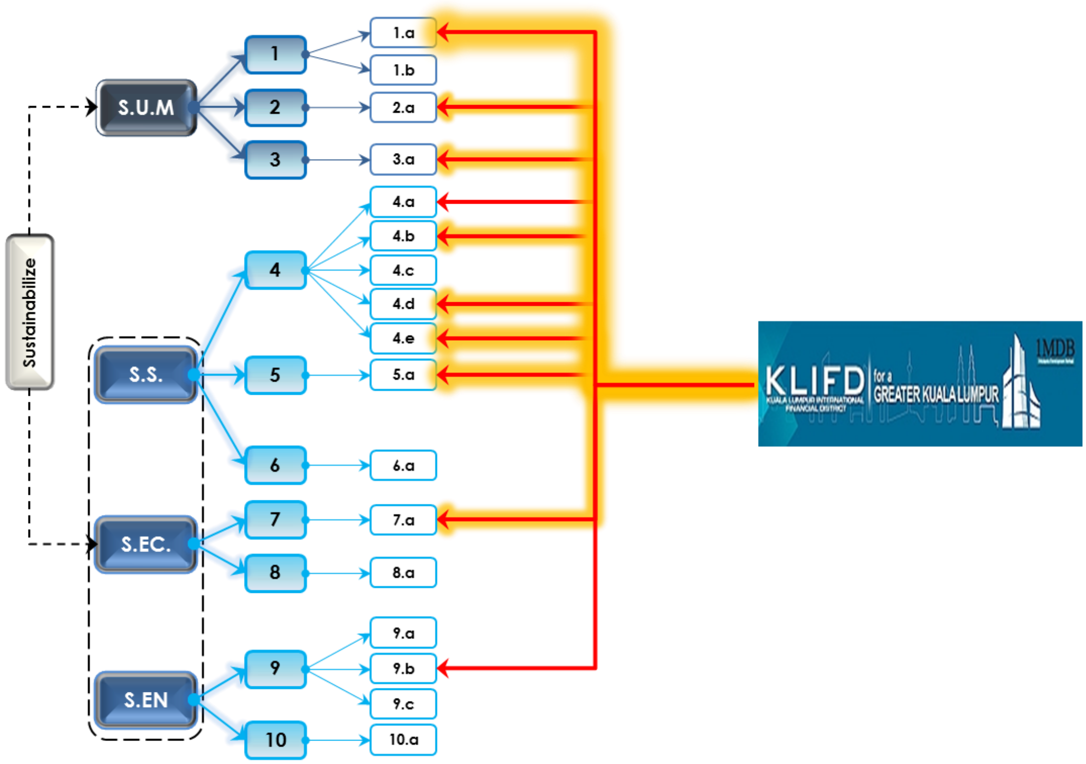


Figure 5.7: Tracking the contribution of project KLIFD to sustainabilizing cities.

Even if the finance and economy are two key words of the KLIFD project, no KCPs encouraging innovation-based activities were identified. The district is committed to attracting high-skilled knowledge workers and plans the construction of a University, but there seems to be a lack of mechanisms that take advantage of the talent that will be clustered in the district for nurturing of innovation. Therefore, it can be concluded that the ICPs planned for implementation will mainly contribute to the short-term competitiveness of Kuala Lumpur by attracting high-value financial services and reducing public expenditures (7.a.ii, 7.a.iii and 7.a.iv)

Considering the fourth and last pillar of sustainabilizing cities, the ICPs and KCPs planned for implementation were not observed to significantly contribute to the achievement of a sustainable environment. A minor contribution was observed in the moment that an improved management of the transport and building sector reduces the consumption of energy deriving from fossil fuels. This does not, however, mean that the KLIFD project is neglecting the preservation of the natural environment as one of its objectives. The only conclusion that can be made is that the specific Smart City Technologies implemented do not seem to contribute to environmental goals.

Table 5.12: Application of the Intelligent-Sustainable Assessment Table to project KLFID.

Value Added by ICPs and KCPs		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
ICPs	Improved mgmt. of env. compartments																	
	• Aquatic																	
	• Atmospheric																	
	• Terrestrial																	
	Improved mgmt. of urban sectors & infra.						ii[2]				i[2]/ii[2]		ii[2]/iii[2]/iv[2]					
	• Buildings	o[2]			i[2]/ii[2]												i[2]	
	• Energy																	
	• Public administ.																	
	• Transport	iii[2]			i[2]/ii[2]	i[2]				i[2]	i[2]		iv[2]				i[2]	
	• Waste																	
	• Water																	
KCPs	Behavior changes																	
	Development of a Knowledge Based Ec.																	
	Better governance								o[2]		i[2]/ii[2]							

[1] = based of retrieved data ; [2] = based on project's plan and/or stated objectives ; [3] = based on personal assumptions ; o = contribution to parameter but not specifically to any of its indicators. Cells colored in yellow derive from the central hypothesis formulated in section 5.1.1

Conclusions

Final reflections and future research opportunities

Chapter 6

6.1 Conclusions and reflections

The goal of this research project was to develop a methodology for investigating the modalities through which Intelligent and Knowledge City Programmes (ICPs and KCPs) contribute to the achievement or urban sustainability. In order to accomplish this goal, this project went through the following steps:

1. Develop a working definition of sustainable development (ref. Chapter 1);
2. Apply the proposed concept to urban systems for the formulation of a working definition of Sustainable Cities (ref. Chapter 2);
3. Design a conceptual model for describing and monitoring the progress of Sustainable Cities (ref. Chapter 3);
4. Develop a framework for characterizing urban projects identified as ICPs and KCPs (ref. Chapter 4);
5. Develop a methodology for assessing the modalities through which ICPs and KCPs contribute to the achievement or urban sustainability, and formulate a central hypothesis regarding their contribution (ref. Chapter 5).

Altogether, this project focused on developing an auditing tool for assessing the modalities through which ICPs and KCPs enable the "sustainabilizing" transition of cities, with the final goal of answering the main question tackled by this research: how are ICPs and KCPs contributing to the achievement of urban sustainability?

To answer this question the proposed methodology was applied to the information on ICPs and KCPs retrieved from the performed bibliographic research (ref. Chapter 4), and four case studies. In carrying out these two activities, the project continuously refined both the assessment methodology and the central hypothesis. This cycle was performed several times before arriving to the final preliminary conclusions which are resumed in the following points:

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.

The first argument was evidenced in bold and requires further discussions for two reasons: (1) its importance within this project's definition of sustainable development, and (2) the intrinsic limitations deriving from the application of the assessment methodology in this research.

Considering the first reason, it is necessary to initially re-call the working definition of sustainable development and urban sustainability adopted in this research (ref. Chapter 1 and 2). Following from a thorough bibliographic research performed on the principles, it was concluded 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, once again, 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 this research there are three main strategies for achieving a sustainable urban metabolism:

- Higher efficiency
- Behavior changes (less energy and resource intensive lifestyles)
- 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 (e.g. the energy data platform developed for the Nordhavn Intelligent District Project) KCPs were observed to contribute to reducing the consumption levels of the city by stimulating innovation in the fields of energy efficiency.

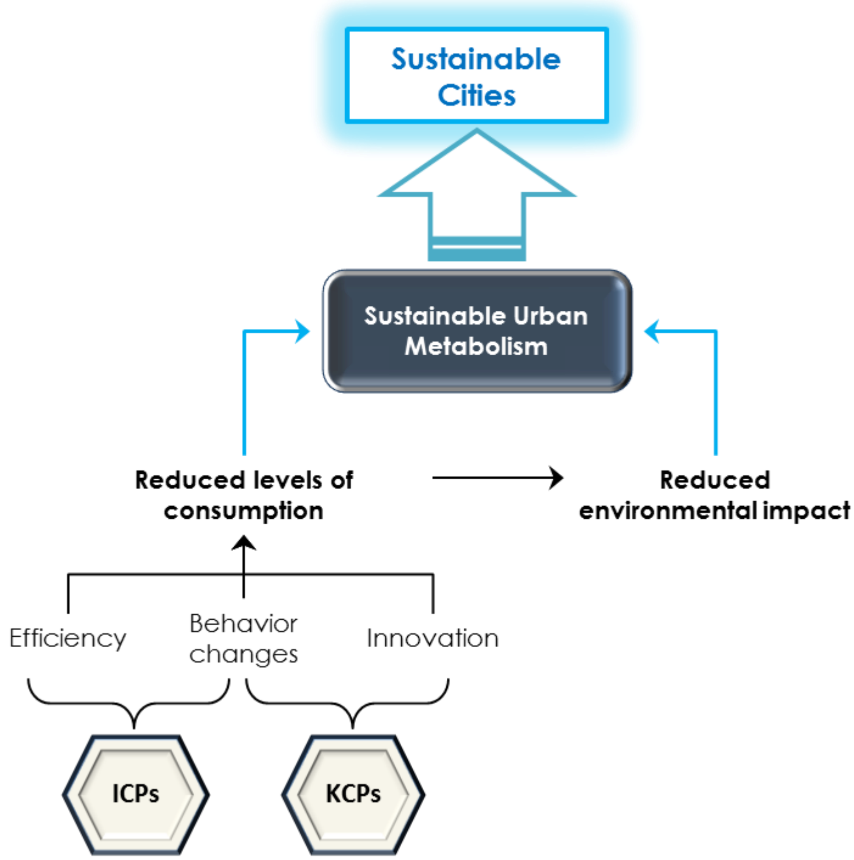


Figure 6.1: Tracking the contribution of ICPs and KCPs to the achievement of sustainable cities.

Turning to the second reason that justified the importance of the first argument, this derives from the limitations encountered while applying the assessment methodology in this research. As it was underlined several times during the design of the *Sustainabilizing City Tree* (ref. Chapter 3) that the parameters of 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. 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.

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 (i.e. Amsterdam Smart City). Whereas the costs of ICPs and KCPs are quantifiable, their exact benefits are still vague and too dependent 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 (ref. Chapter 4, Section 4.3.3), 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 there is not much that ICPs and KCPs can do to slow them down. These programmes can, however, limit the negative impacts of these two trends, but other actions are urgently required. 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 (according to the monitoring system developed in Chapter 3) despite being more intelligent because of these three scenarios.

In conclusion, this research 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 the best tools for supporting cities (especially the ones with a significant infrastructure legacy) in their journey towards true sustainability, but other actions are required for the achievement of this goal. Altogether, the conclusions of this research indicate that Intelligent and Knowledge City Programmes are the best known enablers of sustainable urban environments.

Being an Intelligent-Knowledge City is a necessary but not sufficient condition for being a Sustainable City.

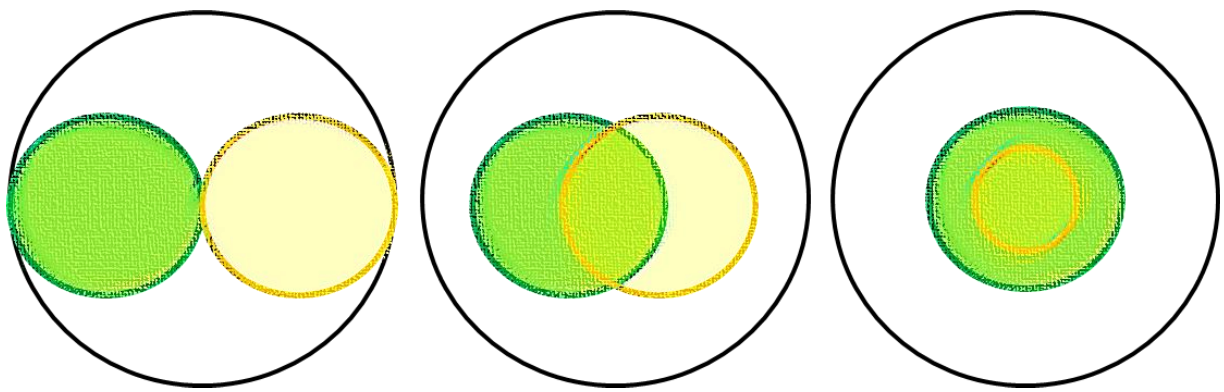


Figure 6.2: "Being an intelligent-Knowledge city is a necessary but not sufficient condition for being a Sustainable City". The black circles represent the entire set of cities; dark blue circles represent the Sustainable City subset; and light blue circles represent the Intelligent-Knowledge City subset. In the first diagram on the left, the two sets are disjointed, in the second they intersect, and in the third Intelligent-Knowledge Cities are the core subset of Sustainable Cities.

6.2 Value of the project, limitations and future research opportunities

6.2.1 The Scientific and social value of the project

The scientific and practical value of the research project is summarized in the following points:

Scientific value

- A review on the debated topics of Sustainable Development, Urban Sustainability, Intelligent and Knowledge Cities;
- A clear method for systematically characterizing sustainable cities, branching out the complexity of the concept in a simple way (ref. "*the sustainabilizing city tree*", Chapter 3);
- An approach for planning and monitoring the progress of cities towards sustainability (ref. "*the sustainabilizing city cycle*", Chapter 2, and "*the sustainabilizing city tree*", Chapter 3);
- A conceptual framework for characterizing Intelligent and Knowledge City Programmes (ref. chapter 4);
- A methodology for assessing the modalities through with ICPs and KCPs contribute to the achievement or urban sustainability (ref. *"the intelligent-sustainable assessment table",* Chapter 5);
- Insights on the role played by Intelligent and Knowledge City Programmes in supporting the "sustainabilizing" transition of cities;
- The recognition of the relation between Intelligent-Knowledge and Sustainable Cities.

Social value

The project has value for the society as it investigates on the modalities through which citizens of future Intelligent and Knowledge Cities will contribute to the achievement of sustainable development. Furthermore, by evidencing the contingent nature of certain aspects of sustainability, this research has provided insights on the role of public participation and stakeholders' negotiations in the process of planning Sustainable Cities.

6.2.2 Limitations of the project

Unfortunately, this project could not give precise indications on the extent of the contribution of ICPs and KCPs to the achievement of urban sustainability. The system developed for monitoring the exact impact of ICPs and KCPs on the parameters of sustainabilizing cities could not have been applied as desired to the selected case studies due to the following obstacles:

- Most of the projects analyzed were either in the implementation phase or had just been executed, which meant that data regarding their outcomes and value brought to the city were not available;
- Given the novelty of most of the technologies adopted by the assessed ICPs and KCPs, and their dependency on human behavior, forecasts regarding their expected outcomes were often impossible to formulate;
- Some of the projects assessed were protected by intellectual property rights, which meant that a detailed analysis of the ICPs/KCPs implemented was not possible;
- The time frame and scope of this project did not leave space for investigating the case studies on site.

For these reasons, the efficacy of the assessed ICPs and KCPs could have not been specified. Furthermore, some of the contributions identified in the *Intelligent-Sustainable Assessment Table* derive from a personal understanding of the information contained in the retrieved project plans. The robustness of these assumptions can be improved in the future by discussing them together with the people involved in the projects.

Finally, it should be underlined that the project is limited by the own nature of sustainable development. In fact, the conclusions formulated regarding the contribution of ICPs and KCPs to the parameters of *contingent sustainability* are subject to the definitions provided in this research and cannot be generalized. In order to be more specific, the assessment should be carried with the specific vision of the sustainable society, economy and environment approved by the urban community.

The above discussed limitations indicate the strength and weaknesses of the outcomes of this project. In sum, the strong points rely in the design of a well thought policy and assessment framework, supported by a thorough bibliographic research of the concepts treated. Turning to the weak points, these are to be found in the empirical verification of the conceptual model and central hypothesis which require further investigation work[1]

[1] The empirical verification phase could not have been carried out given the time and scope of this thesis.

6.2.3 Future research opportunities

The natural continuation of this project would be the verification (or falsification) of the preliminary conclusions reached regarding the contribution of ICPs and KCPs to urban sustainability. This requires:

1. On site investigation of the ICPs and KCPs implemented;
2. Collection of data regarding the outcomes of the programmes executed;
3. Application of the data to the developed system for measuring the progress of cities towards urban sustainability over a time frame to be decided.

These three activities require a considerable amount of time and resources, and will have to deal with the challenges discussed in the list above.

However, this project sets fertile ground for other future research opportunities in the field of Sustainable, Intelligent and Knowledge Cities. In this instance, the following questions are proposed as the base of future research efforts in this topic:

- Which strategies should be implemented in order to increase the probabilities that citizens maximize the benefits enabled by ICPs and KCPs? In other words, which policies could support ICPs and KCPs in effectively changing the behavior of citizens so that they result more eco-compatible and sustainable? (Proposed methodology: *Agent Based Modeling*)
- Using the developed system for monitoring sustainabilizing cities, how can we predict the effects of ICPs and KCPs based on human behavior changes? (Proposed methodology: *Discrete Systems Modeling* and *System Dynamics*)
- Under the assumption of different human behaviors, when will the ICP or KCP implemented have a positive return on investments? (Proposed methodology: *Cost Benefit Analysis*)
- What are the precise effects that ICPs bring to the sustainable environment pillar through the optimization of urban sectors and infrastructure? (Proposed methodology: *Environmental Impact Assessment*)
- How can a "smarter planet" deal with the prospects of growing urban populations and levels of consumption? In other words, what strategies could ICPs and KCPs leverage for tackling these two global trends?

Appendix 1

Interviews

The paragraphs below illustrate, for the four case studies assessed in this research, the names of the people of Accenture involved in the project and the questions posed during the interview. My sincere gratitude goes to them and the many other people of the company for the time and energy that they dedicated to my project. Their help and contribution has been essential for the success of this work.

The questions posed during the interviews (which varied according to the nature of the project and the role played by Accenture in its implementation) can be resumed in the following groups:

1. An executive summary providing an overview of the project and on the role played by Accenture in its design and implementation phase.
2. A description of the implemented Intelligent Cities offerings.
3. The adopted methodology for measuring the (expected) benefits of the implemented ICPs and collected data
4. The final outcome of the project (measured or forecasted)

Below are presented the main questions posed relative to the specific Intelligent City Project assessed.

Project: **Amsterdam Smart City**

Contact: Joost Brinkman

Email: joost.brinkman@accenture.com

Questions:

- Is it possible to have an overview of the entire project, including the implementation plan and scope?
- What Smart Technologies have been implemented in the various projects, why are they considered "smart" and what was their scope?
- What are the parameters/indicators for measuring the benefits of the Amsterdam Smart City Project (and have they been measured or forecasted)?

Project: **Nordhan Intelligent District Development**

Contact: Christian B. Pedersen

Email: christian.b.pedersen@accenture.com

Questions:

- Which parameters/indicators are used to measure “smartness” of the developed energy grid?
- Has the Smart Grid for Nordhavn been developed? If not, at what stage (e.g. design, construction, operational) is the project currently at?
- Is it possible to have an overview or short description of the smart grid designed?
- What are the indicators for measuring the benefits of the smart grid and how are they expected to differ from the adoption of traditional electricity grids?

Project: **Bilbao Global Knowledge City**

Contact: Laura Martinez Alvaro

Email: laura.martinezalvaro@accenture.com

Questions:

- What were the initiatives that took part to the project of Bilbao to implement urban intelligence in the city’s structure? What was their value added and was this measured/forecasted?
- How will the Bilbao Knowledge Platform be designed and what features will it possess?
- How will the knowledge sharing system developed help the city leverage the potential of its intelligent infrastructure already installed? What are the expected benefits of this system and have they been numerically estimated with the use of indicators?
- How does the programme fit in the city’s vision of sustainability?

Project: **1MDB Kuala Lumpur - Malaysia**

Contact: George Mendes

Email: george.mendes@accenture.com

Questions:

- Is it possible to have an executive summary giving an overview of the digital master plan developed for the client?
- What are the parameters/indicators for measuring the benefits of using a digital master plan and how are they expected to differ from the adoption of traditional urban planning approaches?
- How was the Digital Master Plan used and what where the objectives that it helped achieve? How are these objectives measurable (and have they been measured up to date)?
- How do we measure the success of the financial district that Accenture helped creating (and has it been measured up to date)?

Appendix 2

Sustainable development according to different public and private organizations

Actor typology: Non-Governmental organizations **Name: Friends of the Earth**	
Definition of S.D.	"SD is development that improves the quality of life for all people while respecting environmental limits and the ability of future generations to enjoy a similar quality of life."
Objectives related to S.D.	To raise awareness, enhance the participation of people and citizens organizations in politics, and influence decision makers on all levels.
Strategies	• Fighting Climate Change by supporting the realization of energy sovereignty through proactive, grassroots community based campaigns and projects • Supporting global food sovereignty helping small scale peasant and family farmers in resisting the corporate powers • Resisting neoliberalism for economic justice • Protecting forests and biodiversity • Promoting fair management of water resources • Resisting mining activities • ATALC Sustainability School – promoting sustainable development in Latin America and the Caribbean.
Source	http://www.foeeurope.org/

Actor typology: Non-Governmental organizations **Name: Greenpeace**	
Definition of S.D.	Not explicitly mentioned
Objectives related to S.D.	The underlying goal of all our work is a green and peaceful world - an earth that is ecologically healthy and able to nurture life in all its diversity.
Strategies	• Fighting Climate Change • Protection of forests • Opposing the introduction of GMOs in agriculture • Fighting nuclear energy • Eliminating toxic chemicals • Defending oceans and marine life
Source	http://www.greenpeace.org/international/en/

Appendix 2

Actor typology: Non-Governmental organizations **Name: EarthAction**	
Definition of S.D.	Not explicitly mentioned
Objectives related to S.D.	EarthAction's mission is to inform and inspire people everywhere to turn their concern, and passion into meaningful action for a more just, peaceful and sustainable world
Strategies	• Preventing dangerous climate change and promote renewable energy • Protecting the last great forests • Eliminating nuclear weapons
Source	http://www.earthaction.org/

Actor typology: International institutes **Name: Earth Watch Institute**	
Definition of S.D.	Not explicitly mentioned
Objectives related to S.D.	To engage people worldwide in scientific field research and education in order to promote the understanding and action necessary for a sustainable environment.
Strategies	• Scientific field research on pressing environmental issues • Capacity building in developing countries • Engaging the public in conversation with governmental authorities • Changing consumer attitudes through education programmes • Working with business to reduce their environmental impact
Source	http://www.earthwatch.org/europe/

Actor typology: International institutes **Name: International Institute for Sustainable Development**	
Definition of S.D.	"Sustainable development is an ongoing process of evolution in which people take actions leading to development that meets their current needs without compromising the ability of future generations to meet their own needs." (Hardi and Zdan, 1997)
Objectives related to S.D.	Champion innovation, enabling societies to live sustainably. IISD promotes the transition toward a sustainable future; we seek to demonstrate how human ingenuity can be applied to improve the well-being of the environment, economy and society
Strategies	• Policy research and analysis • Information exchange • Advocacy
Source	http://www.iisd.org/about/

Appendix 2

Actor typology: Non-Governmental organizations **Name: WWF**	
Definition of S.D.	"Sustainable development means improving the quality of life while living within the carrying capacity of supporting ecosystems." (Expert Group on the Urban Environment, 1996)
Objectives related to S.D.	To stop the degradation of our planet's natural environment, and build a future in which humans live in harmony with nature
Strategies	• Reduce the ecological footprint of human societies • Conserving the natural environment • Protecting living species and safeguarding biodiversity
Source	http://wwf.panda.org/what_we_do/

Actor typology: International institutes **Name: European Business Council for Sustainable Energy**	
Definition of S.D.	A sustainable society is composed of 5 dimensions: economy, efficiency, environment, energy, and employment.
Objectives related to S.D.	To promote the potential of sustainable energy use and the implementation of modern, climate-friendly technologies in the European Union (EU) and at the early international climate negotiations
Strategies	• Lobbying activities • Providing a dialogue platform that advances knowledge exchange between business, science, civil society and policy-makers. • Participate in policy development
Source	http://www.e5.org/index.php

Actor typology: International institutes **Name: World Business Council for Sustainable Development**	
Definition of S.D.	"We define sustainable development as forms of progress that meet the needs of the present without compromising the ability of future generations to meet their needs." (World Business Council for Sustainable Development)
Objectives related to S.D.	To provide business leadership as a catalyst for sustainable development and to support the business license to operate, innovate and grow in a world increasingly shaped by sustainable development issues
Strategies	• Develop co-operation between businesses, governments and organizations concerned with environment and sustainability • Information exchange on best practices • Participate in policy development • Advocacy
Source	http://www.wbcsd.org

Appendix 2

Actor typology: Scientific research institutes	
Name: Barkley Centre for Sustainable Resource and Development	
Definition of S.D.	"Sustainable development is the activity that expands human opportunities in ways that avoid unacceptable fluctuations and irreversible losses in ecological, social and economic options over time". (Barkley Centre for Sustainable Resource and Development)
Objectives related to S.D.	To provide science-based leadership in the identification and implementation of sustainable development strategies, that effectively balances concerns for efficiency, environmental conservation and social equity.
Strategies	• Training programmes and seminars for business and governmental leaders • Policy-oriented research • Development of knowledge for managing natural resources in a self-sustaining way • Advocacy • Network for exchanging information
Source	http://cnr.berkeley.edu/csrd/about/about.htm

Actor typology: Scientific research institute	
Name: International Institute for Environment and Development	
Definition of S.D.	"Sustainable development is taken to mean achieving a quality of life that can be maintained for many generations because it is: socially desirable (fulfilling people's cultural, material and spiritual needs in equitable ways) economically viable (paying for itself, with costs not exceeding income), and ecologically sustainable, maintaining the long-term viability of supporting ecosystems." (IIED, 2000)
Objectives related to S.D.	To build a fairer, more sustainable world, using evidence, action and influence in partnership with others.
Strategies	• Policy research and analysis • Information exchange • Advocacy
Source	http://www.iied.org/general/about-iied/about-iied

Actor typology: Scientific research institute	
Name: Platform for scientific co-operation on Indicators for Sustainable Development	
Definition of S.D.	Not explicitly mentioned.
Objectives related to S.D.	To create an interface between the users and developers of indicators on sustainable development (ISD) that increases the participation of different actors in the development of ISD, improves the collaborations between users and developers and raises the awareness for ISD in sustainable development strategies and policies. (Platform for scientific co-operation on Indicators for Sustainable Development)
Strategies	• Enhance exchange between multiple actors towards formulation and use of ISD • Stimulate information exchange between research communities • Provide information on ISD to interested users
Source	http://www.belspo.be/platformisd/

Appendix 2

Actor typology: Scientific research institute	
Name: The Centre for Social and Economic Research on the Global Environment	
Definition of S.D.	"The condition for sustainable development, therefore, amounts to each generation leaving the next generation a stock of productive capacity, in the form of capital assets and technology, that is capable of sustaining utility or well-being per capita than that enjoyed by the current generation." (Pearce and Atkinson, 2012)
Objectives related to S.D.	Ongoing commitment to explore issues that are important not only to a range of academic interests, but also relevant to policy-makers and stakeholders in the field of environmental sustainability and human wellbeing.
Strategies	• Scientific research activities (waste and water management, sustainable development indicators, resource valuation, green accounting and coastal management). • Policy guidance • Participate in policy development
Source	http://www.cserge.ac.uk/about-cserge/more-about-cserge

Actor typology: Scientific research institute	
Name: Ecologic – Pathways to Sustainability	
Definition of S.D.	Not explicitly mentioned. However, the institute defines the main elements and assessment criteria of sustainable development in their report "Sustainable Development: a summary of key concepts" (Sinner, Baines, Crengle, Salmon, Fenemor, & Tipa, 2004).
Objectives related to S.D.	Support the design, implementation and measurement of pathways towards sustainability.
Strategies	• Policy research • Consultancy for "greening" the strategies and practices of governments and private organizations • Communicating information to local and central government of New Zealand, including the public and other actors.
Source	http://www.ecologic.org.nz/?id=23

Actor typology: Private Organizations	
Name: The Boston Consulting Group	
Definition of S.D.	Sustainability means adaptability: it requires a company to adapt to changes in the ecological, social, and economic spheres across different time horizons (The Boston Consulting Group)
Objectives related to S.D.	Through Sustainability Practice, the BCG supports clients in developing robust, long-term strategies and leverage competitive advantages from their sustainability efforts.
Strategies	• Sustainability practices include supply chain optimization, energy efficiency, waste reduction and green building solutions.
Source	http://www.bcg.com/expertise_impact/capabilities/sustainability/default.aspx

Appendix 2

Actor typology: Private Organizations **Name: Accenture**	
Definition of S.D.	"Good performance on sustainability amounts to good business performance overall" (Accenture). The concept of sustainability is translated into 5 operational objectives: (i) Risk reduction; (ii) Better image; (iii) Cost reductions; (iv) Higher revenues.
Objectives related to S.D.	Give support to private organizations in the process of embedding environmental, social and corporate governance issues within core business, and assist governments in implementing their sustainability agenda.
Strategies	• Sustainability strategies (e.g. City growth and strategy management; Sustainability strategy and journey management; Sustainability Policy and Regulation) • Operational excellence (e.g. Green six sigma; Green IT; Sustainable supply chain) • Emissions management (e.g. Clean energy solutions; Carbon market and carbon trading) • Intelligent Infrastructure (e.g. Intelligent transport; Smart grids; Smart building solutions)
Source	http://www.accenture.com/SiteCollectionDocuments/PDF/Accenture-Sustainability-Services-Brochure.pdf

Actor typology: Private Organizations **Name: IBM**	
Definition of S.D.	"Today, sustainability is a strategic business imperative" (IBM Institute for Business Value)
Objectives related to S.D.	Help private organizations and governments optimize resource consumption and environmental efficiencies, drive brand value, reduce risk and exploit growth through product and service innovations.
Strategies	• Environmental sustainability services (e.g. Definition of "environmental strategies"; Green branding; Compliance management; Cost-efficient sustainability) • Smart Cities (e.g. Smart Infrastructure Services) • Business sustainability strategies (e.g. Supply chain optimization; Sustainable growth strategy definition)
Source	http://public.dhe.ibm.com/common/ssi/ecm/en/gbe03246usen/GBE03246USEN.PDF

Actor typology: Private Organizations **Name: Cisco**	
Definition of S.D.	Not explicitly mentioned.
Objectives related to S.D.	Integrate Information Technology systems in business operations and urban management for helping organizations and governments cope with environmental challenges. Cisco sees the Internet and networking technology at the heart of a global technological ecosystem where people and businesses can begin to work, live, play, and learn in new and more sustainable ways (Cisco)
Strategies	• Green service delivery • Network efficiency • Energy optimization • Platform life cycle • Smart buildings and Smart grid solutions
Source	http://www.cisco.com/en/US/solutions/ns341/ns525/green_sp.html#

Appendix 2

Actor typology: National and International Governmental Authorities Name: Italian Government	
Definition of S.D.	"A developing economical system can be regarded as sustainable only if it exploits natural resources up to a set quantity and quality limit within the earth renewal capacity by never exceeding this threshold." (Italian Ministry for the Environment and Territory, 2001)
Objectives related to S.D.	New sustainability-oriented projects are most needed in order to reset ecological balances, to change consumption and production patterns, to promote ecological efficiency and to restore social equity conditions.
Strategies	• Integration of environmental, economic and social issues in a unique framework for policy-making • Implementation of strategies in line with Agenda21 objectives • Creating awareness for the economy and environment and stimulate public and stakeholder participation in decision-making processes. • Increase energy efficiency and use of renewable energies. • Promote "prevention policies" over "end of cycle" interventions • Improved waste management • Support local cultural and economic activities of the territory
Source	http://www.minambiente.it/home_it/menu.html?mp=/menu/menu_attivita/&m=argomenti.html|Sviluppo_sostenibile__SvS_.html|Lo_Sviluppo_Sostenibile__SvS_.html|Strategia_dazione_ambientale_per_lo_Svil.html

Actor typology: National and International Governmental Authorities Name: Belgian Federal Government	
Definition of S.D.	The Federal Government of Belgium adopts the definition and principles of Sustainable Development contained in the Rio Declaration (1992).
Objectives related to S.D.	"Harmonizing the economy, ecology and social protection" is one of the key objectives of government policy and that the Federal Government will make all possible efforts to fulfill Belgium's international commitments in the field of sustainable development." (Federal Government of Belgium, 2000)
Strategies	• Actively contribute in the formulation of international policies • Develop an effective legal framework for the integration of environment and development issues at national, subregional, regional and international decision-making levels • Support scientific research directed towards acquiring essential knowledge about society and nature. • Integration of sustainable development objectives in the tax system through national fiscal policies • Improve decision-making process through the use of sustainable development indicators and scientific knowledge.
Source	http://diplomatie.belgium.be/en/policy/policy_areas/striving_for_global_solidarity/sustainable_development/

Appendix 2

Actor typology: National and International Governmental Authorities Name: European Commission	
Definition of S.D.	"Sustainable development is development that delivers basic environmental, social and economic services to all residents of a community without threatening the viability of the natural, built and social systems upon which the delivery of these services depends." (Expert Group on the Urban Environment, 1996)
Objectives related to S.D.	In establishing the Expert Group on the Urban Environment in 1991, the aim of the European Commission is to identifying the principles of sustainable development and the mechanisms needed to pursue it, not only in cities, but at all levels of the urban settlement hierarchy.
Strategies	• Identify and divulgate best urban management practices • Develop policy integration frameworks • Diffusion on the holistic "eco-systems thinking" principle as dominant approach for policy-making amongst state members. • Establishment of local and international partnerships
Source	http://sustainable-cities.eu/index.php

Actor typology: National and International Governmental Authorities Name: Dutch National Government	
Definition of S.D.	"The Dutch government believes that sustainable development involves balanced, coordinated management of three domains: the sociocultural domain (people); the ecological domain (planet) and the economic domain (profit)." This definition is summarized in the following form: "Sustainability: people, planet, profit, here, elsewhere, now and later". (Government of the Netherlands, 2003)
Objectives related to S.D.	The implementation of long-term policies that will contribute to the fulfillment of 12 pre-defined sustainability themes (ref. Gov. of the Netherlands, 2003)
Strategies	• Improve management systems in the waste, water, energy, transport, health and safety sector. • Construct international relations and partnerships for fighting climate change, poverty, hunger and improving international trade and financial structure. • Support transition towards sustainable production and consumption processes • Protect of the environment and biodiversity
Source	http://www.un.org/esa/sustdev/natlinfo/nsds/summary.pdf

Appendix 3

Reviewed definitions of sustainable development

1. Author: Brundtland Commission

   Year: 1987

   Perspective: Environmental, Economic, Social

   Definition: Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs. It contains within it two key concepts:

   - the concept of needs, in particular the essential needs of the world's poor, to which overriding priority should be given; and
   - the idea of limitations imposed by the state of technology and social organization on the environment's ability to meet present and future needs."

2. Author: Lélé S. M.

   Year: 1991

   Perspective: Environmental, Economic, Social

   Definition: A Form of societal change that, in addition to traditional developmental objectives, has the objective or constraint of ecological sustainability.

3. Author: Haughton G.

   Year: 1999

   Perspective: Environmental, Economic, Social

   Definition: Sustainable development is a type of growth based on the following five principles:

   1. Futurity (inter-generational equity)
   2. Social justice (intra-generational equity)
   3. Transfrontier responsibility (geographical equity)
   4. Procedural equity (people treated openly and fairly)
   5. Inter-species equity (importance of biodiversity)

4. Author: Robinson J. and Tinker J.

   Year: 1997

   Perspective: Environmental, Economic, Social

   Definition: A development which is sustainable needs to embody three imperatives:

   1. Ecological imperative (stay within the biophysical carrying capacity of the planet).
   2. Economic imperative (provide an adequate material standard of living to all).

3. Social imperative (provide a system of governance that propagates the value that people want to live by).

5. Author Van der Ryn and Calthopes

Year 1991

Perspective Environmental

Definition Sustainability implies that the use of energy and materials in an urban area be in balance with what the region can supply continuously through natural processes such as photosynthesis, biological decomposition and biochemical processes that support life."

6. Author Brown

Year 1987

Perspective Environmental

Definition In the narrowest sense, global sustainability means the indefinite survival of the human species across all the regions of the world. A broader sense of the meaning specifies that virtually all humans, once born, live to adulthood and that their lives have quality beyond mere biological survival. Finally the broadest sense of global sustainability includes the persistence of all components of the biosphere, even those with no apparent benefit to humanity."

7. Author Pearce *et al.*

Year 1988

Perspective Economic

Definition We take development to be a vector of desirable social objectives, and elements might include:

- increases in real income per capita;
- improvements in health and nutritional status;
- educational achievement;
- access to resources;
- a 'fairer' distribution of income;
- increases in basic freedoms.

... Sustainable development is then a situation in which the development vector increases monotonically over time.

8. Author Governor's Commission for a Sustainable South Florida

Year 1996

Perspective Environmental, Economic, Social

Definition Sustainable development involves "achieving positive change that enhances the ecological, economic, and social systems upon which South Florida and its communities depend. Once implemented these strategies will bolster the regional economy, promote quality communities, secure healthy South Florida ecosystems, and assure today's progress is not achieved at tomorrow's expense"

9. Author: President's Council on Sustainable Development

Year: 1996

Perspective: Environmental, Economic, Social

Definition: Our vision is of a life-sustaining Earth. We are committed to the achievement of a dignified, peaceful, and equitable existence. A sustainable United States will have a growing economy that provides equitable opportunities for satisfying livelihoods and a safe, healthy, high quality of life for current and future generations. Our nation will protect its environment, its natural resource base, and the functions and viability of natural systems on which all life depends.

10. Author: Cambridge Planning Board

Year: 1993

Perspective: Environmental, Economic, Social

Definition: Sustainable development is "the ability of [the] community to utilize its natural, human and technological resources to ensure that all members of present and future generations can attain high degrees of health and well-being, economic security, and a say in shaping their future while maintaining the integrity of the ecological systems on which all life and production depends"

11. Author: Repetto

Year: 1985

Perspective: Economic, Social

Definition: The core of the idea of sustainability, then, is the concept that current decisions should not impair the prospects for maintaining or improving future living standards. This implies that our economic systems should be managed so that we live off the dividend of our resources, maintaining and improving the asset base

12. Author: Goodland and Ledec

Year: 1987

Perspective: Economic, Social

Definition: Sustainable development is here defined as a pattern of social and structural economic transformations (i.e. 'development') which optimizes the economic and societal benefits available in the present, without jeopardizing the likely potential for similar benefits in the future. A primary goal of sustainable development is to achieve a reasonable (however defined) and equitably distributed level of economic well-being that can be perpetuated continually for many human generations.

13. Author: Tanguay *et al.*
Year: 2010
Perspective: Environmental, Economic, Social
Definition: For development of a given territory to be considered sustainable, it must integrate the qualities associated with interactions and overlapping of these dimensions. Accordingly, development must be equitable (interaction between the economic and social dimension), livable (correspondence of the environment to social needs, which can refer to the concept of quality of life) and viable (economic development must abide by the supportive capacity of the ecosystems, and depletion of non-renewable resources must be avoided).

14. Author: Berke and Manta-Conroy
Year: 2000
Perspective: Environmental, Economic, Social
Definition: Sustainable development is a process in which communities anticipate and accommodate the needs of current and future generations in ways that reproduce and balance local social, economic, and ecological systems, and link local actions to global concerns.

15. Author: World Bank
Year: 1991
Perspective: Environmental, Economic, Social
Definition: The goal of sustainability is the conservative effort to maintain the traditional meaning and measures of income in an era in which natural capital is no longer a free good. At a conceptual level the justification for making sustainability a sine qua non for project eligibility could not be stronger or more conservative. (…) All projects must comply with Environmental Assessment standards in order to be considered sustainable.

16. Author: Bossel
Year: 1999
Perspective: Environmental, Economic, Social
Definition: Sustainability is a dynamic concept. Societies and their environments change, technologies and cultures change, values and aspirations change, and a sustainable society must allow and sustain such change,

i.e., it must allow continuous, viable and vigorous development, which is what we mean by sustainable development. (…) The shape and form of a sustainable society must allow perpetual change for being sustainable.

Appendix 4

Example of defined indicators of sustainable development (1)

Table: Final list of 29 SDI developed using the SuBSelect method by Tanguay *et al.*, 2010.

Concept	Dimension	Category
Absence of presence policies or strategies supporting SD	Sustainable	Public Administ.
Density of urban population per km^2	Sustainable	Demographics
Daily water consumption	Sustainable	Water
Ecological footprint	Sustainable	Unclassified
% of citizens claiming they feel well or very well)	Sustainable	Health
% of users of MT vs other means of transport	Sustainable	Transport
Fraction of surface allotted to nature conservation of the total land	Sustainable	Ecosystem
Costs of living per capita	Economic	Well being
Participation rate for all sectors	Economic	Employment
Number of new jobs created per year for all sectors combined	Economic	Employment
Mean or median of household income per year	Economic	Income & Exp.
% of households spending 30% or more of income on housing	Equitable	Housing cond.
% of population < 18 years with less than high school diploma	Equitable	Education
Unemployment rate	Equitable	Employment
Ratio of high income to low income population	Equitable	Income & Exp.
% of population receiving social assistance	Equitable	Income & Exp.
% of low income households	Equitable	Income & Exp.
Crime rate	Equitable	Security
Rate of participation in municipal elections	Social	Governance
% of citizens participating to public affairs	Social	Governance
Annual consumption of energy from renewable sources	Viable	Energy
Businesses with environmental certification	Viable	Businesses
% of waste recycled	Viable	Waste
Concentration of PM10 particles in atmosphere	Livable	Air
GHG emission (excluding transport)	Livable	Air
% of population exposed to Lnigh > 55dB	Livable	Noise
Quality of water ways	Livable	Ecosystem
Average quantity of waste produced per household per year	Livable	Waste
% of population participating in sports in parks or swimming pools	Livable	Social

Appendix 5

Example of defined indicators of sustainable development (2)

Table: Final list of 40 SDI developed by Moles *et al*., 2008.

Concept	Domain	DPSIR classification
Sustainable Development Index	Composite	State
Environment Index	Environment	State
Quality of Life Index	Quality of Life	State
Socio-Economic Index	Socio-Economic	State
Transport Index	Transport	State
Population Density	Socio-Economic	Driving Force
Services Index	Socio-Economic	Driving Force
Annual income per capita	Socio-Economic	Driving Force
Waste volume per capita	Environment	Pressure
% sewerage connection	Environment	Pressure
CO_2 emissions from transport sector	Environment	Pressure
CO_2 emissions from energy production sector	Environment	Pressure
Level of wastewater treatment	Environment	Pressure
Distance to hospital	Quality of Life	Pressure
% 45 + hours employment	Quality of Life	Pressure
% households in whole houses	Socio-Economic	Pressure
% primary education as highest level	Socio-Economic	Pressure
% of population with diploma as highest level	Socio-Economic	Pressure
Distance to nearest train station	Tansport	Pressure
FIPS_10000 radius	Environment	State
NHA_5000 radius	Environment	State
Drinking water NO_3	Environment	State
GPs per 1000 population	Quality of Life	State
% rented from LA	Socio-Economic	State
House price income ratio	Socio-Economic	State
% population working in same town	Transport	State
% population working within distance < 8km	Transport	State
% population working within distance > 24km	Transport	State
Distance to shops	Transport	State
Distance to work	Transport	State
% of population with health insurance	Quality of Life	Impact
% population reporting odor problems	Quality of Life	Impact
% population reporting noise problems	Quality of Life	Impact
% population satisfied with sports facilities	Quality of Life	Impact
% population satisfied with green areas	Quality of Life	Impact
% population satisfied with quality of life	Quality of Life	Impact
% households with central heating	Socio-Economic	Impact
% houses with internet access	Socio-Economic	Impact
% relative car use	Transport	Impact
% households with more than 2 cars	Transport	Impact
% population using public transport	Transport	Impact
Index of traffic flow	Transport	Impact
% of total waste recycled	Environment	Response
% of population reporting interest in green energy	Environment	Response
% population involved in public participation	Quality of Life	Response

Appendix 6

Main sectors composing urban systems

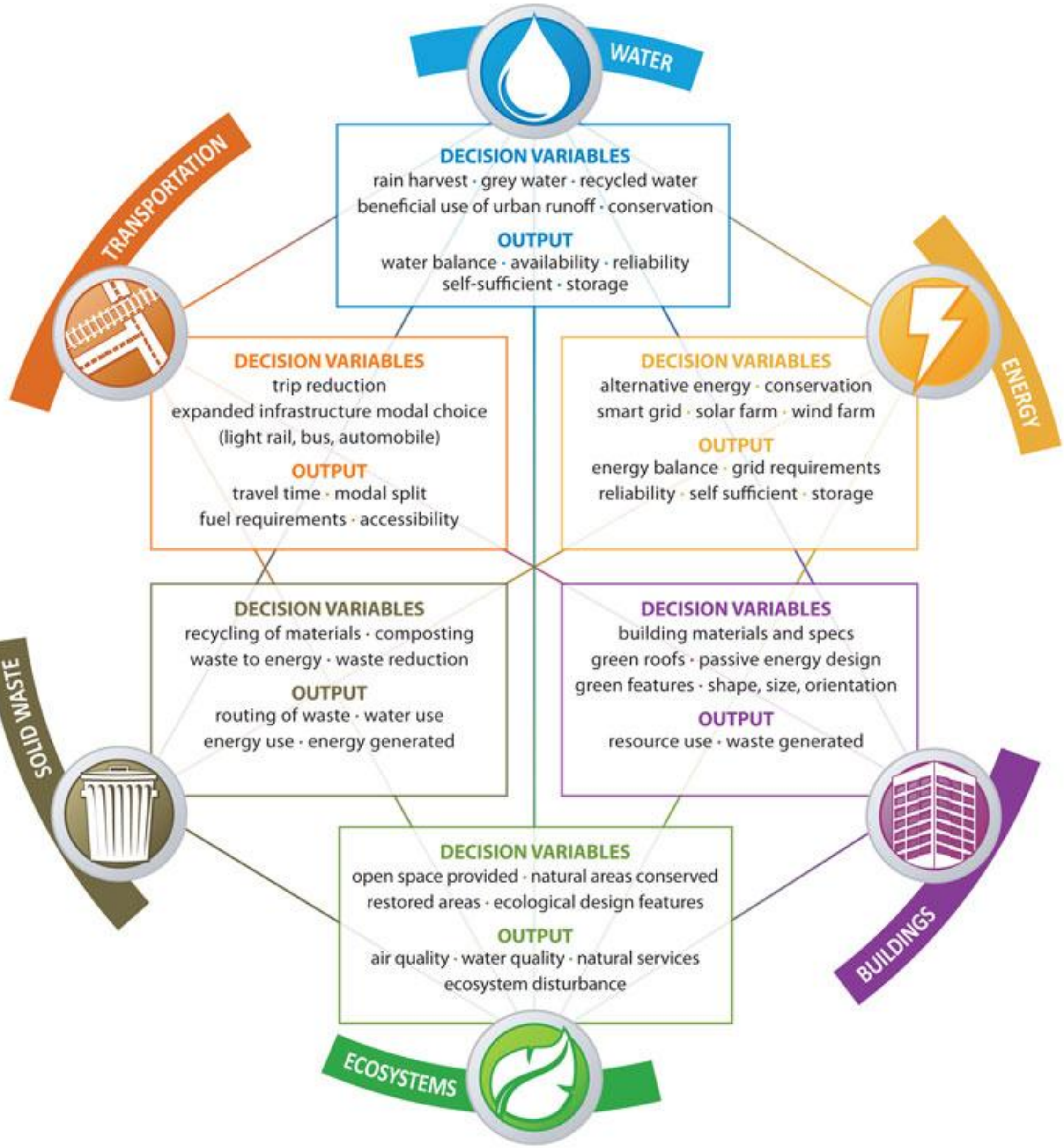


Figure: Main sectors composing urban systems
Source: http://cdmsmith.com/en-US/Insights/Neysadurai-Centre/Urban-Systems-Model.aspx

Appendix 7

Maslow's hierarchy of needs

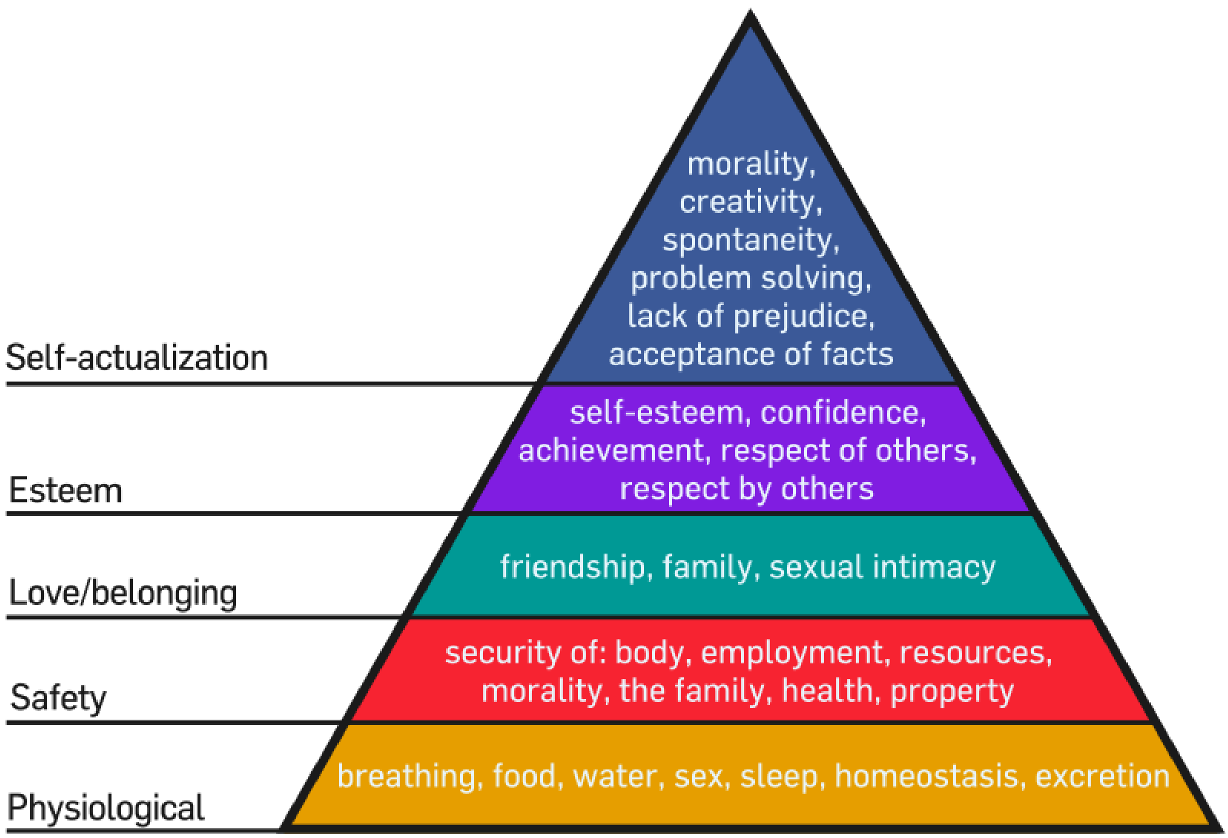


Figure: Maslow's hierachy of needs
Source: http://en.wikipedia.org/wiki/File:Maslow%27s_Hierarchy_of_Needs.svg

Appendix 8

Description and source of the selected indicators of sustainable development

This section has the purpose of illustrating in more detail the meaning of the 41 SDI defined. Moreover, a reference is provided for each indicator, with the scope of giving the reader an example of a public or private organization measuring them within a specific territorial context.

– Indicators of Sustainable Urban Metabolisms –

(1) Input flows

(1.a) Reducing consumption of non-renewable energy sources

(1.a.i) *Share of renewable electricity in Gross Final Electricity Consumption (GFEC) of the region.*

i. *Unit:* % of total final gross electricity consumption

ii. *Description:* The GFEC is calculated as the gross generation of electricity, net generation by pumped-storage plants, plus imports and minus exports (from/to foreign countries or regions) pursuant to Directive 2009/28/EC. Consumption includes electricity used by agriculture, service sector, industries, and households. The indicator is obtained as the ratio of the total energy generation from renewable sources (RES: energy produced form non-fossil sources, namely wind, solar, aerothermal, geothermal, hydrothermal and ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases) to the GFEC.

iii. *Reference:* Renewable-Energy Power Plants – Statistical Report 2010 by GSE[1] (Gestore Servizi Energetici, 2011)

(1.a.ii) *Gas consumption for heating building sector*

i. *Unit:* Gwh per year[2]

ii. *Description:* Besides being used for the production of electricity, gas is the primary source of energy for heating households. The annual gas consumption of the city's housing sector can be calculated by adding the data collected by domestic gas meters, which is usually presented in the National Statistics

[1] Italian state-owned company for the promotion and support of renewable energy sources.

[2] N.B. This indicator needs to be in some ways standardized with regards to the climate conditions of the city, and should take into account that some years may be on average colder or warmer than others.

datasets. These datasets generally include information regarding the typology and dimensions of dwelling units, as well as the socio-economic characteristics of their households.

iii. *Reference:* UK Department of Energy and Climate Change – Energy trends 2012 (UK Department of Energy and Climate Change, 2012)

(1.a.iii) *Total petroleum consumption of city's vehicle fleet*

i. *Units:* thousand gasoline and diesel liters per year

ii. *Description:* All states and municipalities have records on the number and typologies of licensed vehicles owned by the population and the government. Through national surveys, it is possible to determine the average annual miles and number of passengers for each typology of vehicle (e.g. light trucks, SUVs, sedans and station wagons, etc.). By combining this data with the average power and weight of each vehicle typology, it is possible to calculate the total average annual fuel consumption of the city's vehicle fleet.

iii. *Reference:* U.S. Department of Energy – Transportation Data Book: (Chapter 7) Fleet Vehicles and Characteristics (U.S. Department of Energy, 2011)

(1.b) Reducing consumption rate of natural resources

(1.b.i) *Consumption of natural resources (i.e. fresh water, wood, metals, non-urbanized land, limestone and other extracted rock material for construction) per urban sector*

i. *Units:* Quantity of natural resource consumed per urban sector per year

ii. *Description:* Depending on the type of natural resource selected, different calculation methods will be adopted. Generally, the data needed for these calculations can be found in the Government National Statistics records. For example, the total consumption of water per sector (e.g. industrial, domestic, agriculture, and thermal power) is measured as the total amount of water needed to carry out a particular activity. Another example is the consumption of natural land for urbanization, which is calculated as the area of soil sealed each year with the use of Geographic Information Systems and satellite images.

iii. *Reference:* Italian National Institute of Statistics (ISTAT) – soil sealing trends (Italian National Institute of Statistics, 2012), and – Urban Environmental Indicators (Italian National Institute of Statistics, 2009a)

(2) Output flows

(2.a) Reducing quantity of wastes produced and disposed

(2.a.i) *Total quantity of municipal waste produced per capita*

i. *Units:* Kg of waste per capita per year

ii. *Description:* Total amount of waste produced by a city (all compartments included) each year is given as the sum of the waste that is disposed in landfills, incinerated, recycled or composted. The indicator is obtained by dividing this quantity by the total population of the city. In some cases, it is possible to specify the source of production (e.g. construction, manufacturing, service industries) and type of waste produced (urban or special)[3]

iii. *Reference:* Eurostat – Environment and Energy: Generation and Treatment of Municipal Waste (Eurostat - Environment and Energy, 2011) and Italian National Institute of Statistics (ISTAT) – Environmental Statistics Report (Italian National Institute of Statistics, 2009b)

(2.a.ii) *Share of municipal waste recycled*

i. *Units:* % of total waste produced

ii. *Description:* The city's share of recycled waste is given as the fraction of waste which is not disposed in landfills, incinerated nor composted. In some cases, it is possible to specify the typology of waste being recycled and the processes adopted for recycling.

iii. *Reference:* Statistics for Wales – Municipal Waste Management Report 2007-2008 (Welsh Government National Statistics, 2008) and Italian National Institute of Statistics (ISTAT) – environmental statistics report (Italian National Institute of Statistics, 2009b)

(3) Environmental impact of urban sectors

(3.a) Reducing environmental impact of urban sectors

(3.a.i) *GHG emissions per capita for the commercial, industrial, domestic and transport sector.*

i. *Units:* Kt of CO_2 per capita per year per sector

ii. *Description:* Total emissions of CO_2 per citizen of local authorities deriving from the commercial, industrial, domestic and transport sector. Emission

[3] In Italy, Legislative Decree no. 152 of 3 April 2006 specifies the attributes of the different typologies of waste produced by the city.

calculations are based on data regarding the energy consumption per capita in the four aforementioned sectors at the regional and local authorities level, which are retrievable from national statistics records.

iii. *Reference:* UK Department of Energy and Climate Change – Carbon Dioxide Emissions with the Scope of Influence of Local Authorities (Previously NI 186) (UK Department of Energy and Climate Change, 2011).

(3.a.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 (energy, industry, agriculture, waste management, transport and domestic)*

i. *Units:* tons of substance per sector per year

ii. *Description:* Total emissions of air pollutants (i.e. SO_X , NO_X , CO, CH_4 , NH_3 , CFCs , PM_{10} , $PM_{2,5}$ and Halons) deriving from different urban sectors of the region. National environmental statistics also possess data on the concentration of these air pollutants for all local authorities (ref. indicator 10.c.i)

iii. *Reference:* Italian National Institute of Statistics (ISTAT) – Environmental Statistics Report (Italian National Institute of Statistics, 2009b).

(3.a.iii) *Estimation of the polluting effect of different urban sectors on water compartments (i.e. natural flows, underground and superficial water bodies)*

i. *Units:* Equivalent total urban inhabitants

ii. *Description:* The polluting effect of different urban sectors on the water compartment can be estimated from data on the quantity and quality of water flowing to urban sewage systems from different sectors (e.g. industrial, domestic, agriculture, etc.). This can be expressed in "equivalent total urban inhabitants" by considering the organic substance produced by an average citizen[4].

iii. *Reference:* Italian National Institute of Statistics (ISTAT) – Estimation of the polluting effect of different urban sectors on water compartments (Italian National Institute of Statitistics, 2009d)

(3.a.iv) *Emissions of soil pollutants (i.e. heavy metals and toxic substances) per urban sector (waste, transport, agriculture and sewage system)*

i. *Units:* tons of substance per year per urban sector

ii. *Description:* soil pollutants may derive directly from the source (as in the case of industrial waste, sewage sludge and chemical pesticides used in

[4] For a more detailed definition of the measurement unit, ref. (Italian National Institute of Statistics, 2009c)

agriculture) or indirectly from the atmosphere (deposition of toxic substances released from internal combustion vehicles and electric plants reliant of fossil fuels). While the former are easier to calculate, the latter are derived through estimations based on the emission of toxic substances from the transport system and energy industry.

iii. *Reference:* UK Department for Environment Food and Rural Affairs – Soil Strategy for England (UK Dep. for Environment, Food and Rural Affairs, 2009)

– Indicators of a Sustainable Society –

(4) Quality of life within the city

(4.a) Satisfying physiological/basic needs of citizens

(4.a.i) *Concentration of air pollutants (proxy for inferring the quality of air)*

i. *Units:* quantity of pollutant per m^3

ii. *Description:* a proxy of the quality of air in urban environments is given by the concentration of pollutants in the atmosphere. These pollutants comprise SO_X, NO_X , CO , N_2O , CH_4 , and Volatile Organic Compounds (VOC).

iii. *Reference:* Italian National Institute of Statistics (ISTAT) – Environmental Statistics Report (Italian National Institute of Statistics, 2009b)

(4.a.ii) *Consumption per food type (proxy for inferring the variety of food available)*

i. *Units:* % of population regularly consuming a food type

ii. *Description:* The concept of high quality of life is linked to the food regime of the population. A city that allows its inhabitants to choose from a wide range of food types at affordable prices is considered to be increasing the quality of life offered. A proxy for the concept "variety of food available" could be the share of citizens regularly consuming a basic food type (i.e. cereals, milk, eggs, cheese, fruit, vegetables, white red meat, and fish). If, for example, the share of people consuming fish and meat is very low, this is indicates that for some reasons the city is not able to offer these goods to its citizens.

iii. *Reference:* Italian National Institute of Statistics (ISTAT) – Health and Life Style Statistics (Italian National Institute of Statistics, 2005)

(4.a.iii) *Density of urban green (proxy for inferring the quality of outdoor spaces)*

i. *Units:* % of green public spaces of the municipality's total surface

ii. *Description:* With the use satellite images, urban plan and GIS software, it is relatively easy to calculate the density of urban green within a city. This is defined as the ratio of accessible green public spaces to the municipality's total surface. Otherwise, it is also possible to calculate the urban green per capita (dividing the total area of green public spaces by the city's population)

iii. *Reference:* Italian National Institute of Statistics – Urban Environmental Indicators (Italian National Institute of Statistics, 2009a)

(4.a.iv) ***Share of households with direct connection to piped water systems (proxy for inferring the state of development of the city's piped water systems)***

i. *Units:* % of total households

ii. *Description:* In general, increased access to piped water results in improved health outcomes in the form of reduced cases of water-borne diseases – hence a healthy population and higher living standards (Statistics South Africa, 2008). This indicator mostly applies to cities of the developing world, where significant shares of the population lack access to basic sanitary systems.

iii. *Reference:* Statistics South Africa – Community Survey 2007, Basic Results: Municipalities (Statistics South Africa, 2008)

(4.b) Improving urban safety

(4.b.i) ***Average waiting time for hospital inpatients (proxy for inferring the efficiency of public health system)***

i. *Units:* Days

ii. *Description:* The indicator measures the average time hospital inpatients have to wait before being admitted for treatment. This is usually taken as a proxy for the efficiency of the city's public health system.

iii. *Reference:* UK Department of Health – Performance Data and Statistics (UK Department of Health, 2010).

(4.b.ii) ***Number of reported criminal code offences (proxy for inferring level of urban safety)***

i. *Units:* Number per criminal code offence

ii. *Description:* Criminal code offences include violent, property, theft, impaired driving, drug and mischief. Depending on the meaning of urban safety, different code offences will be considered. The Municipality's Department of Public Safety generally has detailed records on the reported criminal code offences.

iii. *Reference:* Department of Public Safety of New Brunswick (Canada) – Crime Statistics Report 2010 (New Brunswick Department of Public Safety, 2012)

(4.c) Safeguarding individual freedom

(4.c.i) *Number of reported criminal code offences related to cultural/ethnical reasons (proxy for inferring individual freedom and respect for cultural/ethnical diversities)*

i. *Units:* Number

ii. *Description:* The Municipality's Department of Public Safety generally has detailed records on the reported criminal code offences. From these records it is possible to identify those arising from for cultural/ethnical diversities. The number of these offences can be used as a proxy for the level of individual freedom and tolerance within a city.

iii. *Reference:* Department of Public Safety of New Brunswick (Canada) – Crime Statistics Report 2010 (New Brunswick Department of Public Safety, 2012)

(4.d) Improving social life

(4.d.i) *Provincial Gross Domestic Product by entertainment industry (proxy for inferring the development of the entertainment industry)*

i. *Units:* Local currency

ii. *Description:* The City's Department of Finance and Municipal Affairs have detailed data regarding the economic activities taking place on the territory. This data usually includes a detailed articulation of the city's GDP among the different industries, providing a good indication of their state of development.

iii. *Reference:* Department of Finance and Municipal Affairs of Prince Edward Island (Canada) – 37th Annual Statistical Review (Prince Edward Island Department of Finance and Municipal Affairs, 2011)

(4.e) Improving urban mobility

(4.e.i) *Average commuting time of citizens (proxy for inferring level of urban mobility)*

i. *Units:* Minutes

ii. *Description:* A typical indicator for measuring urban mobility is the average travelling time that citizens need to reach their working location. This indicator has often been used also as a measure of urban sprawl of cities (Gargiulo Morelli & Salvati, 2011).

iii. *Reference:* Statistics Canada – Canadian Social Trends (Statistics Canada, 2011)

(4.e.ii) ***Share of population regularly using public transportation means (proxy for inferring the level of urban mobility)***

i. *Units:* % of total population

ii. *Description:* A measure of the level of urban mobility is the share of the urban population that regularly uses mass transit means. Likewise, the ratio of number of private vehicles (i.e. automobiles and motorcycles) to the total population can be used for the same purpose. Both this measures give indications on the quality of the public transport system of a city.

iii. *Reference:* Italian National Institute of Statistics – Urban Environmental Indicators (Italian National Institute of Statistics, 2009a)

(4.e.iii) ***Ratio of the length of roads within the city's administrative boundaries to the total territorial surface (proxy for inferring the level of urban mobility)***

i. *Units:* %

ii. *Description:* Another indicator of measuring the level urban mobility within the city's boundaries is the development of the transport infrastructure network, destined to the transit of vehicles. This can be measured by calculating the ratio of the length of roads within the city's administrative boundaries to the total territorial surface. Low levels of this indicator suggest that urban mobility is limited within the city.

iii. *Reference:* Italian National Institute of Statistics – Infrastructures in Italy (Italian National Institue of Statistics, 2006)

(4.e.iv) ***Accessibility of public spaces to people holding physical handicaps (proxy for inferring the level of urban mobility)***

i. *Units:* -

ii. *Description:* There are many proxies for measuring the level of friendliness of an urban environment to physically disabled people. Some examples are the number of physical barriers on the city's pedestrian routes, the number of reserved parking spaces to disabled people, the accessibility of buildings and the number of public transport means equipped with special systems for wheelchair mobility.

iii. *Reference:* As an example for measuring the accessibility of public spaces and routes, see (Aznar Ballarín, 2010) and (Church & Marston, 2010)

(5) Attractiveness of the city

(5.a) Increasing the attractiveness of the city to nonresidents and new business activities

(5.a.i) *Immigration flows*

i. *Units:* Number of new immigrants registered in the municipality

ii. *Description:* Immigration flows give a good indication of the attractiveness of a city. It would be preferable to articulate the immigration flow according to the nationality, working skills, level of education and income in order to understand to whom the city results attractive.

iii. *Reference:* Italian National Institute of Statistics – Migration Flows (Italian National Institute of Statistics, 2002)

(5.a.ii) *Number of Mega-Events hosted by the city each year*

i. *Units:* Number

ii. *Description:* Mega-events, also referred to as "hallmark" or "landmark" events, are large-scale events intended to renew investment in host cities, usually in the tourism sector, by projecting a positive image of the city (Greene, 2001). Examples of such happenings are the Olympic Games, International Expos, and the Soccer World Cup tournament. It is generally acknowledged that such events serve as powerful marketing tools for cities to promote themselves on the global stage, an occasion for attracting human resources and financial capital from all over the world. They also have substantial impacts on the economy and society of cities as they drive investments in urban re-qualification and infrastructure development projects (Chen, 2008).

iii. *Reference:* Information regarding the Meg-Events hosted by a city can be searched for in local newspaper in the section "culture and entertainment"

(5.a.iii) *Real estate value range per neighborhood and building use typology*

i. *Units:* Local currency per m^2 per building use typology and neighborhood

ii. *Description:* A widely adopted proxy for inferring the attractiveness of a city (and more specifically of its districts) is the variation in real estate values of the area. In this case, instead of tacking the average, it is more appropriate to consider the range between the maximum and minimum values of real estate per district and building typology (i.e. for residential, commercial, production, or tertiary activities). This data is usually possessed by the national territorial agency and real estate agencies.

iii. *Reference:* Italian Territorial Agency – Real Estate Quotations (Agenzia del Territorio, 2012)

(5.a.iv) Average *Income tax per individual*

i. *Units:* Local currency per individual

ii. *Description:* The income tax on individuals is one of the key factors in determining the attractiveness of a city to all social groups. Even if the taxing system adopted (i.e. progressive, proportional or regressive) including the distribution of the physical pressure on different income groups determine more precisely the social groups for which the city results most attractive, the average income tax per individual can be used in this instance.

iii. *Reference:* Italian Municipalities – Statistics on Income tax per municipality (Comuni Italiani, 2011)

(5.a.iv) Corporate tax per business activity "i"

i. *Units:* Local currency per commercial activity type

ii. *Description:* The tax on business activities generally diverges according to the commercial activity considered. For example, in Italy the corporate tax is calculated differently for commercial companies, agricultural activities, non-commercial companies and public institutions, and banks and insurance companies. While low taxing levels on business activities are favored by all business sectors, the specific corporate taxing system adopted determines to which activities the city results most attractive.

iii. *Reference:* Italian Internal Revenue Service – Statistics on Corporate tax per municipality (Agenzia delle Entrate, 2011)

(6) Distribution of age groups

(6.a) Balancing the age structure diagram of population

(6.a.i) *Median age*

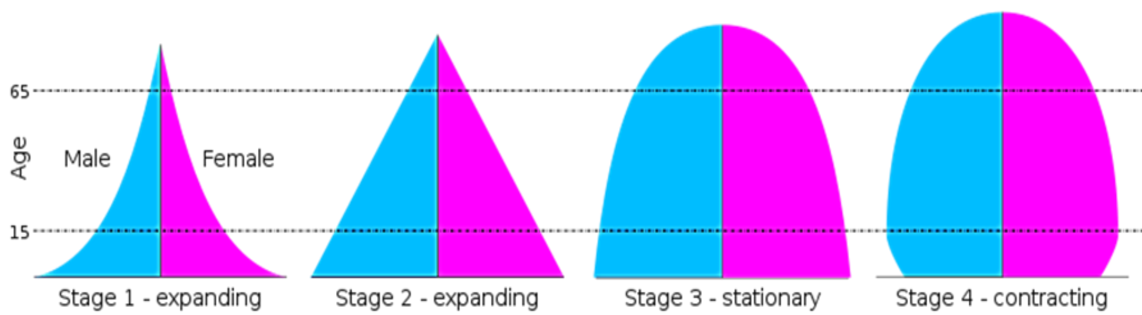
i. *Units:* years

ii. *Description:* There is substantial concern for population ageing phenomena among many countries of the UN[5]. However, in spite of this interest, there seems to be a lack of innovative methods for assessing the state and dynamics of the phenomenon (Sanderson & Scherbov, 2008). Traditionally, "the median age" is the most widely adopted indicator for measuring population ageing. This is defined as is the age at which half the people in a

[5] http://www.un.org/esa/population/publications/worldageing19502050/

region are younger than the median age and half are older. High values of the median age indicate an ageing population which is approaching (or has already reached) the fourth stage of the demographic transition model. Other less popular indicators include: *conventional old-age-dependency ratio* and *proportion of elderly in the population.*

iii. *Reference:* Eurostat – Population structure and ageing: Ageing characterizes the demographic perspectives of the European societies (Eurostat, 2008).



– Indicators of a Sustainable Economy –

(7) Competitiveness of the city in the short-term

(7.a) Improving the market conditions and competitiveness of the city's economic system

(7.a.i) *Net exports of the city*

i. *Units:* Local currency per year

ii. *Description:* The net exports of a city is defined as the difference between the goods, products and services (expressed in monetary values) that are being exported and imported by the urban system. If a city has positive annual net export values, this can been interpreted as an indicator of a strong and competitive economic system.

iii. *Reference:* Italian National Institute of Statistics – National Accounting Statistics (Italian National Institute of Statistics, 2011a)

(7.a.ii) *Unemployment rate*

i. *Units:* % of total population belonging to labor force

ii. *Description:* The unemployment rate is defined as the ratio of unemployed workers to the total labor workforce of the region. This is a classic indicator used for measuring the state of a region's economy. As there are various types of unemployment (e.g. full, structural, long and short-term, involuntary, frictional and hidden) and different theories used for explaining its causes and consequences (e.g. Marxist theory as opposed to the one considered in neo-classical economy), the indicator has to be appropriately defined according to the economic phenomenon to be investigated.

iii. *Reference:* Italian National Institute of Statistics – Unemployment (Italian National Institute of Statistics, 2011b)

(7.a.iii) ***Annual Gross Domestic Product of the city***

i. *Units:* Local currency

ii. *Description:* The Gross Domestic Product (GDP) of a city refers to the market value of all officially recognized final goods and services produced within a region in a given period. GDP Is often used as an indicator of the strength and growth of an economic system, and also of the level of living standards within a region (in this case it is usually expressed as GDP per capita)

iii. *Reference:* Italian National Institute of Statistics – Principal Aggregates and Regional Accounting Statistics (Italian National Institute of Statistics, 2010a)

(7.a.iii) ***Expenditures per public administration "i"***

i. *Units:* Local currency per public administration

ii. *Description:* The competitiveness of a city in the short-term can be observed in the expenditures of its public administration compared with the level of services provided to citizens. It is generally accepted that a city making efficient use of financial resources for providing high quality services to its citizens is more competitive than a less virtuous one.

iii. *Reference:* Italian National Institute of Statistics – Statistics on Local Finances (Italian National Institute of Statistics, 2006)

(7) Competitiveness of the city in the long-term

(8.a) Higher capacity to foster innovation and stimulate a knowledge-based economy

(8.a.i) ***Distribution of city's working population per educational qualification, per sector of specialization, and per working status (proxy for inferring the heterogeneity and conditions of labor force)***

i. *Units:* % of population per educational qualification; per sector of specialization; per working status

ii. *Description:* The heterogeneity and conditions of the city's labor workforce can be measured by observing how it is distributed over "educational classes" (e.g. educational qualifications such as primary school diploma, secondary school diploma, University degree, PhD, MBA, etc), sectors of specialization (e.g. engineering, law, economy, sociology, medicine, natural sciences, etc.) and working status (e.g. employed, unemployed and searching for employment, unemployed and not searching for work).

iii. *Reference:* Italian National Institute of Statistics – Labor Workforce (Italian National Institute of Statistics, 2010b).

(8.a.ii) ***Distribution of city's enterprises, annual gross profits, employed workforce and average payroll per sector (proxy for inferring the heterogeneity of the city's industry and development of each sector)***

i. *Units:* Number of enterprises per industrial sector; local currency per industrial sector; number per industrial sector

ii. *Description:* The heterogeneity of a city's industry can be measured by observing the number of operating enterprises[6] per industrial sector (e.g. utilities, construction, manufacturing, information, finance and insurance, entertainment, etc.). The state of development of each industrial sector can be measured by collecting data regarding the annual gross profits, employed workforce and average payroll per sector.

iii. *Reference:* U.S. Census Bureau - Enterprise Statistics (U.S. Census Bureau - Dep. of Commerce, 1997)

(8.a.iii) ***Number of new start-ups per industrial sector "i" (proxy for inferring the facility to open new businesses)***

i. *Units:* Number per sector industrial sector

ii. *Description:* The friendliness of an economy to new businesses can be measured by observing the number of start-ups that enter the market each year. It is recommendable, in order to provide a more detailed picture of the region's economy, to specify the industrial sector of pertinence of the start-up.

iii. *Reference:* U.S. Census Bureau - Enterprise Statistics (U.S. Census Bureau - Dep. of Commerce, 1997).

(8.a.iv) ***Regional expenses on R&D activities per institutional sector "i" (proxy for inferring the level of Investments in innovation)***

[6] An enterprise is a business organization consisting of one or more domestic establishments under common ownership or control. For companies with only one establishment, the enterprise and the establishment are the same. The employment of a multi-establishment enterprise is determined by summing the employment of all associated establishments (U.S. Census Bureau - Dep. of Commerce, 1997)

i. *Units:* Local currency per institutional sector "i" (i.e. NGOs, Enterprises, Universities, Public Institutions)

ii. *Description:* There are many indicators used as proxies for measuring the efforts made for supporting innovation at the regional level. One of the most widely adopted indicators is the regional expenses on R&D activities.

iii. *Reference:* Italian National Institute of Statistics – R&D in Italy (Italian National Institute of Statistics, 2010c)

(8.a.v) ***Index of Flexibility in Labor Relations Law***

i. *Units:* Decimal scale

ii. *Description:* There are various advantages that a flexible labor market can bring to economic systems. According to Neo-classical economists, these include improved market efficiency, reduced structural unemployment, stronger employment creation, improved occupational mobility, higher productivity growth, improved responsiveness of markets to external economic shocks and higher competitiveness overall (Riley & College, 2006).

iii. *Reference:* As an example for measuring the flexibility of labor markets, see (Karabegović, Godin, Clemens, & Veldhuis, 2004)

(8.a.vi) ***Share of households passed by an infrastructure that enables a cable modem Internet connection (proxy for inferring the level of Urban Broadband Connectivity)***

i. *Units:* % of total households

ii. *Description:* One of the most common ways for measuring the level of broadband connectivity of a city is by assessing household accessibility to internet connection. This is done by calculating the share of households passed by an infrastructure that enables a cable modem internet connection (i.e. cable networks enabling at least a 256 Kbps advertised downlink Internet access to be included). By specifying the type of connection (e.g. DSL, xDSL, cable modem, FTTH/B) it is also possible to provide a picture of the state of development of the city's network infrastructure. Unfortunately, this indicator does not provide any information regarding business access to broadband. An indicator providing this type of information is difficult to adopt due to the fact that data on business broadband availability are rarely publicly available (OECD, 2009).

iii. *Reference:* OECD – Report on Indicators of Broadband Connectivity (OECD, 2009).

(8.a.vii) *Corruption Perception Index*

i. *Units:* Decimal scale

ii. *Description:* Corruption was defined by the Transparency International organization as "the misuse of public power for private benefits". It is acknowledged that high corruption levels in the city's public administration act as strong deterrents to private companies willing to invest in the city. Thus, corruption can be regarded as an institutional factor hampering innovation and economic activities in a city.

iii. *Reference:* As an example for measuring corruption of a region, see (Transparency International, 2011)

(8.a.viii) *Share of population with 3G coverage of at least one operator* (proxy for inferring level of Ubiquitous Connectivity*)*

i. *Units:* % of total population

ii. *Description:* Ubiquitous connectivity refers to the possibility for citizens of accessing broadband services in any point of the city. This can be measured by calculating the coverage of 3G technologies (following IMT-2000 standard) in terms of population percentage (or area of the city). Coverage data are normally provided by operators, whose databases may mostly be based on estimates.

iii. *Reference:* OECD – Report on Indicators of Broadband Connectivity (OECD, 2009).

(8.a.ix) *Number of national/international Metropolitan Areas[7] directly connected to the city (proxy for inferring the level of urban physical interconnection)*

i. *Units:* Number per transport mode

ii. *Description:* The urban physical interconnection refers to the position held by a city within the network connecting Metropolitan Areas on national and international scale. A proxy of this concept is the number of Metropolitan Areas that can be directly (i.e. without transfers) reached from the city (and vice versa) by air, rail or water transport systems.

iii. *Reference:* No references of organizations measuring this indicator were found. However, as an example of measuring transport infrastructure in light of sustainable development objectives, see (Victoria Transport Policy Institute, 2012).

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[7] The term Metropolitan Area is used to indicate regions consisting of a densely populated urban core and its less-populated surrounding territories, that can be classified as NUTS2 (minimum number of citizens of the area has to be greater or equal to 800.000) level or above

Appendix 8

– Indicators of a Sustainable Environment –

(9) Health of the three environmental compartments

(9.a) Preservation of the health of the aquatic compartment

(9.a.i) *Biological and Chemical Oxygen Demand of closed water bodies and effluents (proxy for inferring the health of aquatic compartment)*

i. *Units:* mg of O_2 per liter of water

ii. *Description:* The Biological and Chemical Oxygen Demand (BOD and COD) of water bodies and effluents are the two most widely adopted indicators for measuring the level of contamination of the regions aquatic compartment. The BOD measures the amount of dissolved oxygen needed by aerobic biological organisms in a water body or effluent to break down organic material present in a given water sample at certain temperature over a specific time period. The COD is similar to the BOD with the only difference that it measures the oxygen needed for the oxidation of ammonia into nitrate through anaerobic processes (known as nitrification).

iii. *Reference:* Italian National Institute of Statistics (ISTAT) – Environmental Statistics Report (Italian National Institute of Statistics, 2009b)

(9.a.ii) *Concentration of pollutants in closed water bodies and effluents (proxy for inferring the health of aquatic compartment)*

i. *Units:* mg of pollutant per liter of water

ii. *Description:* The health of water bodies and effluents can be measured by observing the level of concentration of certain substances regarded as pollutants of aquatic systems. The most common ones are cadmium, mercury, fecal and total coliforms, and salmonella.

iii. *Reference:* Italian National Institute of Statistics (ISTAT) – Environmental Statistics Report (Italian National Institute of Statistics, 2009b)

(9.a.iii) *Coast and lake fish productivity (proxy for inferring the state of the fauna of aquatic compartment)*

i. *Units:* quantity of coast and lake fish catches

ii. *Description:* The state of the fauna of water bodies, areas of the coast and water effluents gives indication on the health of the aquatic system. There are several indicators used as proxies for measuring this property, proving the difficulty of measuring the conditions of the marine fauna. An example is the quantity of fish catches deriving from coast and lake fishing activities in the city's region.

iii. *Reference:* Italian National Institute of Statistics (ISTAT) – Statistics on fishing activities and zootechnics (Italian National Institute of Statistics, 2001)

(9.b) Preservation of the health of the terrestrial compartment

(9.b.i) *Concentration of soil pollutants (proxy for inferring the health of terrestrial compartment)*

i. *Units:* mg of pollutant per unit of area

ii. *Description:* Soil contamination refers to the presence of xenobiotic (human-made) chemicals or other alteration in the natural soil environment[8]. Examples of these substances are heavy metals (e.g. mercury, cadmium, lead), hydrocarbons, chemical solvents and pesticides.

iii. *Reference:* Ministry of the Environment of Japan – Water, Soil and Ground Statistics (Japanese Ministry of the Environment, 2001)

(9.b.ii) *Share of land sealed (proxy for inferring the health of terrestrial compartment)*

i. *Units:* % of the city's total area

ii. *Description:* Soil sealing is referred as the process of permanently covering land with impermeable layers of buildings, asphalt roads, parking lots and other construction works which causes an irreversible loss of the ecological functions of soil (e.g. surface irrigation to underground water reservoirs)[9]. In order keep the terrestrial compartment in a healthy state and to safeguard its ecosystem services, it is necessary to limit the surface of urbanized area.

iii. *Reference:* Italian National Institute of Statistics (ISTAT) – Soil Consumption Statistics (Italian National Institute of Statistics, 2012)

(9.c) Preservation of the health of the terrestrial compartment

(9.c.i) *Concentration of air pollutants (proxy for inferring the quality of air)*

i. *Units:* mg of substance per m^3

ii. *Description:* This indicator considers the same substances measured by indicator 5.b. However, in this case the indicator focuses on the concentration levels of the pollutants, not on emissions estimates. Low levels of concentration of air pollutants are regarded as signs of air quality

[8] http://en.wikipedia.org/wiki/Soil_contamination
[9] http://ec.europa.eu/environment/soil/sealing.htm

iii. *Reference:* Italian National Institute of Statistics (ISTAT) – environmental statistics report (Italian National Institute of Statistics, 2009b)

(10) Biodiversity in the city's hinterland

(10.a) Preservation of biodiversity

(10.a.i) *Share of the region's surface designated as natural protected areas*

i. *Units:* % of the total surface of the region

ii. *Description:* Most Governments have nature conservation policies that aim at preserving natural environments classified as particularly valuable to the community and/or to the functioning of the ecosystem. For example, according to the *Habitats Directive 92/43/EEC*, members of the European Union have the obligation to identify and preserve such valuable natural areas, with the finality of safeguarding the biodiversity of the region[10]. Preventing a loss of biodiversity is important for mankind, given that humans depend on the natural richness of the planet for the food, energy, raw materials, clean air and clean water that make life possible and drive economies and societies[11].

iii. *Reference:* Italian National Institute of Statistics (ISTAT) – Environmental Statistics Report (Italian National Institute of Statistics, 2009b)

(10.a.ii) *Population index of common birds*

i. *Units:* Number of observed bird species

ii. *Description:* Birds are considered good proxies for measuring the diversity and integrity of ecosystems as they tend to be near the top of the food chain, have large ranges and the ability to move elsewhere when their environment becomes unsuitable; they are therefore responsive to changes in their habitats and ecosystems[11]. Thus, indicators that measure the average changes in population levels of common birds are being used to reflect the health and functioning of the ecosystems they inhabit.

iii. *Reference:* The Council of European Communities – Birds Directive of 2 April 1979 (79/404/EEC) (Council of European Communities, 1979)

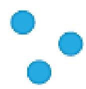
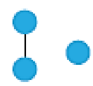
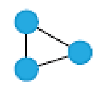
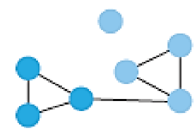
[10] http://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm
[11] http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Biodiversity_statistics

Appendix 9

Framework for a Smarter City by The Climate Group, Accenture, Arup and Horizon

The Climate Group, in collaboration with Accenture, Arup and Horizon, carried out an investigation on the Smart City Initiatives underway in urban centers around the world. Based on this analysis, the team developed a useful framework for assessing the extent to which a city can be considered Smart (according to their definition). The framework, which is presented below, focuses on state of development of the city's soft and hard infrastructure.

Figure: "Framework for a Smarter City"

Smart City Project Implementation	 **Level 1**	 **Level 2**	 **Level 3**	 **Level 4**
Soft Infrastructure				
Value Assessment	Individual project business cases	Some non-financial value assessed	Holistic value assessment (social/ environmental/financial)	Holistic value assessment supporting diversification of funding sources
Governance	Departmental governance structures	Some cross-departmental collaboration	Cross-departmental 'Smart City' management positions in place	City-wide governance structures and shared performance targets combined with international collaboration
Strategic ICT Focus	Limited ICT capability	Some strategic focus on ICT	ICT vision for the city	ICT vision and strategy overseen by dedicated City CIO
Citizen Engagement with Service Design	Limited citizen engagement	Project-level, basic needs analysis, pilots	Citizen feedback loops established	Citizen participation in integrated service design
Hard Infrastructure				
IT project focus	Little or no ICT projects	Targeted ICT project investments (e.g. Smart Grid)	Integrated ICT investments (including embedded sensing, control and actuation)	Real-time city operations optimisation
Integration of Data Streams	No data integration	Small scale data integration	Creative data mash ups pulling data to a common platform	Open data and crowd-sourcing initiatives
Digital Service Provision	Little or no digital service provision	Handful of digital services	Integrated digital services around the city environment	Diversity of cloud-based citizen services

Source: The Climate Group, Accenture, Arup, Horizon, 2011.

Appendix 10

Annexes to Amsterdam Smart City Project

Project: ITO Tower Office Building	
Elements of ICP	**Description**
A. Physical scale of programme	Building (potentially expandable to settlement scale)
B. Technological foundation	Smart Meters; Smart Plugs; Energy displays and monitoring systems; Smart Lighting Systems
C. Implemented enabler(s) of Intelligence	*Data acquisition/processing systems*
D. Types of intelligence empowered	*Artificial intelligence*: automated management of lighting system *Human Intelligence*: incentivize behavior changes that optimize energy consumption in buildings
E. Additional requisites/hyp.	Users voluntarily optimize personal energy consumption patterns
F. Finality of programme and value added to city	Live monitoring of energy consumption in office for encouraging energy saving and optimization, and implementation of automated lighting systems ✓ Improved management of buildings

Project: Decentralized Generation	
Elements of ICP	**Description**
A. Physical scale of programme	Building (potentially expandable to settlement scale)
B. Technological foundation	Fuel Cell Technology combined with Remote Control and Energy Metering
C. Implemented enabler(s) of Intelligence	*Data acquisition/processing systems*
D. Types of intelligence empowered	*Artificial Intelligence:* automated transfer of energy production/consumption data to the grid *Human intelligence*: enhanced decision-making performed by managers of the energy utility grid
E. Additional requisites/hyp	-
F. Finality of programme and value added to city	Integration of decentralized energy efficient production units in the electricity grid ✓ Improved management of energy infrastructure

Project: Online Monitoring Municipal Buildings	
Elements of ICP	**Description**
A. Physical scale of programme	Public Buildings
B. Technological foundation	Online Energy Monitoring Systems
C. Implemented enabler(s) of Intelligence	*Data acquisition/processing systems*
D. Types of intelligence empowered	*Human Intelligence:* enhance decision-making performed by managers of public buildings
E. Additional requisites/hyp	Building managers use information to optimize energy consumption patterns
F. Finality of programme and value added to city	Support managers in taking decisions that improve the performance of buildings by reducing energy inefficiencies ✓ Improved management of public buildings

Project: Smart School Context	
Elements of ICP	**Description**
A. Physical scale of programme	School Buildings
B. Technological foundation	Smart Meters; Online Energy Monitoring Systems
C. Implemented enabler(s) of Intelligence	*Data acquisition/processing systems* combined with *knowledge sharing systems*
D. Types of intelligence empowered	*Human Intelligence:* incentivize behavior changes that optimize energy consumption in buildings Collective Intelligence: incentivize discussions and educate children towards a more efficient use of energy
E. Additional requisites/hyp	Users voluntarily optimize energy consumption patterns
F. Finality of programme and value added to city	Live monitoring of the consumption behavior of schools for encouraging energy saving and optimization, and virtual environments where children and learn and discuss about energy use ✓ Improved management of buildings ✓ Behavior changes

Project: Moet je Watt	
Elements of ICP	**Description**
A. Physical scale of programme	Settlement scale
B. Technological foundation	Smart Meters and Electrical Charging Boxes
C. Implemented enabler(s) of Intelligence	*Data acquisition/processing systems*
D. Types of intelligence empowered	*Human Intelligence*: enhance decision-making performed by managers of transport infrastructure and electricity grid
E. Additional requisites/hyp	Increase in the number of users of electric vehicles
F. Finality of programme and value added to city	Support the expansion and consolidation of electric mobility ✓ Improved management of transport infrastructure ✓ Improved management of energy infrastructure

Project: Climate Street	
Elements of ICP	**Description**
A. Physical scale of programme	District scale (potentially expandable to settlement scale)
B. Technological foundation	Energy Displays; Smart Meters
C. Implemented enabler(s) of Intelligence	*Data acquisition/processing systems*
D. Types of intelligence empowered	*Human Intelligence:* incentivize behavior changes that optimize energy consumption in buildings
E. Additional requisites/hyp	Users voluntarily optimize energy consumption patterns
F. Finality of programme and value added to city	Live monitoring of energy consumption in shops for encouraging energy saving and optimization ✓ Improved management of buildings

Appendix 10

Project: ZonSpot	
Elements of KCP	**Description**
A. Physical scale of programme	District level
B. Technological foundation	Wi-Fi Connection
C. Implemented enabler(s) of Intelligence	*Knowledge sharing systems*
D. Types of intelligence empowered	*Collective Intelligence*: encourage social gatherings in outdoor spaces where people can meet and discuss while incentivizing the use of internet
E. Additonal requisites/hyp	People engage in social interaction in outdoor spaces
F. Finality of programme and value added to city	Stimulate the interaction among citizens, re-vitalize outdoor public spaces and promote solar panels technology ✓ Behavior changes ✓ Development of a knowledge based economy

Project: Ship-to-Grid	
Elements of ICP	**Description**
A. Physical scale of programme	Harbor area
B. Technological foundation	Remote Control and Energy Metering; Online Energy Account
C. Implemented enabler(s) of Intelligence	*Data acquisition/processing systems*
D. Types of intelligence empowered	*Human intelligence*: enhanced decision-making performed by managers of the energy utility grid
E. Additional requisites/hyp	Energy supplied to ships derives from renewables
F. Finality of programme and value added to city	Large scale energy supply from renewable sources (i.e. *green suppliers*) to ships for replacement of old inefficient and polluting diesel generators ✓ Improved management of port infrastructure ✓ Improved management of energy infrastructure

Appendix 11

Annexes to Bilbao Global Knowledge City project

The initiatives that were identified as part of the Bilbao Global City project (either as already existing, or under construction or attending implementation) were grouped according the targeted urban sector. These are briefly presented below:

Transport sector

- Contact less: an e-ticketing system for the Transport Consortium of Bizkaia.
- 127 Information terminals for providing users of public buses on the estimated waiting time at stations.
- Audio information systems on public buses and at bus stations for blind people.
- Web portals containing real-time information on traffic conditions and public transportation (routes and frequencies).
- Live video surveillance systems on board of public buses.
- Traffic light priority systems on 45 road junctions (traffic lights are regulated based on the delays of public buses).
- Increasing the share of the total fleet of public vehicles running on biodiesel
- Construction of two additional metro lines (line 1 and 2 with a length of respectively 31 and 22 km).
- Bicycle sharing system.
- Carpooling and carsharing systems.
- Installation of 20 electric charging stations in public parking spaces for supporting the large scale implementation of electric vehicles.
- Economic incentives for stimulating the purchase of electric vehicles (target is to have 20% of the city's vehicle fleet running on hybrid or electric energy).
- Traffic Geoportal: a centralized geographic platform for the management of traffic in the municipality's region, containing information such as intensity of congestion and average speed on roads.
- Live video monitoring systems installed in strategic points of the city.
- Installation of energy efficient LED lighting systems in 1,600 traffic lights.
- Smart Logistics: programmes for enterprises to reserve loading and unloading places in the city to make the procedure more efficient.

Energy sector

- Definition of legal agreements and initiatives with the local provider of Energy Services (Empresa de Servicios Energéticos) for reducing the energy consumption from heating/cooling and lighting systems of certain public buildings of the city. Most of these initiatives have the goal of reducing the energy consumption of the building sectors and installing solar panels on the roofs. Below are illustrated some of the initiatives that have been implemented:

- Replacing old heating/cooling systems in the building of "Servicios Centrales" with new more efficient ones in the
- Installation of an energy monitoring systems in the building "Servicios Centrales" buildings that provide information on consumption patterns;
- Installation of energy efficient LED lighting systems in several residential and public buildings;
- Installation 291 solar panels on the roof of the building of San Ignacio and a photovoltaic plant of 15kw on top of the municipality's building;
- Installation of solar thermal panels on the roofs of 72 public buildings each year.

Water sector

- The initiatives implemented in the water sector targeted the efficiency of the distribution network. In sum, a series of sensor and meters were installed in the water infrastructure of the city that would collect real-time information on certain parameters of the aqueduct (e.g. water demand, pressure, velocity and volume of water flow) and successively mapped on the network by means of Geographic Information Software applications. Furthermore, inspectors of the aqueduct were provided with smartphones connected to the sensors that localize possible malfunctioning of the network and thus indicate were action is needed.

Hard infrastructure

- Installation of fiber cables supporting high speed internet connection to all public buildings of the municipality.
- Establishment of free Wi-Fi spots in public spaces of the city (squares and public buildings)
- Substitution of old light bulbs with high energy efficient lighting systems based on LED technologies in public spaces of the city
- Installation of "green tiles" (pavements made of substances that can capture CO_2 molecules) around the municipality's central building.

Soft infrastructure

- Public programmes for sharing knowledge on Climate Changes ("Oficina contra el Cambio Climático de Bilbao")
- "Biotruek", street markets where citizens can exchange, sell and buy second hand products
- "Programa Hogares Verdes", an initiative to educate households on climate change and sustainability topics.

- Public campaigns and events (e.g. "Mercados de trueke", "Día sin dinero" and "Mercados de manualidades") for promoting more sustainable and eco-compatible behaviors among the population
- Implementation of the *Eurocities* project, an initiative aimed at favoring the integration of people with different cultural backgrounds in the life of the urban community

Public Administration

- The municipality of Bilbao launched a web portal (www.bilbao.net) that provides integrated information on the municipality to citizens and firms and allows public participation through web forums. The portal also provides online services (e.g. licenses, electronic emission and payment of invoices, information of creditors, etc.) and live information on traffic and weather conditions.

Appendix 12

Annexes to Kuala Lumpur International Financial District project

The tables below illustrate how the framework for identifying ICPs and KCPs was applied to the Smart City Technologies planned for the Kuala Lumpur International Financial District.

Project: Intelligent City Management systems	
Elements of ICP	**Description**
A. Physical scale of programme	Urban scale
B. Technological foundation	Service-Oriented Architecture platform (SOA) that connects information captured by ICT instrumentation is to the physical layer of the city
C. Implemented enabler(s) of Intelligence	*Data acquisition/processing systems*
D. Types of intelligence empowered	*Human Intelligence*: enhanced decision-making performed by urban managers
E. Additional requisites/hyp.	-
F. Finality of programme and value added to city	Enable more effective and efficient urban management practices ✓ Improved management of urban sectors

Project: Digital urban security	
Elements of ICP	**Description**
A. Physical scale of programme	Urban scale
B. Technological foundation	Biometric access devices in buildings, video surveillance systems and pre/post-emergency response systems
C. Implemented enabler(s) of Intelligence	*Data acquisition/processing systems*
D. Types of intelligence empowered	*Artificial intelligence*: automated mechanisms for allowing access to buildings and surveillance *Human Intelligence*: enhanced decision-making performed by managers working in the law enforcement department
E. Additional requisites/hyp.	-
F. Finality of programme and value added to city	Monitoring and surveillance systems that increase the level of within the district ✓ Improved management of law enforcement department

Project: Smart Buildings	
Elements of ICP	**Description**
A. Physical scale of programme	Urban scale
B. Technological foundation	Smart meters and energy display monitors
C. Implemented enabler(s) of Intelligence	*Data acquisition/processing systems*
D. Types of intelligence empowered	*Human Intelligence*: incentivize behavior changes that optimize energy consumption in buildings
E. Additional requisites/hyp.	Users voluntarily optimize energy consumption patterns
F. Finality of programme and value added to city	Live monitoring of energy consumption in buildings for encouraging savings and optimization ✓ Improved management of buildings

Project: E-governance systems	
Elements of KCP	**Description**
A. Physical scale of programme	Urban scale
B. Technological foundation	Online portals supporting a two way flow of information between citizens and public administrations
C. Implemented enabler(s) of Intelligence	*Data acquisition/processing systems* combined with *knowledge sharing systems*
D. Types of intelligence empowered	*Collective Intelligence*: enhanced co-operation between public authorities and citizens
E. Additional requisites/hyp.	-
F. Finality of programme and value added to city	Enhanced communication channels between citizens and public administrations ✓ Better governance

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