# The Green Dimension in 11 Smart City Plans: Is There an Environmental Ethic Embedded in Long Term Strategic Commitments?

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**Abstract** We analyze and compare 11 city cases in three continents to find out differences and commonalities in the green dimension in smart city plans globally: Shanghai (China), four cities in Japan, Iskandar (Malaysia), New York (United States), and Amsterdam, Málaga, Santander, Tarragona (Europe). The aims of the work has been to test whether there is an environmental ethic embedded in long-term strategic commitments in these local contexts, how different environmental values are, and what lines of research might be interesting to tackle from scientific perspectives in future works where the green dimension is addressed in smart city plans. We find that plan design is very different in the search of a model of a smart city in the 11 cases studied. As we expect choices in plan design to have a long-term impact in terms of environmental outcomes and further resilience, both locally and globally, the environmental ethics attached to the local plans, or the lack thereof, we argue have a strong impact.

**Keywords** Smart cities · Greening · Sustainable cities · Environment · Urban planning · Comparative public policies

The funding to collect the data for this work was supported by the Colegio Oficial de Ingenieros de Telecomunicación (COIT), and a report was written then with the comparative results. The idea to focus on the green dimension in smart city plans and build this comparison is novel, and the assemblage of the data for the purpose of this article written in 2019–2020 did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. The author thanks the anonymous reviewers of this chapter for their very valuable comments.

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E. Estevez et al. (eds.), *Smart Cities and Smart Governance*, Public Administration and Information Technology 37,
https://doi.org/10.1007/978-3-030-61033-3_7

## Introduction

As Bakker and Ritts (2018) contend, we already have tools to exert significant changes in environmental governance thanks to the data available through Smart Earth technologies. Bakker and Ritts's very interesting work has propelled us to ask first of all whether there is a green dimension in the smart city plans being carried out by city governments globally. A second question is to what extent and how different this green dimension is treated in smart city plans. We are interested in understanding these differences, from theoretical and practical approaches, and we are eventually interested in contributing to the debate that tackles the ethics of sustainable local environments and in relation with technological development. Through the following sections, definitions of smart cities are introduced along with the hypothesis to be tested, followed by the model of analysis. Later on, the smart city cases are analyzed using a qualitative and comparative perspective. Conclusions, based on both quantitative and qualitative results are provided. The research finds an ethical gap in smart city plans which mostly avoid environmental issues, placing a main focus on technology. This lack of focus on long-term environmental issues at a strategic level is quite evident in the comparison of all these plans, active in 2013–2014. Here we present the results of the research showing the wide differences among measures taken, and the small focus in long-term public policies addressing smart goals in environmental grounds in the first smart city plans drafted for cities. The wide space available to plan policies addressing environmental issues from the perspective of smart city plans is also shown.

## Toward a Definition of Smart Cities and the Hypothesis to Test

Drawing upon the literature studying smart cities in the last two decades, we found two traditions and a first set of differences in the definitions of smart cities. Differences in definitions in applied local contexts are important because these are translated into differences in governance locally, as we have later found. Theoretically we found differences among two main approaches to defining smart cities. The first approach focuses on human capital. The second approach focuses on technological progress.

## Human Capital

From an economic and growth perspective, a seminal article by Shapiro (2006) draws the link among quality of life, productivity and the growth effects of human capital as main components of the smart cities definition. Winters (2011), in his study on "Why are smart cities growing? Who moves and who stays" in the US, considers a smart city as a "metropolitan area with a large share of the adult population with a college degree, often small and mid-sized metropolitan spaces containing flagship state universities." In the European tradition we find the idea of inclusiveness and regeneration linked to the smart cities concept. Digitally inclusive and regeneration are at the core of Deakin and Allwinkle's (2007) work defining smart cities as those having an e-learning platform, knowledge management and library with the org-ware communities need to support digital inclusive regeneration projects across Europe, meeting advanced visualization, simulation, and benchmarking requirements. For Hollands' work (2008), the social capital is critical to embed the informational and communicative qualities of smart cities. Hollands is linked to an academic tradition that purposely avoids defining intelligence in terms of the world of devices. Such a definition would constraint the smart concept to the artificial intelligence available (Komninos, 2009), and would neglect two other forms of intelligence: human and collective, from the collective skills of population to the social institutions articulating cooperation. Allwinkle and Cruickshank (2011) highlight from Hollands' definitions the emphasis on people and their interactions. In this view, the most important thing about information technology is not its capacity to create smart cities, but the possibility it offers to empower and educate citizens, allowing them to become members of a society that engages in a debate about their environment and social aspirations. It this view, how citizens interact is key to any successful community, enterprise, or venture.

In all contexts, following Deakin and Al Waer (2011), the smartest places combine the best of both the physical and virtual worlds, where presence and telepresence are fused together in a specific location. Physical locations would be pervasively penetrated by digital technologies to provide a collaborative meshing of physical and virtual environments. And this is so because:

> irrespective of how digital technologies are developed to exploit the electronic opportunities they offer, the physical places of urban spaces will retain their relevance in society because people still care about meeting face-to-face and gravitate to places which offer particular cultural, urban, scenic or climatic spaces, unable to be experienced at the end of a wire and through a computer screen (Deakin & Al Waer, 2011).

In Europe, Caragliu, Del Bo, and Nijkamp (2011) argue that a smart landscape is linked to the presence of a creative class, the quality and attention paid to the urban environment, the level of education, and the accessibility to and use of information and communications technologies for public administration. They further show the positive correlation of these variables with urban wealth. Caragliu et al. (2011) argue that those aspects should be part of the formulation of a new strategic agenda for European cities to achieve sustainable urban development and a better urban landscape. Komninos (2009) also brings in knowledge, creativity and social capital as baselines for the definition of intelligent cities. In the tradition of Florida (2002, 2005): the generation of prosperity would depend of the creative class, knowledge workers, scientists, artist, engineers, lawyers, entrepreneurs, and innovators. They are the producers of new ideas, theories, products, and strategies.

According to Komninos (2009, p. 352) three layers are needed in an intelligent environment: (1) the physical space, with the agglomeration of people, innovative clusters and companies, (2) the institutional innovation mechanisms and policies needed for technology transfer, product development and innovation, and (3) the collaborative spaces and tools allowing for people collaboration and participation. Shen, Ochoa, Shah, and Zhang (2011), from a different perspective, but also connected to a sustainable dimension, conducted work doing a comparison of urban sustainability indicators. Shen et al. (2011) used the International Urban Sustainability Indicators List (IUSIL). IUSIL contains 115 indicators, formed into 37 categories, where indicators are structured within four sustainable development dimensions including environmental, economic, social, and governance aspects.

## Technology

In the literature one can find scholars from various disciplinary areas, from e-government to information science, urban studies and public administration, and from many different geographic backgrounds (Nam & Pardo, 2011). Within this stream of research, Chourabi, Nam, Walker, et al. (2012) identifies eight critical factors in smart city initiatives that we find interesting to analyze and evaluate to understand innovations in smart city plans: management and organization, technology, governance, as a different variable in Chourabi's approach, policy context, people and communities, economy, built infrastructure, and natural environment. Chourabi et al. (2012) is a very useful integrative framework to examine how local governments are envisioning and pursuing smart city initiatives. This same framework devised by Chourabi et al. allows a focus on the environmental variable and a way to evaluate this variable in smart city initiatives.

In the two theoretical traditions, the environment is a relevant variable. Caragliu et al. (2011) defend a strategic agenda for sustainable urban development as a main part of the smart city concept. Chourabi et al. (2012) also make the natural environment a critical factor in their model. From these two perspectives we could infer the following hypothesis: that the natural environment should be a key focus in smart city plans unveiled by local governments. From this hypothesis we formulated the following questions that we may answer in each of the case studies: Is it really the case that the natural environment is a focus of the smart city plan? If so, to what extent? And, what have been the differences, if any, in smart city plans with regard to strategy and the green dimension associated with long-term goals?

Our choice of cases is driven by an interest to learn from innovative practices in different global institutional settings. It is also driven by the fact that innovation in Asia has been growing at very high rates previously to the period of study. From 2000 to 2005 the growth rate in research and development in China rose by 17% while figures for North America where 5.2% and Europe 3.8% (Komninos, 2009). Moreover, since 2015 the world has changed dramatically, with life becoming more difficult and challenging for the west, yet across Asia these are hopeful times, with rising wealth opening its scale (Frankopan, 2018, p. 10). Isolation and

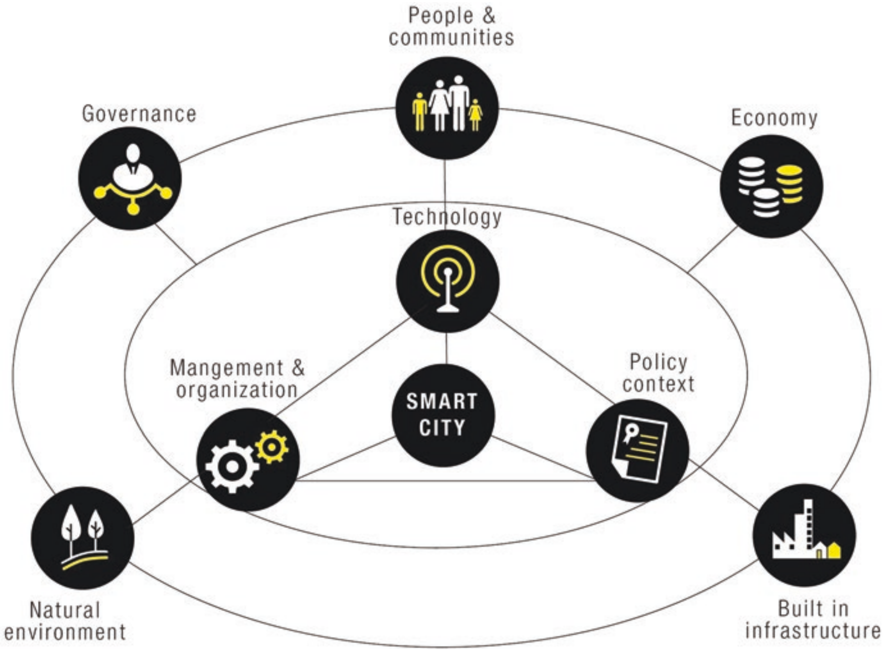



**Fig. 1** Smart cities initiatives framework: a visualization developed from the model by Chourabi et al. (2012) and our empirical research

fragmentation in the west stands in sharp contrast with what has happened in the Silk Roads since 2015 (Frankopan, 2018, p. 52), with the shift of global GDP from the developed economies to the east, and China's emphasis on the mutual benefits of platforms for long-term cooperation and collaboration. Thus, we decided against a research design based on the most similar and most different cases. Instead, the decision was to explore first plans of smart cities in Asia, and later on exploring New York and cases within the European context. Thus, we explore cases in Shanghai, China, four cities in Japan, Malaysia (Iskandar), the United States (New York), and the European Union (Amsterdam, Málaga, Santander, and Tarragona—these last three in Spain). We are interested in variations in the selected set of cases. In particular, to what extent and how the natural environment is a focus in each smart city plan. We follow Chourabi et al. (2012) in Fig. 1 and we focus on natural environment public policies in the selected smart city plans.

## Research Design and Case Studies

The unit of observation is the smart city plan and the initiatives outlined in each plan. In the selection of cases in terms of, cities and initiatives, we have followed a purposive approach because we are interested in doing logical deductions from different

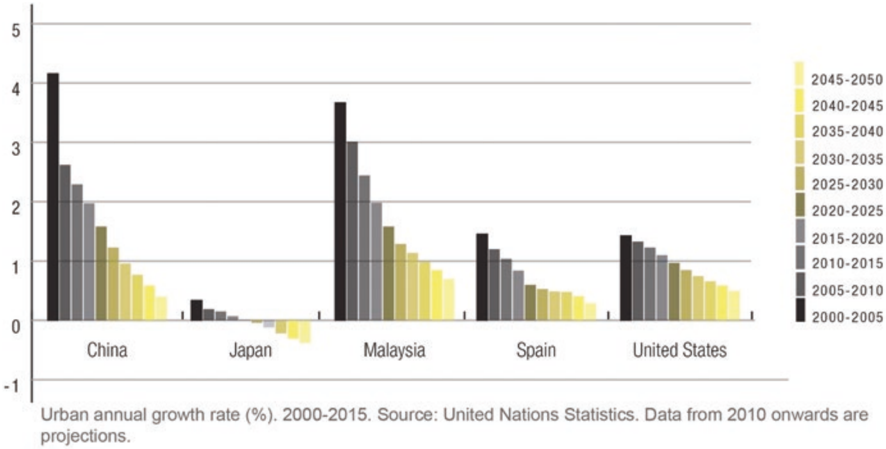



**Fig. 2** Urban annual growth rate (%). 2000–2015. (Source: United Nations Statistics. Data from 2010 onwards are projections)

world settings. Following Komninos, "the challenge today is … to gather and integrate knowledge from every available source all over the world (and) for global open systems of innovation (Komninos, 2009, p. 352)" In this empirical study we go on making suggestions for directions and agendas useful for smart city planners, policies and implications for both policy makers and professionals, as well as committed associations with the environment in civil society. For this research we have relied on primary materials, government documents, as reported in the References section, and secondary sources, academic articles, and articles from the press.

The following sections present the empirical analysis of our cases: Shanghai in China, Iskandar in Malaysia, Japanese cases -Yokohama, Toyota City, Keihanna and Kitakyushu-, and New York in the United States, followed by a set of European case studies. Cities diverge widely in terms of demographics, economy, location, population growth, and levels of urban development, among other dimensions. Some differences are reflected in urban annual growth rates, as shown in Fig. 2, and in the initiatives untaken in those cities.

## The Green Dimension in the Smart City Plan for Shanghai

We use our hypothesis, that the natural environment is a key focus in the first smart city plan, to analyze the green dimension in the smart city plan of Shanghai in China. The municipality of Shanghai (24 million inhabitants) put in place a 3-year action plan in 2011 to build a smart city (Gil & Zheng, 2017). The idea behind the plan has been to attain an "innovation driven transformation." The plan insists on the guiding principle of socialism with Chinese characteristics guided by Deng Xiaoping Theory. The defined aim has been to become an international economic, financial, trade, and shipping center as well as a socialist modern international metropolis (Lin, 2002). In practice, the plan built on measures taken in the decade of 1990, when informatization was the basis of modernization in three consecutive 5 year plan periods. The tools to make the vision possible draw on:

> Improving the Internet broadband and intelligent application level, build an information infrastructure system of international level, a convenient and highly effective information sensing and intelligent application system, an innovative new generation of IT industry system and a credible and reliable regional information security protection system. [Giving] full play to market mechanism and enterprises, attach importance to government guidance, improve market supervision, vigorously promote the building of future-oriented Smart City carrying mainly digital, network and intelligent features … to raise the city's all-round modernization level and let the citizens share the benefits offered by [a] Smart City.

The natural environment in the smart city plan for Shanghai is related to the energy dimension, and it is concerned with the setup of a smart grid to transport energy to coastal cities in the east coast. Technology and energy are keys to smart developments in China (Liu & Peng, 2013). China has been the most active investor in infrastructure that incorporates intelligence into networks, making them smart in a technological sense—the so-called smart grids. China is focusing on building a smart grid capable of generating and transporting energy from remote inland areas to populated areas on the coast (Gil & Zheng, 2017). This project aims to tackle the challenge of an expected increase in electricity consumption reaching increases of 8.5% per year. China interest on smart grids focuses on technical aspects such as the transmission, standards, integration of renewable energy and electric vehicles, and the implementation of systems that support bidirectional power flows. Challenges include basic questions such as standard network sockets, since there are three different types within the country. With respect to energy, the Shanghai includes a grid-based management system. The city seeks to make applied demonstrations of the smart grid: "building Shanghai into a Smart Grid demonstration city." The original 3-year-plan has contemplated conducting statistics evaluation: Establishing a complete statistical system and social evaluation system to building up the smart city, to strength the capacities of professional institutions by regularly conducting tracking and analysis and releasing the evaluation results. It has contemplated establishing a follow-up and assessment mechanisms for the coordination and implementation of the 3-year Action Plan, incorporating it into the annual performance appraisal system of the relevant departments and districts and county.

From the case analysis of Shanghai, the natural environment is not focal in the first smart city plan in Shanghai. Instead, it appears that growth and the energy needed to support it are focal.

## Iskandar, Malaysia

We use our hypothesis, that the natural environment is a key focus in the first smart city plan, to analyze the green dimension in the smart city plan of Iskandar, in Malaysia. The development of Iskandar goes hand in hand with increased linkages within Asia-Pacific countries by air and sea hubs (Ho et al., 2013, Hang, 2011). The government of Malaysia has wanted to strengthen a competitive edge for this Asian region, and thus, it created an Iskandar development region plan in 2006 (Bhaskaran, 2009). The Iskandar Regional Development Authority was later appointed to advance the so-called “new smart goals.” Instead of a green dimension as such, in Iskandar the plan leverages on built infrastructure, focused on new residential and business developments as well as educational and recreational areas. For built infrastructure, Iskandar Regional Development Authority reports do not include clear strategies of master planning where the natural environment is focal. According to Iskandar Regional Development Authority reports, these are the pillars of smart Iskandar: (1) Incentives for developers and investors for using green technology and infrastructure; (2) The introduction of a green economy and carbon credits; (3) A public transit system rather than more roads to improve easier movement.

The draft of Iskandar Regional Development Authority for the smart city includes active policies for the natural environment addressing sustainability and reflecting the fact that urban managers acknowledge the challenge of climate change and rapid urbanization for Malaysia. Iskandar Malaysia is currently experiencing population growth rate of 4% and an economic growth rate of 6–8%, and will continue to grow until 2025. With the option of population reduction difficult and remote, planning for a low carbon region would entail reducing $CO_2$ emission by reducing three main variables: the per capita activity, energy intensity, and carbon intensity of the region (Siong Ho, Matsuoka, Simson, & Gomi, 2013). Policy measures for the reduction of per capita activity could be designed to include (1) promoting low carbon lifestyle and consumption through behavioral change of the increasingly affluent population-including energy saving awareness program and promotion of policies of reuse and recycling campaigns (2) changing building and planning code toward low energy building. However, Siong Ho et al. (2013) notice that these measures have not been adopted in practice. Siong Ho et al. (2013) propose instead, policy actions at a national level to reduce the use of fossil fuel, provide tax incentives to increase use of renewable resources, to use biofuel, hybrid vehicles and buses and use of renewable sources of power in urban areas. These forward looking policies to reduce $CO_2$ emissions, however, have not been contemplated in Iskandar, Malaysia for the period of study focusing on the first smart city plan.

In the case analysis of Iskandar, we find measures included in the published draft, but there is also a lack of data on how and to what extent the drafted measures have been implemented or turned into policies. The natural environment is not focal in the first smart city plan in Iskandar, however, it comes, in principle, as an acknowledged point to address in the form of changes to building and planning codes toward low energy building.

## The Green Dimension in Smart City Plans in Cities in Japan

We use our hypothesis, that the natural environment is a key focus in the first smart city plan, to analyze the green dimension in the first four smart city plans in Japan for the period 2012–2014. The smart city plans in Japan during this period were drafted at the national level (Gil & Navarro, 2013). We selected the first four city pilot projects: (1) The Yokohama project, embarked on a demand response deployment on six large commercial buildings to test the effects of drawing power from storage batteries and energy efficiency measures; (2) Toyota City examines power demand increases as multiple electric vehicles are charged, the use of battery storage and an energy management system; (3) The Keihanna project, that evaluates the use of parked electric vehicles as storage batteries, combined with other recycled storage batteries to reduce power demand from factories; (4) Kitakyushu project, that conducts a dynamic pricing trial with residents as part of its smart communities creation Project, setting incentives to lower consumption and to share data with power firms. The Japanese government acknowledges that social infrastructures, involving electricity, energy, water, buildings, transportation, communications, administrative services, and other elements, are "indispensable factors for ensuring that the lifestyles of the people and businesses can be supported." In order to have all of these established within short periods of time and in a way that makes them useful in the future, the national government set up the master plan for smart cities. The time period for the pilot projects contemplate operational experiments conducted for a 5-year period from 2010 to 2014 in four cities. Projects search ways to make power use visible, to control home electronic devices, hot water systems, demand response, which involves the adjustment of energy demand that is encouraged from the supply side, the linking of electric vehicles and homes, the optimal design of energy storage systems, electric vehicles charging systems, and transport systems. The smart city projects developed in Japan focused on the construction of a next-generation energy society:

> *For resource-poor Japan, the large-scale introduction of renewable energies such as solar and wind power is absolutely essential to the nation's energy security and the reduction of $CO_2$emissions. The importance of these measures only increased in the wake of the Great East Japan Earthquake of March 11, 2011. However, in order to introduce these renewable energies on a large scale, we must also increase the efficiency of power use and balance supply and demand, and establish a smart grid as a power transmission and distribution network able to stably supply power (Japan Smart* City Portal. http://jscp.nepc.or.jp/en/, http://nepc.or.jp/).

The smart grid and smart cities are considered related to each other in the Japanese model:

> *If we are to utilize energy more efficiently than we have to date, we must not focus exclusively on the power system, but also reexamine our lifestyles looking towards, for example, the use of heat energy and transport systems. This means that it is essential for us to study the feasibility of new social systems, i.e. the ideal form of smart cities. If we take into consideration electric vehicles, the use of which is expected to expand in future, then the way we use energy will also change significantly, for example, electric vehicles batteries will be charged in ordinary households (Japan Smart City Portal.*http://jscp.nepc.or.jp/en/, http://nepc.or.jp/).

The natural environment is a key focus of smart city projects in Japan. Urbanization is a significant issue for Japan, with agricultural land being converted into urbanized areas at the same pace as the rapid growth of developing nations (JSCP, 2014). The focus on the natural environment in smart city projects in Japan has to do with the aftermath of the Great East Japan Earthquake that struck on March 11, 2011, and the subsequent nuclear power plant accident of Fukushima (JSCP, 2014; McLellan, Zhang, Utama, et al., 2013). The smart city projects in Japan mix decentralization of tasks and responsibilities to local and regional governments and include experimentation with modes of non-hierarchical coordination among public agencies and companies. The evaluation of implementation is embedded in the smart city projects, and it is centralized and assessed periodically. Sub-projects carried out within the selected cities are later supervised by the Community Energy Management System (CEMS), in charge of verification and evaluation.

From the case analysis of Japan, we find smart city plans linked to the environment in the particular dimension of energy and the transition from nuclear to electricity power (McLellan et al., 2013). We also find a focus on studies to understand how the population could adhere to a green transition thus defined. For these two reasons, in the case of Japan the hypothesis is proved: the natural environment is a key focus in the first smart city plans, affecting four big conurbations of cities, with the following epicenters built around the Yokohama, Toyota, Keihanna, and Kitakyushu projects.

## The Green Dimension in the First Smart City Plan in New York

We use our hypothesis, that the natural environment is a key focus in the first smart city plan, to analyze the green dimension in the smart city plans of NYC developed for the period 2010–2014**.** The evidence links us to the work developed by Dr. Steven E. Koonin, former Under-Secretary for Science in the Department of Energy in the Obama Administration heading the research agenda in New York University's (NYU) Center for Urban Science and Progress. Koonin, with a background as a theoretical physicist and science policy expert, heads the research carried out and linked to NYC's smart city program. The second smart project was developed at the city hall, and focused on smart data (Lohr, 2013, Howard, 2011). As regard to green dimensions, natural environment in public policy has been part of joint programs of the city council with NYU regarding the consumption of water, electricity and computer simulations, such as climate models for weather prediction. However, the focus has been mainly on data. There are no projects that tackle environmental issues from a smart perspective. For former New York Mayor Michael R. Bloomberg, data was set at the forefront to guide operations in city hall. In 2010, the city set up a team of data scientists for special projects in the Mayor's office. The city government committed to giving NYU access to all its public data. That is a rich asset, not only for research, but also for its potential to change government operations and public behavior. Smart plans were adopted by universities such as NYU, investing in urban studies and development with the recently created Urban Informatics School in Brooklyn in spring 2013, with industry partners including IBM, Microsoft, Xerox, Cisco, Consolidated Edison, Lutron, National Grid, Siemens, AECOM, Arup, and IDEO. Institutional partners included nearly 20 offices at various governmental levels, including the Office of Long-Term Planning and Sustainability (OLTPS), The Port Authority of New York & New Jersey, Department of Parks & Recreation (DPR), and the Department of Transportation (DOT). Policies have focused on efficiency. For example, the city council reports that when tapping into data it is possible to streamline building inspections, increasing the efficiency of finding risky conditions in 70% of the inspections. Efficiency is also the axis of partnership with IBM from 2009 launching the IBM Business Analytics Solution Center to address "the growing demand for the complex capabilities needed to build smarter cities and help clients optimize all manner of business processes and business decisions." IBM projects help the city prevent fires and protect first responders as well as identify questionable tax refund claims—a move that is expected to save the city about $100 million over a 5-year period.

From the evidence collected in the case of New York, we find data as the main focus of the smart city plan, and a limited focus on the environment, except for weather prediction. Thus, the hypothesis that natural environment is a key focus in the smart city plan in NYC is not confirmed by the case analysis, except for the focus on weather predictions.

## The Green Dimension in Smart City Plans: The Case of Amsterdam

We use our hypothesis, that the natural environment is a key focus in the first smart city plan, to analyze the green dimension in the smart city plan of Amsterdam, Holland. In Amsterdam, the local municipality initiative links the concept of smart with a change in the *energy model and with energy open connectivity*, and through it, aiming to become one of the world's most sustainable cities by 2040 (Peck, 2012, Mak, 2010, Scott, 2009). To achieve this goal, a partnership called Amsterdam Smart City (ASC) among businesses, authorities, research institutions and the citizens of Amsterdam was established. Since its inception in 2009, Amsterdam Smart City Partnership has grown into a broad platform, with more than 70 partners involved in a variety of projects focusing on energy transition and open connectivity. This bottom-up approach to sustainability encourages, in particular, the active involvement of citizens to test-drive new technologies. The municipality's ultimate goal is that these smart, sustainable projects reduce carbon dioxide emissions in line with the targets set at European, national and city levels. However, this aim is today more difficult, considering that the nuclear power moratorium in Germany after the accident at Fukushima in Japan is bringing carbon back in the neighboor country. Nuclear power accounted for 22.4% of national electricity supply in 2010 in Germany, dropping to 17.7% in 2011 and the still growing difference is covered mainly with energy coming from carbon.

Onze Energie, Our Energy in English, one of Amsterdam Smart City Partnership's largest projects, was designed to supply 8000 households with renewable energy, mostly through windmills. The introduction of twenty-first century technology in historical buildings from the seventeenth century of Amsterdam, is expected to reduce $CO_2$ these households emissions by 50%. By using innovative decentralized generation technology, Ceramic Fuel Cells, the aim is to generate electricity on site. After 20 years of research and development in Australia, cell manufacturer Ceramic Fuel Cells Limited developed a higher powerful cell yield than the modern gas-fired power plant. The $CO_2$ emissions might be reduced by 50%.[1] Fuel cell technology is very diverse with the experience of many disciplines, from chemistry to materials science to engineering and thermodynamics. Because fuel cells are highly efficient and in the use the fuel is not processed by combustion, fuel cells do not emit large amounts of greenhouse gases such as carbon dioxide ($CO_2$), methane ($CH_4$), and nitrous oxide ($NO_x$). The only emission of fuel cells is in the form of water steam, and low levels of carbon dioxide. Companies such as Coolendeavour, Eneco, Gasterra Liander find Ceramic Fuel Cells a promising technology and have decided to introduce a 2 kW fuel cell CFCL jointly a Proof of Concept in the center of Amsterdam: not in a laboratory, but in a 'living lab' environment. With this living test, the so-called Green Bay buildings are fully equipped with self-generated electricity. In this model, electricity is generated at the place of consumption and transmission losses are just about 5%. The total return achieved on energy grounds amounts to 85%.

Since 2012, Amsterdam's Department for Infrastructure, Traffic and Transportation (DIVV) has tried to contribute to resolving traffic congestion by making available to the public all its data on traffic and transportation. Information about parking availability, taxi stands, cycle paths, and live traffic updates are available for all main roads across the city. The data provided has allowed developers and entrepreneurs to create apps to improve the flow of people across the Dutch capital, giving Amsterdammers the chance to make decisions based upon facts and figures, given the city another way to make the city more eco-friendly. Projects include 300 power hookups to recharge electric cars, solar panels on Amsterdam's historic seventeenth century townhouses, and infrastructure upgrades that allow households to sell the energy they generate, from small-scale wind turbines or solar panels, back to the city's electricity grid for a profit. From the evidence collected in the case of Amsterdam, we find policies with a strong environmental focus with regards to energy production and distribution, including empowering citizens and residents to be self-sufficient and to contribute to the public electricity network. In this particular case, we find evidence that the hypothesis is confirmed: the natural environment is a key focus in the smart city plan in Amsterdam.

[1] See: https://amsterdamsmartcity.com/projects/fuel-cell-technology#about. Retrieved on Feb, 21rst, 2020.

## The Green Dimension in Smart City Plans: Case of Málaga

We use our hypothesis, that the natural environment is a key focus in the first smart city plan, to analyze the green dimension in the smart city plan of Malaga, Spain. The Malaga Smart City project aimed to be a "remarkable" European initiative for eco-efficient city. Does the city government have grounds to claim so? On-going projects on natural environment in Malaga include the following: (1) V2G technology research (vehicle to grid) aims to develop a delivery system of electric vehicle batteries to the grid, and subsequent analysis of the technical and economic feasibility of the solution; (2) PLC communications between processing centers; (3) Energy efficiency in public and private buildings. Possible energy management of Hospitals; (4) Sensors for noise, pollution, surveillance, communications; (5) Battery management and storage facility in the generators; (6) There has also been an agreement with the building firm Ferrovial, focused on efficient energy management in buildings. Málaga's objectives on eco-efficiency include: increase energy efficiency, reduce $CO_2$ emissions, and increase the use of renewable energies. A consortium of 11 companies led by Endesa, is deploying, in the Malaga area, technologies for smart metering, network automation, distributed generation and storage, and smart charging infrastructure vehicles.

The goal is better management of energy networks, efficient demand balances and the involvement of all actors in the power system, from generation to consumption. However, compared to the pilot developed in Amsterdam, houses and firms may not become producers rewarded for the energy produced within their own facilities. This is in part due to the fact that national regulations have prevented, measuring and charging citizens for the energy they might produce either at home or at work. Thus, even though the project aims to meet the European guidelines for the energy sector that drives efficiency, use of renewable energy and advanced network storage capacity, the impact is limited for citizens defining their own consumption models. Reduction of $CO_2$ emissions, automated meter reading, visualization of data online, and the reception of notifications in case of network disconnection are new services, focused on efficiency.

From the evidence collected in the case of Malaga, we find a lack of data showing a focus on the environment in the smart city plan. Thus, the hypothesis that natural environment is a key focus in the smart city plan in Malaga is not confirmed.

## The Green Dimension in the Smart City Plan of Santander

We use our hypothesis, that the natural environment is a key focus in the first smart city plan, to analyze the green dimension in the smart city plan of Santander, Spain. Smart Santander started as a 36 month project in September 2010 under EC (European Commission), call FP7-ICT-2009-5. This smart city project was conceived as a pilot project; sensors would be installed in an area of six square kilometers—or 2.3 square miles: The project includes the deployment of 20,000 sensors in partner cities that include Belgrade, Guildford, Lübeck as well as Santander with up to 12,000 sensors, using a "large variety of technologies." The projects include the following natural environment concerns: The lamps adjust their brightness as needed, dimming when there is no one on the street, and emitting less light during a full moon than on a rainy night. Environmental concerns are addressed in this way. In the Parque de las Llamas, sensors also optimize the amount of watering, so that no water is wasted. Garbage collectors might eventually be able to avoid making unneeded trips, because sensors will inform beforehand which garbage containers need emptying. From the natural environment point of view, smart city policies are driven in the context of economic crisis, and the extent to which pilots might become widely available will very much depend on efficiency as well as to the response to the needs of citizens.

Even though technology is used to provide new smart city functionalities in the city in Santander, from the data collected it is evident the lack of the natural environment as focus in the first smart city plan. Thus, the hypothesis: that the natural environment is a key focus in the first smart city plan of Santander is not supported by the case analysis.

## The Green Dimension in the Smart City Plan of Tarragona, Spain

We use our hypothesis, that the natural environment is a key focus in the first smart city plan, to analyze the green dimension in the smart city plan of Tarragona, Spain. The projects drafted for Tarragona's smart city plan included the following natural environment concerns: (1) Thermal isolation pilot in school with BASF technology, Termabead, to measure the resulting energy savings, (2) Environmental impact of public transportation, to be carried out by the Chemical and Tech Center of Catalonia, funded by Repsol, (3) Pilot on the use of biofuels produced by seaweed, a research project application from Repsol laboratories, (4) Smart metering for water in neighborhoods and public swimming pools, with AGBAR, EMATSA and AQUALOGY, expecting the results of a competitive project from the European Union on telemetry, (5) New asphalt installed in zones of intensive use by heavy industrial vehicles, the properties allow capturing contaminated diesel particles, better water absorption, and fissure self-repair, and (6) Water quality control of beaches in Tarragona accessible through mobile phone and tablets apps.

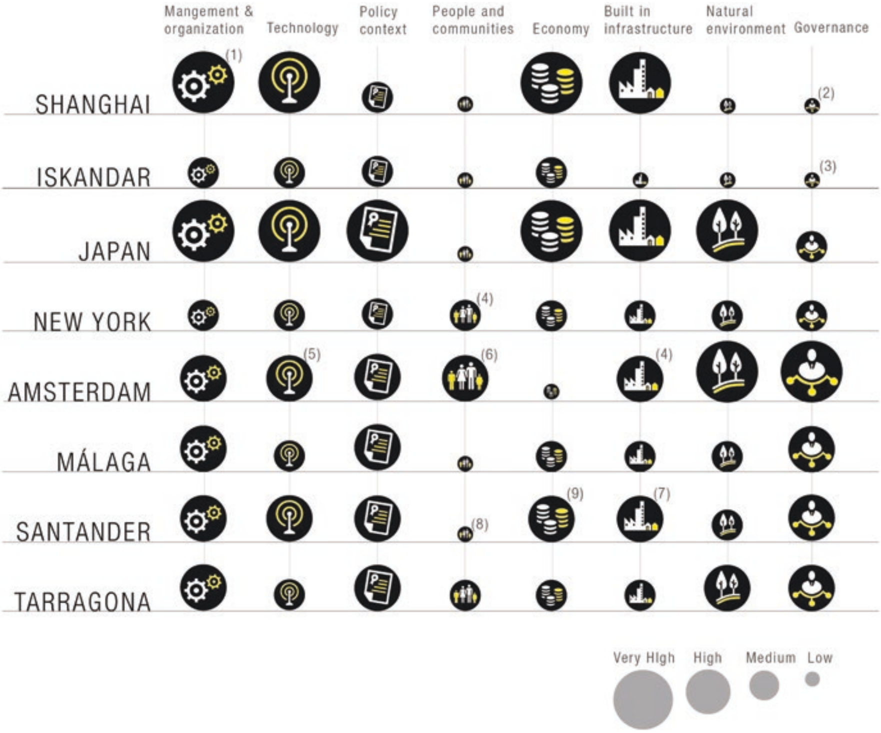
In Tarragona, we found a change that was defined by the Town Hall as going "from improvisation to programming" in environmental policies linked to the smart city project. The data collected shows that the natural environment is present in the first smart city plan. Thus, the hypothesis: that the natural environment is a key focus in the first smart city plan of Tarragona is to certain extent support by the data—and mostly focused on pilots.

## Analysis and Findings from Our Cases

In our analysis of the eight smart city plans from Shanghai in China, Iskandar in Malaysia, Japan four smart city plans-Yokohama, Toyota City, Keihanna and Kitakyushu-, New York in the United States; and Amsterdam, Málaga, Santander and Tarragona in Europe, we have identified two theoretical traditions in the study of smart cities, one with a focus on sociology, and a second one, engrained on technology. In both traditions we have shown that the environment is a relevant variable. Thus, Caragliu et al. (2011) when studying the smart city introduce the need of a strategic agenda for sustainable urban development as main part of the concept. Chourabi et al. (2012), from a technological background also make the natural environment a critical factor in their model. From these two perspectives we have inferred the following hypothesis: that the natural environment will be a key focus in the smart city plans unveiled by local governments, and we have proceed to test it in our eleven city cases. From this hypothesis we formulated the following questions that we have answered in each of the case studies: Is really the case that the natural environment is a focus of the smart city plan? To what extent? And, what have been the differences, if any, in smart city plans with regard to strategy and the green dimension associated with long-term goals?

From this exploration we founded interesting differences and some similarities among the cases. We find that the multifaceted sides of the green dimension in smart city plans are being established locally, to a fundamental extent from local governments, except for the particular case of the four cities in Japan and Iskandar in Malaysia, where the national governments have had a say in the smart city level plan design. The focus on how the natural environment should be addressed in the smart city plans varies in the different cases. Only in one case society engagement has been also important in the implementation: Amsterdam is the relevant case in this particular ground.

From the cases analyzed it is interesting to see that the green dimension is not strategically ingrained in long-term plans for the smart cities in the cases analyzed, except for Amsterdam. A certain approximation to natural environment is done from the perspective of energy and smart grid modernization, for instance both in Shanghai in China and cities in Japan. However, there is a lack of attention to the “green dimension” as a fundamental part of smart city plans in terms of focus. In this regard, we should stress the fact that the environment is fundamentally a focus covering energy production and emission’s concerns, and technology is paramount in implementation in first smart city plans covering over eight cases worldwide. Resilience to climate change, however, is poorly addressed. The following table from Gil, Navío, and Pérez de Heredia (2015) shows the results when we compare the eight cases of the study, and our focus on the seventh dimension in this work, the natural environment, showing the extent to which smart city plans include it.




Concerns about the natural environment are, to an extent, present in the eight cases, but they are not equally central to any of the smart cities plans. We find a there is not a consistent focus on policies tackling resilience to climate change, energy consumption and reduction of emissions. As such, there is an interesting scope for improvement in policy conceptualization and design. Shanghai faces severe environmental concerns that are not addressed in their first smart city plan. Malaysia is also aware of severe environmental concerns, but there are no incentives set in place to protect and preserve the natural environment. Japan did set up the smart city pilots in the aftermath of the nuclear accident, and in those efforts made the environment an important concern. New York suffered the impact of climate change brought by hurricane Sandy in November 2012 and plans focus on computer simulations for weather forecasts, updating government data management and efficiency. Energy consumption and reduction of emissions are less of a focus in New York though. In the European cities, Amsterdam, Málaga, Santander, and Tarragona we find some concerns about the environmental dimension translated into smart city plans, in particular on energy consumption and reduction of emissions. Smart policies here address transport issues in all cases. In Malaga, where research on electric batteries and electric cars is some of the smart pilots, we found some similarity with Japan. Amsterdam is concerned with energy and through the use of citizen engagement initiatives, citizens have been given a role in defining a possible new model of energy democratization. Málaga is developing modern metering, Santander is experimenting with sensors, and the Internet of Things and Tarragona is concerned with the chemical industry and transport efficiency. The public policies proposed with regard to the environment and the partnerships to attain them are varied in the over eight cases examined.

Our hypothesis, that the natural environment is a key focus in the smart city plans analyzed, has not been supported in the cities that were the focus our case studies, except for cities in Japan -under the Yokohama, Toyota City, Keihanna and Kitakyushu smart city plans- and the city of Amsterdam. Our analysis has shown the different ways the natural environment is addressed in these plans, and shows a consistent lack of attention to the green dimension in smart city plans. We may also point out the interest to take into account three sources of environmental ethics, covering resilience to climate change, energy consumption, and reduction of emissions in future plans for smart cities. There is much to be gained from smart city plans where technology as tactics is ingrained in long-term strategy addressing environmental ethics and sustainability, which is actually lacking to a great extent at the moment of the cases studied. There is also need for research that addresses these issues in a consistent manner.

In our cases studies, we found shortcomings in the data in each case to validate the hypothesis, namely, that the natural environment is focal in each smart city plan, because there were other variables, unrelated to the environment, key to the smart city plans. This is supported by the case analysis, except for cities in Japan and Amsterdam, where the environment was paramount. We also find a lack of further commitments, as evaluations of the smart city plans have not been published. Further, we find plans that once finished, have not been renewed. The lack of evidence in our cases on the natural environment being a focus of the smart city plans, and the lack of evaluation and further redraft of future plans make the conclusions of this work more valuable: first of all, there is a need to draw a necessary link between smartness and the environment in order to tackle challenges derived from sustainability at the local level, in line with the work of García Fernandez and Peek (2020). Efforts might also be placed to ingrain the green dimension and the environmental challenges we face in technological leaps forward. The work might also be extended in the line suggested by Jax, Calestani, Chan, et al. (2018), and embed the green dimension in smart city plans in a broader and richer set of human relations with nature, which transcends the distinction between instrumental and intrinsic values. In the view of Jax et al. (2018) this perspective considers both the question of what nature does for people and also acknowledges a diverse set of other relationships with nature and the values associated with it. It might also be extended in the sense precluded by Himes and Muraca (2018), allowing for the operationalization of relational values into frameworks for ecosystem services and nature's benefits to people in different local contexts.

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