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Overview of Smart City Projects in Different Countries

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Table of Contents

List of Figures

List of Tables

Abstract

Urbanization, globalization, immigration from different cultures, new demands and expectations, technological advances led the transformations of our current cities. As cities are growing and transforming, stakeholders of the cities are becoming more complex and city planning need some improvements. Consequently, it is clear to note that city planning is facing disruptive changes and becoming more important each day. Local governments, city leaders, and international organizations always work to find strategic solutions for the optimal and sustainable growth of the cities and new ways of organizing and governing plans to achieve better outcomes for their stakeholders. In the 21st century, smart city is seen to be the answer to all these challenges. The motivation of this thesis started with the lack of common definition of smart cities. Because each country has different social, economic and political backgrounds. Therefore, the usage of ICT and other technologies are shaped by cultures and needs of the cities' and by political choices of local authorities. Consequently, different cities have different processes to follow. ICT Center for City Logistics and Enterprises (ICE Lab) of Politecnico di Torino introduce a new taxonomy in the paper of "A new taxonomy of smart city projects" (Perboli et al. 2014). According to the literature review, the taxonomy introduced by Perboli et al. (2014) is the one that covers existing smart city concept with a managerial concept of the SCPs such as social inclusion, business and governance model and human and social relations. The aim of this thesis to collect data about different smart city projects at the global level, identify the trends in objectives and tools, promoting the successful business model, and give information about the outputs of the projects. Asia, Australia, Brazil, Europe, Canada, and the USA selected for this study. Therefore, the social, political and economic background of countries are investigated, characteristics of the projects are analyzed, and business model and value propositions are generated for each project. As a conclusion, it was confirmed that Asia has two counterparts of the population growth where China and India have an unprecedented growth, while Japan is facing an aging population. However, smart services for the citizen is the key value proposition cover for all Asian countries with the use of open data and innovative sensors and solid business models. Australia has one of the highest living standards, yet needs to implement big data and ICT to improve energy management, transportation systems, and buildings. Europe has a leadership position in smart cities. Thanks to European Commission initiatives like Horizon 2020, Europe is transforming its cities to become more sustainable and improve the quality of lives. In the case of Brazil, like other countries in Latin America,

they need to do more progress in smart cities because they have major problems in traffic, energy, water, and government. For now, Brazil mostly focuses on energy-related strategies. Lastly, the USA and Canada already have advanced organization in most of their cities. However, both countries aim to transform their cities more innovative, more connected and more sustainable. Furthermore, the foundation of public and private entities for the management, infrastructure and equipment financing and financial resources are the key success factors for SCPs around the world.

Acknowledgment

To my parents,

I can not thank you enough for all the

support and love you have given me...

Introduction

Cities are definitely different than what we knew about them in the past. In history, there are three big events that changed the way of our lives. Firstly, when humanity settled around the rivers and start to do agriculture. This was the first sparkle of cities and later politics, religions, and new inventions led the evolution of cities. The second big event was the industrial revolution, where medieval cities transformed into industrial cities. The efficiency of production is increased and consequently, consumption has also changed. Mass production, availability of goods and the services attracted everyone, but the industrial revolution brought many negative results in the background. Cities were not ready for this rapid population growth, consequently, CO2 emissions and air pollution was increased dramatically, cities were rife with disease, infrastructure was not enough for the population and so on. However, cities continued to grow, business districts were constituted, and transportation systems were developing thanks to the arrival of cars. Lastly, the third big event is the digital revolution that now humanity is witnessing the era of technology and we must find a sustainable way to transform our cities.

According to the United Nations' report "The World's Cities in 2016", currently 54,5% of the World's population lives in urban areas. This ratio is expected to grow to 70% by 2050. Although megacities are expected to have higher urbanization rate than developing cities, developing cities, especially in Asia and Africa, have the fastest urban growth. As cities face major problems, emerging cities need to cope with several different problems. Therefore, the right planning, financing and managing models for cities can help governments to provide solutions. Regarding management models, decentralization has become a political phenomenon in most countries. However, decentralization has failed in many developing countries because financial resources are not adequately passing down to local governments. Related to the problem of population growth and decentralization, governments have challenging of providing urban services and developing the infrastructures. According to the World Bank (2017), global infrastructure investment needs will reach $94 trillion by 2040. Asia has the highest proportion of the global infrastructure needs, $51 trillion, and the other countries following Asia, the United States of America needs $20 trillion, Europe needs $15 trillion, Africa needs $6 trillion and Oceania needs $2 trillion. The amount needed for the infrastructure investment is enormous and public entities don't have enough capital, human resources, and technical capabilities to answer this significant demand. Therefore, there is an urgent need for new governance models to cope with the challenges.

Urban transformation is a complex and multi-faceted endeavor where stakeholders of cities have different requirements, creating different problems and solutions. Together with rapid urbanization, increasing health and security problems are noticed in the cities. On the other hand, the energy demand of cities is between 60% and 80% and generate 70% of human-induced greenhouse gas emissions alone. Therefore, cities are playing a huge role in climate changes. In conclusion, more people means more energy, more housing, more food and water consumption, more disease, higher crime rates and so on. Therefore, creating eco-efficient and sustainable cities are not an option anymore, it is the most important necessity in the 21st century.

Based on the previous information about the city, the current urbanization model is not suitable for sustainable development in economic, social and environmental ways. Therefore, Smart City seems to be the answer to respond to all the challenges laid by overpopulation, urbanization growth, expectations rise, economic competition, global climate change, and new business models for the management of cities.

There is still not a common definition of smart cities but it can be described as the modern cities with the utilization of information technologies to improve quality of lives of people, increase the efficiency of the urban services and infrastructures and remain the competitiveness of the city. The perspectives of the smart city are changing by the problems and objectives, economic characteristics, culture, and political background of the cities. Therefore, the ICT Center for City Logistics and Enterprises (ICE) from Politecnico di Torino create a taxonomy to examined Smart City Projects through the analysis of objectives, tools, stakeholders, business models, and purposes. This new taxonomy enables practitioners to compare SCPs, and consequently to identify successful implementations and trends in different countries or regions. The main objective of this thesis is showing the performance of the taxonomy which used on different SCPs at the global scale and illustrating a global result for a smart city. Along these lines, the present thesis is divided into five chapters:

In the first chapter, the urbanization processes and the drawbacks of the urbanization in both developed and developing countries are described. After understanding the challenges, how smart city has become the answer to these challenges is described along with the timeline of the smart city concept. This literature review showed us the interchangeable use of digital city and sustainable city, thus comparison of smart city with digital city and sustainable city is included. It was a fundamental study to describe the development aspects of a smart city.

Each enabler technologies is described with some successful examples. Furthermore, smart city definitions by regions have introduced which has taken from the main national institutions. These definitions are explained shortly and compared among each other to underline their main differences according to their cultural, political and social backgrounds briefly. Lastly, some mostly theoretical initiatives and visions, that promote smart programs and projects in national or international are described.

In chapter 2, it has been a treaty the used taxonomy in this research. Therefore, the taxonomy introduced by Perboli (2014) is deeply analyzed in this chapter. Many researchers have already introduced different taxonomies to rank SCPs but this taxonomy is a well-structured taxonomy that gives information about objectives, tools, stakeholders, business models and the output of the projects. Since the taxonomy allows to identify the business model, Business Model Canvas and Value Proposition Canvas proposed by Osterwalder has been chosen to examine the projects with a perspective more managerial. Thus, these tools are also deeply analyzed in chapter 2.

In chapter 3, the results obtained from taxonomy and business model tools are summarized, organized and analyzed with the examples from SCPs. Firstly, qualitative results for each region are undertaken and illustrated with graphs which give to the reader an easier and intuitive approach to the outcome. After, the statistical analysis and the value proposition analysis of the regions are merged and analyzed with cross-region considerations, relations with the history of the country and the political/social characteristics.

In chapter 4, the overall analysis and outcomes of the taxonomy are presented, including key takeaways, success factors, best practices, and potential gaps of the Smart City Projects.

In chapter 5, the conclusion and the future recommendation of the smart cities are addressed.

1. How Smart City Concept is Evolved?: Literature Review

1.1 Evolution of Cities and How We End Up with Smart City Concept

How people are organized and when they create a city? Examination of the evolution of the city will be a good guiding light for the beginning of this thesis. Yanrong, K., et al. (2014) said that since there is no common and standard definition of smart city concept, most could agree on that smart city are a general concept of city modernization. The history of cities has dated back to 10.000 BC. According to the resources, very first cities have developed in Mesopotamia, Asia, and America. What are the drivers to create the city from the very early age of humanity? Agriculture, politics, trade routes and industrialization are the main reasons to shape the way of the people's lives. Beginning of the foundation of the cities, agriculture and farming played a key role to make a denser population and settled them around the resources. Humanity has started to learn how to use effectively the resources that nature gives to them and they have changed the environment actively to satisfy their needs. As time passed by, surpluses from farming led them to start to do a trade. People start to interact with other populations in this way and the development of the cities is unavoidable. Rather than only agriculture, economic benefits, politics, and religion are also affect the urban style of the ancient cities. For instance, preindustrial cities were born because of political reasons. It is mentioned in the literature, Lord's rules and rural obligations are so strict to follow for people who lived in the medieval era. On the other hand, the city allows them to experience freedom. According to the literature, 80% of society was living in a rural area in the pre-industrialized era. However, starting from the late 18th century, the industrial revolution brought so important results of world history. Quality of lives of the people increased, production pass through from hand-made to the machines and factories. Thus these results in mass production, massive consumption, and more labor force. Another result of the industrial revolution is developing new technologies, which affects advanced agriculture, better health condition, and social life and so on. Therefore, first in Europe after in all other regions, we start to see new cities and massive urbanization around the world.

Figure 1 shows us the population change for different countries, which have chosen for this thesis such as Brazil, Australia, the United States, Canada, Europe, and Asia. However, we can notice one common result that from the 15th century until the 18th century that industrial revolution happened in the late 18th century, people were living in the rural area because the technology was not enough and they were spending their lives depend on only husbandry and farming.

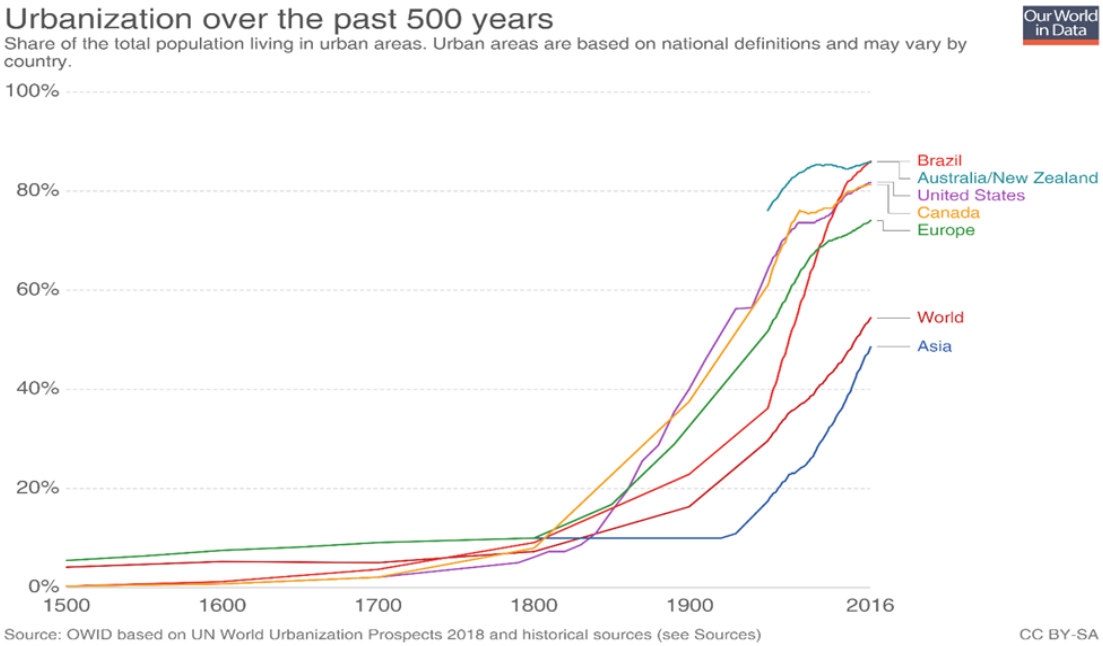


Figure 1: Urbanization over the past 500 years by Our World in Data

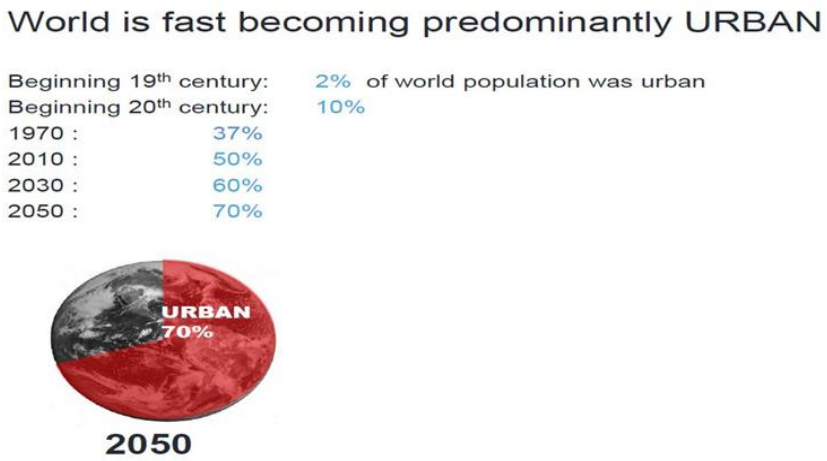


Figure 2: Worldwide urbanization rate over the years by Vancutsem (2019)

As it can be noticed from both figures, the urbanization level is rising from the late 18th century and the new technological advance and population growth accelerate the urbanization. As seen in Figure 2, at the beginning of the 19th century, only 2% of the world population was urban and it expects to be 70% in 2050 (Vancutsem, 2019).

Nevertheless, before going further analysis it is better to answer what is city and what is the components of a city? As it is discussed before, the city is founded where the humans are settled near the rivers or sea for agriculture. According to the literature, the increasing interaction among people, government, business causes cities enlarged by the services and systems for building, mobility, sanitation, utilities, and communication by time. Therefore, cities become a system that is more complex.

A better understanding of the complex city, we can classify the components of the city.

Neirotti et al. (2014) claim that cities components can be grouped into hard and soft. Respectively, hard domains consist of energy grids, public lightings, natural resources and water management, waste management, environment, logistic, transport and mobility, buildings and healthcare which creates the city's tangible resources. Later, soft domains are concerning about education and culture, social inclusion and welfare, public administration and e-government and economy, which can be seen as intangible resources. All the domains of the city are developed by the technological developments, innovations, trade and all of these make the cities are more attractive for people. Consequently, the reason for this massive immigration that we have seen from Figure 1 and Figure 2, cities are the source of economic growth, productivity, innovation, and social inclusion. People are moving from the rural area to urban area to have better opportunities for themselves but also for their future generations. Therefore, cities have continued evolution to satisfy different stakeholders' stake and at the same time has to consider the wealth of society and the sustainability of the earth.

The migration from rural areas to urban areas was the very first start of the evolution of the smart city. This rapid growth of the population in the cities brought positive results as well as negative results. Some of the main advantages are brought people, ideas and goods together and consequently reduce the transportation cost of them. As following the former advantages, cities focus on worker productivity, safety, and social inclusion of people; create new job occasions, better health and education opportunities.

On the other hand, the growth of the urban population brought also problems to society. Cities were rife with diseases, sanitation of goods, air pollution, and noise and safety problems. In addition, growing cities have negative environmental results. Uncontrolled construction, decreasing in the environmental quality, increasing in the use of fossil fuel for mobility and heat, increasing in the use of cars are just some of the negative results of the urbanization. According to the literature, urbanization can create urban "heat islands" which are formed when industrial and urban areas replace and reduce the amount of land covered by vegetation or open soil. In the normal cycle of evaporation, ground helps regulate the temperature and create the cooling effect with vegetation and soil. On the other hand, irregular urbanization and glass curtain wall on the skyscrapers are increasing the temperature in the cities. (Didier Vancutsem, 2019). Consequently, this result of the greenhouse effect. It is mentioned in World Bank Cities and Climate Change an urgent agenda (2010), 80% of worldwide energy production is consumed by cities. According to ongoing development processes, greenhouse gas emissions will produce by energy

services required for lighting, heating, and cooling not by the industrial actions. International Energy Agency (IEA) (2008) claim that urban areas cause energy-related greenhouse gasses by over 67% and it is expected to rise to 74% by 2030. Also, according to the report; developing countries will be the major CO2 sources from the energy uses, which is expected to be increased by 89%.

The findings make clear meaning and the foundation of cities are not the same in the 19th century and 21st century. City planning is facing disruptive changes and becoming more important each day. Globalization, immigration from different cultures, new demands and expectations, technological advances are the main drivers of the transformation of the cities. As cities are growing and transforming, stakeholders of the cities are becoming more complex and city planning need some improvements. Cities have to find new ways of organizing and governing planning to achieve better outcomes for their stakeholders. Ruhlandt (2018); Axelsson et al (2018) argues that "*the governance processes in cities become enormously complex, as they are multi-faceted and multi-level ecosystems of various agencies and stakeholder groups such as local governments, citizens, urban planners that are often driven by conflicting interests*." Therefore, we understand that cities have major conflicts with an upward trend in population, environmental issues such as energy consumption, resource management, and multi-faceted and multi-level ecosystems caused by the technological layer added to cities.

Since technological advancements made an appearance, urban planners, academicians and local governments start to search new city planning to solve the increasing conflicts of the cities according to different demands of its own stakeholders, characteristics of the city and geographical situations. Smart City, Digital City, Sustainable City, Intelligent City, Green City, Livable City, Eco City, Resilient City are just some of the examples of the new specific terms for the city is promoted by universities, local entities, business environment. Moir, Moonen, and Clark (2014) claim that although we have different terms for new city concepts, cities have to cope with some challenges:

1. Climate Change
2. Technological Developments
3. Insecurity
4. Changing institutional and governance frameworks
5. Population Growth
6. Geo-political changes

7. Ageing Populations
8. Globalization of economy, demographics, risks and ecologies dependencies
9. Human mobility
10. Inequality and social tensions

While generally cities face these challenges, developing cities will experience toughest challenges:

1. Greatest degree of change
2. Not enough level of resources and institutional capabilities to overcome problems
3. Vast majority of urban growth in 30 years

As a conclusion, today's cities, even with different aim or title, are in the competition with one another. Each city has to satisfy its citizen and deliver high quality of life and safety, use its resources in an optimal way, attract new business and protect the environment on a global level. On the other hand, when the local economies are growing, it does not mean as a good indicator indeed it can often damage nature. Like in the case of industrial revolution, developments in the technology gained acceleration and economy was developed. On the other side, local environmental problems have witnessed in big cities such as London called "Black country" because of heavy industrialization and now Beijing is still fighting with air pollution. Although some previous localized problems have solved, urbanization and globalization bring problems into the scene globally.

Smart city, digital city, sustainable city, intelligent city, green city were born to cope with major challenges as mentioned before. In the later part of this chapter, the timeline of the smart city, digital city, and sustainable city will explain in detail. Before going to that part, it is good to see how different stakes of stakeholders shape the future of cities. Cocchia (2014) present that according to the literature review, there are different terms are used as synonymous of smart city. However, before doing this we have to understand the similarities and differences between all the other definitions and she define and create a table to compare different definitions of cities.

Table 1: Different concepts of cities by Cocchia (2014)

Concept	Definition	Reference
Intelligent city	*"Intelligent cities are territories with high capability for learning and innovation, which is built-in the creativity of their population, their institutions of knowledge creation, and their digital infrastructure for communication and knowledge management"*	Komninos (2006)
Digital city	*"The digital city is as a comprehensive, web-based representation, or reproduction, of several aspects or functions of a specific real city open to non-experts. The digital city has several dimensions: social, cultural, political, ideological, and also theoretical"*	Couclelis (2004)

Smart Community	*"A geographical area ranging in size from neighborhood to a multi-county region whose residents, organizations, and governing institutions are using information technology to transform their region in significant ways. Co-operation among government, industry, educators, and the citizenry, instead of individual groups acting in isolation, is preferred"*	California Institute (2001)
Sustainable city	*"Sustainable city uses technology to reduce CO2 emissions, to produce efficient energy, to improve the buildings efficiency. Its main aim is to become a green city"*	Batagan (2011)
Eco City	*"Ecological cities enhance the well-being of citizens and society through integrated urban planning and management that harness the benefits of ecological systems and protect and nurture these assets for future generations"*	The World Bank Suzuki et al. (2010)

As can be noticed from Table 1, although there are many different definitions of a city, they are sharing some common aspects. Such as ecological city and sustainable city share the environmental aspects; digital, intelligent and smart cities are sharing the economic aspects while digital and smart cities are focusing on environmental and governance aspects of the city. As can be seen from the literature, digital city was popular in the 90s and after it drops behind of smart city and smart city take place of it. Concurrently, Eremia, Mircea, Lucian Toma, and Mihai Sanduleac (2017) highlighted the fact with google trends that bring the global analysis of the popularity of the different terms. Ecological city is widely used in South Asia, West Europe, Northern America, and Australia. Since the extreme weather conditions and natural disasters are harm these countries, all the countries are listed have a wider acceptance of eco-city. On the other hand, smart city has widely accepted in Europe and Northern America. For instance, Europe 2020 initiative is the driver of the majority of the smart city projects in Europe. India chooses sustainable city to define its project since its massive population growth pushed the city leaders to take into consideration of sustainable and optimal usage of the resources.

Consequently, there is a high volume of different meanings of the city and as we discussed before most of them shares similar aspects. Especially, in the next part, smart city, digital city, and sustainable city concepts will be explained in detail because they are sharing more common aspects of the smartness and sustainability of the city.

1.2 Smart City was Born

Smart city is a natural process after the industrial revolution and following the rapid urbanization. The city has finite hard and soft resources but at the same time, population growth is unstoppable. People are still moving to the cities and the city has not enough resources and infrastructures to serve a high-quality life to its citizens. Therefore, local governments, city leaders, and international organizations always work to find strategic solutions for the optimal and sustainable growth of the cities. Information and Communication Technology (ICT) was the only way to achieve optimal usage of the resources, increase the interaction between components of cities and thus make cities smarter. Therefore, ICT becomes an essential element of smart cities. Smart Council (2015) define the smart cities "*A smart city uses information and communication technology (ICT) to enhance its livability, workability, and sustainability*". While rapid urbanization, the industrial revolution, and ICT are seen as the main drivers, there are important milestones that are going to be explained in this part of the thesis. However, before going to explain milestones, it is better to underline one of the first studies for classification of smart cities from Giffinger et al. (2010). This study gave the first operational definition through six pillars with seventy-four indicators. Cocchia (2014) and Shields (2014) draw two quite different timelines for a smart city evolution. Therefore, important dates from both sources will be merged and explained.

1. In 1986, the Greater London Council published first municipal open data. Open data is the smart answer to the different problems of cities such as transportation, governance, emergency, urban planning.
2. In 1992, The United Nations Conference on Environment and Development (UNCED) was held on Rio de Janeiro. The topics covered in the summit were:
    a. New alternative sources for energy production to decrease the dependency of fossil fuels.
    b. Increase the availability of public transportation in order to reduce dependency on personal cars thus decrease the emissions, air and noise pollution, and congestion.
    c. Efficient water supply and demand management.
    d. Intense control of patterns of production especially focusing on hazardous substance.

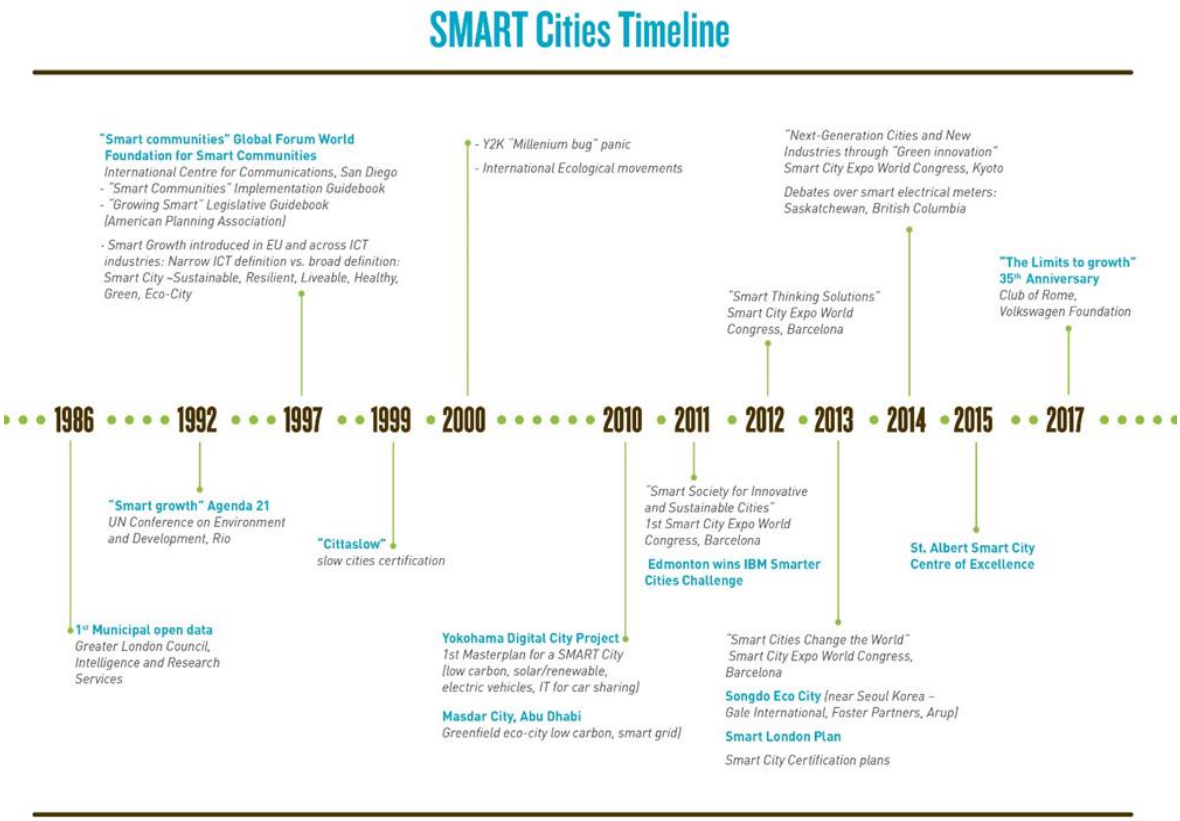


Figure 3: A Timeline of the development of the Smart City notion by Shields (2014)

3. In 1997, the Kyoto protocol was signed by 192 parties. The main purpose of the protocol is a limitation on the CO2 emissions and thus protect the environment globally. Each party prepares their own policies and regulations to decrease CO2 emissions. Kyoto protocol was the extension of the United Nations Conference on Environmental and Development Conference in Rio. The Conference was a successful example of awareness of climate change. Kyoto protocol has two different commitment periods in which are from 2008 to 2012 and from 2013 to 2020.
4. In 1997, the Global Forum World Foundation introduce smart communities. Some of the important events are American Planning Association published Smart Communities Implementation Guide Book and Growing Smart Legislative Guidebook. Europe and the across ICT industry meet with smart growth term. Sustainable city, resilient city, livable city and so on are introduced slowly.
5. In 1999, Italy introduces the new perspective of smart city, which is more related to a sustainable concept. The concept of 'Cittaslow' was born in Italy with a collaboration of four small towns to aim with increasing the quality of life.

6. In 2000, the internet spread all around the world. Despite the foundation of the internet is dated back 1960-1970, the introduction of world wide web (www) and HyperText Markup Language (HTML) and the development of websites such as Yahoo!, Google, Amazon accelerate the use of internet in public. These advances in the internet area make internet available worldwide among academicians, businesses, and people. But the spread of the internet walks hand by hand with ICT. The advances in the ICT such as first computers, storage systems, computation technologies, networked computers, programming languages, wireless sensor network made this internet and communication technologies understandable. These developments allowed people more connected and more intelligent. The invention of mobile phones and later smartphones change the way of our lives. The service providers such as healthcare, energy, education, environment, mobility and public safety is changed and more accessible among people. Now in the cities, the physical world and the virtual world is connected and citizen shares data about their knowledge experience and interests.

7. In 2005, the Kyoto Protocol is entered into force. In spite of the Kyoto protocol was signed in 1997, the aim of reduction of greenhouse gas emission was achieved after Russia agreed to sign protocol in 2005. Therefore, all the parties of the protocol have fostered their strategies about environmental protection.

8. In 2008, IBM is appeared on the scene as the first company to introduce "smart planet" concept. Sam Palmisano, the CEO of IBM said, "*Every human being, company, organization, city, nation, natural system, and man-made system is becoming interconnected, instrumented, and intelligent. This is leading to new savings and efficiency—but perhaps as important, new possibilities for progress."* IBM started to give consultancy to the governments about e-governance, environment management, healthcare, education, energy, transportation, and public safety and so on. After the introduction of IBM, city leaders become more conscious and other companies such as Cisco, ABB, Siemens etc. start new business area and enter the market. This new market area finds smart solutions with the advancement of ICT to the cities and the term cities start to become "smart".

9. In 2008, another significant event occurred in Europe. Thousands of local governments in Europe voluntarily come together to implement EU climate and energy objectives. All the city leaders are following the Sustainable Energy and Climate Action Plan (SECAP) according to their local needs and outline their key

action plan. Some of the important actions to undertake by covenants, reduction of greenhouse gas by 2030, mitigation and adaptation of climate change, decarbonization of their territories, and find the new sustainable and renewable energy sources.

10. In 2010, each region has undertaken important action to implement smart city concept. European Union launched "Europe 2020 Strategy" with the five main purposes to achieve until 2020 by each country of the union. These five main purposes are employment, research and developments, climate change and energy sustainability, education, poverty, and social inclusion. In the same year, we witnessed the first Masterplan for smart city from Japan. Yokohama introduces the smart city plan in areas corban emission reduction, electric vehicles, renewable/solar energies, and IT for car sharing. Another smart city example came from the United Arab Emirates. Masdar City is the first example of sustainable city in the world. Masdar city built from the sketch in Abu-Dhabi by a private-public partnership.
11. In 2011, the First Smart City Expo World Congress held in Barcelona. Congress is a unique opportunity to empower the smart city initiatives, promoting the innovations, establishing the partnerships, to identify the problems of development of smart city projects from different cities.

These important milestones demonstrate that technological advancement and political situations shaped the definition of our current cities. We observe the links between climate change and political actions such as Kyoto and Europe 2020. The spread of the internet, personal computers, and smartphones led the people to redefine their relationships, communications, economic activities, jobs, and lifestyles. Data storage, computation systems allow computers more intelligent, and therefore scientists, academicians, businesses invent new machines, services, and applications. All of these movements in the timelines reshape our cities by 6 main strategies to develop the future of cities. Now, we consider city management through smart people, smart economy, smart governance, smart environment, smart living, and smart mobility.

1.3 Comparison of Smart City with Digital City and Sustainable City

The main motivation of this thesis is showing that smart city has a lack of common definitions worldwide. As we can notice from the previous chapter, the evolution of smart city is also proving that smart city idea is evolving with the challenges which cities face or reshaped by the new technological advancements. However, we can underline the one common goal of the smart city is that increase the quality of the life of its citizen. Another common term we can notice that the use of information and communication technologies (ICT). City leaders and companies are aware that smartness of a city can be achieved by the efficient use of data, processing it and serving new solutions to its citizen. Therefore, these two main instruments of cities, which increase the quality of life, and common use of ICT, bring questions to academia to have clear definitions of cities especially between smart city, digital city and sustainable city because these three definitions mostly overlap and are misunderstood.

1.3.1 Digital City

Since 2000, the development of ICT and the advancement in technology led to define cities as "digital". One of the first definition of digital city made by Qi et al. (2001) "*substantively an open, complex and adaptive system based on computer network and urban information resources, which forms a virtual digital space for a city. It creates an information service marketplace and information resource deployment center*" According to this definition, urban management reshaped by the introduction of the computer network and ICT. The main goal of the city leaders is that increase the quality of life for citizens. Consequently, citizens become more active actors in city management through the e-services. While smart city indicates the "smartness" of a city not only a technological way but also economic and social ways. Therefore, smart city introduces new concepts through the balanced economic growth, creation of new job opportunities, decrease the poverty, new transportation infrastructure, new renewable resources and better management of energy and water aided by ICT. Cocchia (2014) remark that smart city concept comprises the digital city idea. We can argue that the digital city lost its popularity by time because of the evolution of smart city involve digital city ideas and merging both environmental requirements and social aspects of the community.

1.3.2 Sustainable City

There are several different definitions for smart city since each organization focus on one clear aspect of the cities. For example, the European Union definition of smart city brings strict targets for the reduction of greenhouse gas emission and environmental sustainability of the cities. On the other hand, in the literature, there is a clear concept of sustainable cities. Hiremath, Balachandra, Kumar, Bansode, and Murali (2013); H. Ahvenniemi et al. (2017) defined sustainable city "*achieving a balance between the development of the urban areas and protection of the environment with an eye to equity in income, employment, shelter, basic services, social infrastructure, and transportation in the urban areas*". These two definitions of cities bring questions to academia like in the previous section of the thesis that we need to highlight the differences between smart city and sustainable city. Sustainability is described by three main aspects which are social, environmental and economic. However, we observed that sustainable cities are strongly focusing only on the environmental aspects of sustainability. This interest draws a bold line between smart city and sustainable city. H. Ahvenniemi et al. (2017) remark in his research that environmental and social aspects are the center interests of sustainability frameworks while economic sustainability is underrepresented. Such as waste and water management, renewable energy resources, health and safety are the main focuses for the sustainable development of the cities. On the other hand, economic and social sustainabilities are the major issues for smart development of the cities with the use of ICT. Such as citizen participatory democracy, education and innovation are important for the smart city programs.

As a conclusion, we observe a shift from digital and sustainable city to smart city. It is not true that every smart city project can consider as a digital city or sustainable city. Because as we discussed before, digitalization is the center for a digital city and economic sustainability is almost ignored by sustainable city projects. While "smart city" is a general concept, which covers economic, environmental and social issues with help of developing technologies and ICT. People, the physical world and digital world harmonize in the smart city concept to provide better services, optimization of usage of resources, economic and social growth.

1.4 Smart City Development Aspects

1.4.1 Working Principle of Smart City

As described in the previous chapter, cities are the main source of economic activities, human interactions, social events, and innovations. Observations from the very beginning of our history show us cities are shaped by innovations and technologies. When the growth of the population started to increase in the urban area, urban planning is also gain importance for the future of the cities. On a timescale, the innovations about labor, engineering, industrialization, telecommunications, and the internet have accelerated the smartness of the cities and we start to see the advantages of all the interactions between inventions, technologies, and stakeholders of the cities. The advances in technology enable the cities to use their own resources in a more optimal way. However, the city leaders, professionals, businesses have to consider that the differences between development levels of the cities create different approaches to the use of technologies and consequently create different smart city solutions. Harrison, Colin, et al. (2010) represent the differences between the developed and emerging economies. According to their research, in India, China or other emerging economies, rapid urbanization from rural areas to urban areas and increasing number of populations lead to those countries to focus on physical infrastructure and services and to find the optimal use of their resources. The areas that emerging economies have to take actions such as new roads and bridges, increased public safety and health conditions, better air quality and environmental action, water, energy, and waste management. On the other hand, developed economies such as America or Europe have already their complete infrastructure and economic base from the industrial age. However, the global economy and changes in the technologies that create new markets are putting pressure on those countries to compete with the new economy areas and attract new business investments and capable people to their cities. Another pressure on developed countries to think about the improvement of their grown infrastructure while all the services are in full operation. While different smart city solutions will help them to sustain and improve the quality of life and their economy.

The challenges of the current cities of emerging as well as developed ones have been already recognized and the smart cities are offering the solutions with the pervasive use of ICT, internet of things (IoT), big data analysis, cloud computing. In this chapter, the working principle of smart cities will be explained in detail to guide the investment areas that will be explained in the further chapter.

One of the common smart city definition shows the importance of the integrated framework of physical infrastructure, IT and human. According to the Smart City Council Report (2015), "*A smart city uses information and communications technology (ICT) to enhance its livability, workability, and sustainability. In simplest terms, there are three parts to that job: collecting, communicating and "crunching." First, a smart city collects information about itself through sensors, other devices, and existing systems. Next, it communicates that data using wired or wireless networks. Third, it "crunches" (analyzes) that data to understand what's happening now and what's likely to happen next.*"

Therefore, it can be said that smart city technologies use a massive amount of data from different sources, integrate them, and lastly propose solutions or anticipate future events with analyzing those data. For example, the government use the data of users Global Positioning System (GPS) and offer them a new route to mitigate traffic congestions. Another example could be information about the pollution level in the city with the data collected by sensors through the citywide. Other smart city solutions help to increase communication between local governments and their citizen. Data transaction in both ways creates new opportunities for a citizen to develop solutions for their cities and direct participation.

Figure 4: The three core functions of a smart city by Smart Cities Council (2015)

According to the literature, there are three iterative characteristics to shape most of the smart city system and make the city infrastructure "smart". Smart city council (2015) define these

three characteristics as "*collect, communicate and crunch*" while Harrison, Colin, et al. (2010) called these dimensions "*instrumented, interconnected and intelligent*" based on very first smart city studies from IBM Instrumented Planet (2009). At the same time, Balakrishna (2012) summarize these three characteristics as "*real world awareness by the usage of sensors merging the physical world and virtual world, knowledge engineering enable aggregation of those data to applications and services, panoramic access to data and gaining new insights* ". However, in this thesis smart city council approaches will be used to explain the core functions of smart city while other approaches also explain these functions through the same logic.

Collect: It is the process of real-time data collection from sensors, smart meters, smart phones, personal computers, smart home appliances, medical devices, web, or any other data acquisition devices. Smart cities enable to monitor and control their current situation through the instruments such as video surveillance cameras, radio-frequency identification (RFID) detectors for physical infrastructures and services, smart electric meters, smart water meters, and GPS. According to one simple example that smart phones giving information about their owners' position, transportation routes, or their daily location information. Then smart GPS services can use this information to offer better transportation solution or cultural events of the city to its customer. Another example, a smart meter can detect the water leak or information about energy consumption. Therefore, enterprises prevent the leak or anticipate the energy peak in a day. In a nutshell, collecting data is the bridge of the physical world and the virtual world.

Communicate: Internet makes possible communication and interconnection between end users and devices. Nowadays, not only people or machines are communicating, people and machines are exchanging data. Smart cities enable the mix of communication between systems, enterprises, citizens, government. In this way, participants use the data and operate city services. Communication creates a problem with the data variety. Standardization is one possible solution but also service-oriented architecture (SOA) is a powerful method for the interconnection of city services. (Harrison, Colin, et al. 2010) For instance, a sensor can send information to the local governments about the failure of streetlight, and then operators can detect the failure through GPS service and solve the problem from the operation center without going to that place. This communication reduces the time to find failure and time to spend on repair.

Crunch: Crunching data means that intelligent systems make data understandable and useful for both human and machines. Intelligent system analyzes, optimizes and visualizes for the further operations for the service. Data can be used for *simulation* to optimize the current situation. For instance, alternative traffic routes in the morning. *Predictive models* can be created by crunching data such as police departments can analyze the data of the crime rates of a city, predict the future events, and take precautions before it happens.

In conclusion, collecting, communicating and crunching are the main functions of smart cities. However, the integration of multiple departments and third parties lead to cities benefit more from the large variety of information and a wide variety of services and applications to interpret, predict and optimize this information for the stakeholders of the cities. During the last years, there is a positive development of the merging data streams and mine them for enhancing the liveability, workability, and sustainability of smart city.

According to the previous definition of smart city, ICT is the key enablers of the smart city. Neirotti et al. (2014) said, "*Even there is no common definition of smart city, there is a wide agreement about that smart cities are characterized by the pervasive use of ICT.*" However, not only ICT enables the cities smarter, the advanced technology trends such as IoT, Big Data Analytics and Cloud Computing services working together and propose a better solution to dwellers of the city and businesses.

1.4.2 Information and Communication Technologies (ICT)

In the 21st century, societies become smarter and, we create smart societies with smart cities and advanced technologies. According to the International Telecommunication Union (ITU) (2018), estimates that 51.2% of the global population or 3.9 billion people will be using the internet at the end of 2018. (Figure 5) This fact underlines again the importance of ICT-infrastructures between the communities cause it enables the exchange of the data and information and include all the network and technological trends such as big data, internet of things, internet, networks, and protocols.

Anne Håkansson (2018) said that ICT infrastructure plays important role in the foundation of smart cities. Because ICT Infrastructure empowers high-tech society. Traditional services redefine with the use of ICT in a variety segment of society. Such as health care or elder care, become better and personalized by data. ICT will force efficient communication between citizen and government so in this way services will be improved and become more solution oriented. Such as new transportation systems by use of data will increase the user

experiences. ICT enables the integration of the physical world and people, and this combination can improve the welfare of the whole society by person-centered solutions.

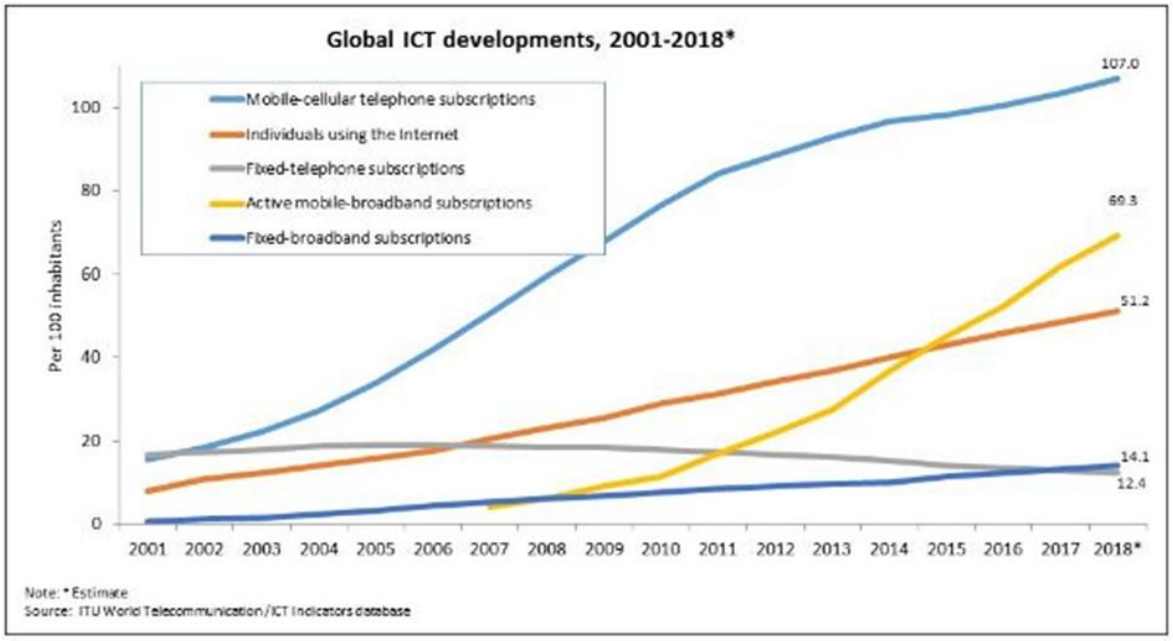


Figure 5: Global ICT Developments 2001-2018* by ITU (2018)

Consequently, we can say that ICT enable people, organization, city leaders to connect with the digital world. It allows modern computing with all of its network, devices, and systems. Hardware and software are the core components of the ICT- infrastructures. This multidisciplinary technology consists of smart devices, computers, sensors, internet and intranet networks, societal infrastructure services such as rail, road, water, and energy, and operational services, databases, software securities. ICT integrates all these components of the city with other stakeholders and act as a platform where all elements enable to interact with each other such as human-to-human, machine-to-human, and machine-to-machine.

Digitalization of the current century drive society and business environment to be connected, smart, more responsive to different actions and consequently, city leaders face rapid change the management of their cities and has to compete with this disruptive global change. As it is mentioned before, different cities have different processes to follow. Some cities need to upgrade their complete infrastructure by simple adding sensors, or some cities has to build cities from the beginning with all these new technological trends.

According to the report of the Kondepudi (2014), "*ICT is a digital platform that finds a solution in terms of resource consumption, quality of life, services with knowledge and information by using data analysis and modern computing systems.*"

Different stakeholders of the cities such as governments create policy directions, such as citizens and businesses can take action by using this information, which is taken from ICT-infrastructures, to improve the quality of life for the society as a whole. Beside this main role of ICT, it also enables three key functions to achieve the goals and maximizing the performance of smart cities:

1. **ICT - enabled information and knowledge sharing:** Real-time information sharing with different stakeholders of the city by using ICT - infrastructures enable the stakeholders to respond quickly and efficiently.
2. **ICT – enabled forecasts:** With the help of sensors throughout the cities, decision makers receive a mass amount of information about the city, natural events such as flooding. Then decision makers can use data to study patterns, identify trends, recognize risk areas, and predict potential problems. ICT enables prediction and take precaution before it is too late.
3. **ICT – enabled integrations:** Cities have different stakeholders and consequently different needs. ICT serves real-time information and therefore city leaders and managers can understand better requirements and acts efficiently.

Combination of this concept enables the cities more innovative, intelligent and sustainable urban centers.

1.4.3 ICT Enablers Technologies

However, ICT is not the only element to describe smart city working principle; it provides the first perspective to define a solution for smart city applications. When we look at the trend in communications technology, IoT, 5G-Wireless technology, cloud services, and big data are the key ICT enablers and accelerate the smart city solutions. According to Deloitte reports on 2017, global technical trends such as e-commerce, sharing economy, virtual databases, social media etc., assessed under the three criteria, which are relevance, timing, and magnitude in order to identify the most important technological trends for the infrastructure of smart city.

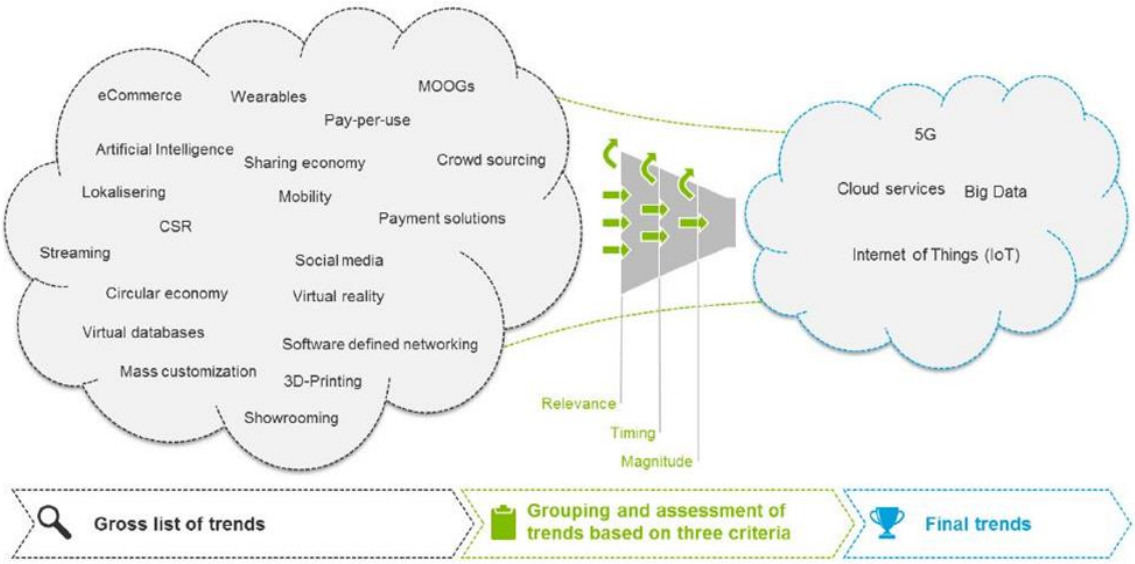


Figure 6: Identification of ICT Enablers by Deloitte (2017)

1.4.3.1 Internet of Things (IoT)

As its name stands for its meaning, Internet of things is a set of technologies and systems that give opportunities to the physical world to communicate with each other and with human analyze the data received and take an action. Haidine, Abdelfatteh, et al. (2016) argues that IoT ecosystem is expected to reach a structure similar to today's internet, where not only connecting different sources of data but also include real-world assets and things. As consequences, IoT facilitates the communication between things and people, business process support and creativity with the help of variable intelligence. Therefore, *"IoT is an extension to the existing Internet, with an automatic data collection, control, and supervision of physical infrastructure, through remote monitoring and control."* (Haidine, Abdelfatteh, et al. 2016) Figure 7 shows the various areas of IoT technologies. For instance, a video surveillance system in the smart cities improve the security level of the cities and send the information to police departments 24/7 and using the intelligent system, thus police can predict the dangerous events in advance. Another example, smart metering systems empower the optimization of the resource consumption, cost savings and give the opportunity to a citizen to enter the energy market. Thus, IoT technologies enable smart home systems, traffic surveillance, water and energy systems, smart parking, and weather prediction in advance.

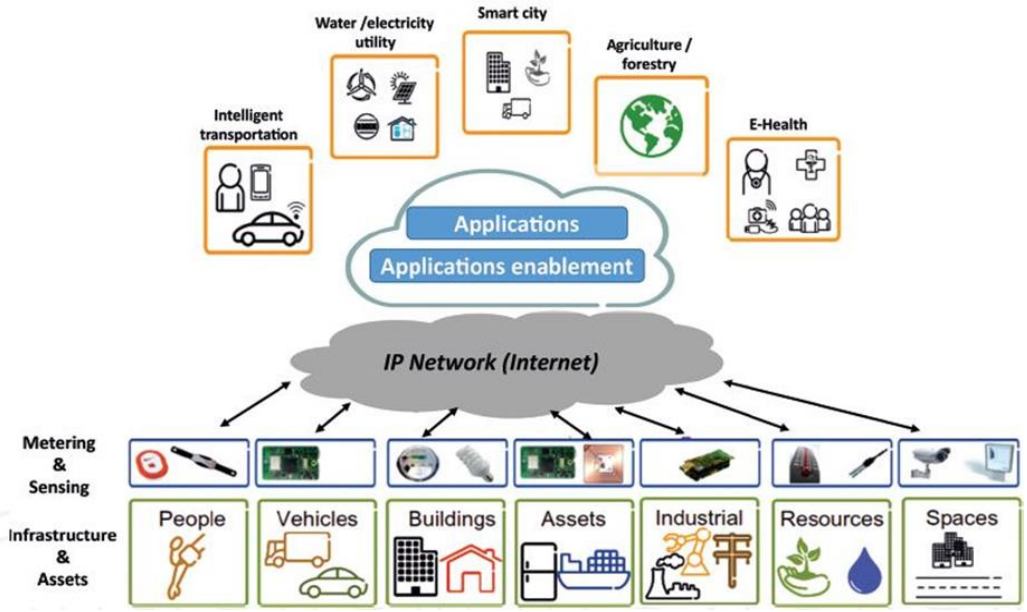


Figure 7: Overview on IoT architecture including different application areas by Haidine, Abdelfatteh, et al. (2016)

Another important fact about IoT is that increasing importance of IoT power. As we can see from Figure 8, it is estimated the number of connected devices worldwide to reach 26.6 million users in 2019 and double more than two times in 2025. (Statista) That means that each year, devices, machines, human activities create big data by the connected sensors. This huge information allows city leaders to study and analyze in detail to optimize resource consumption and increase the quality of life.

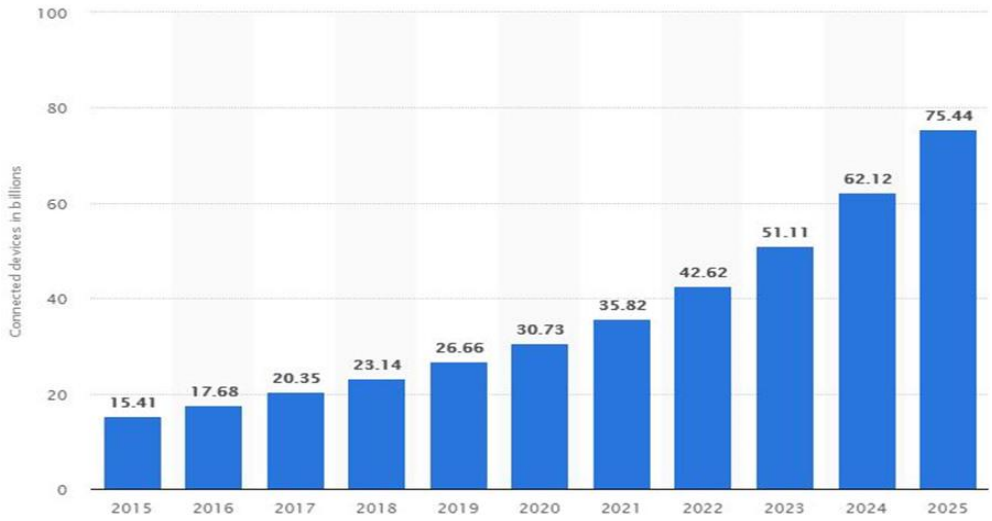


Figure 8: Internet of Things (IoT) connected devices installed base worldwide from 2015 to 2025 (in billions) by Statista

1.4.3.2 Big Data

Big data is generated from various type sources in the form of unstructured and disorganized data. IoT generated big data from different devices in different areas in the cities. To make cities smarter those data have to analyze and make visible to end users. Big data comes into play at that moment. According to ScienceDaily (2013), "*90% of all data in the world generated just in the last two years.*" This significant increase of data generated is the result of the advancement in technologies such as connected devices, sensors, wireless network services. However, for smart city case, we need to consider urban data. City leaders, companies or even citizens have to distinguish the useful data from the waste information to make the right decisions. Why do we need data for our city management? The answer is coming from the value of real-time urban data. Because in the past, decision-making for a city was a long process because of the lack of information about cities. Now, we have myriad data to be useful for the high quality of life for citizens. Novotný et al (2014) represent the data and city services in a scheme as can be seen from Figure 9, smart cities create urban data from buildings with smart meters, human beings with phones and wearable technologies, devices, and machines with sensors, cars with telematics. As a result, we have big urban data for different city systems such as transportation, water, energy, communication, heating and cooling, surveillance and safety. Thanks to information and communication technologies infrastructure, we processed these urban data to find smart solutions and e-services for stakeholders of a city.

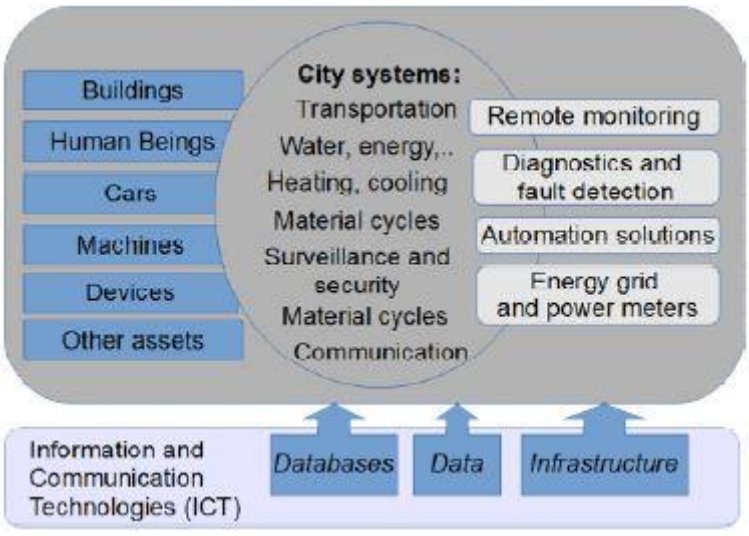


Figure 9: Big Data and City Services by Novotný et al. (2014)

1.4.3.3 5G – Network

Smart city applications already exploit the present technologies such as wireless network and 4G. Especially internet is the core tool for IoT and consequently a wide range of smart city solutions. Haidine, Abdelfatteh, et al. (2016) present some of the challenges we face today in spite of striking technological developments. For example, the number of connected devices is increasing dramatically each year and those devices share the same infrastructure thus we have a capacity problem in case of emergencies. Another example, indoor coverage, and building penetration is very low in the same places such as basements or underground which later create communication problems. According to literature, the 5G network is expected to use commercially in 2020. 5G will enable many smart city applications because it will serve high capacity and high speed to communicate thanks to its low latency. It is mentioned in the Deloitte report in 2017, smart and self-driving cars will use 5G to communicate fastly with other cars, and 5G will enable firefighters or any emergency responder to take action rapidly. Healthcare services will monitor in real-time and doctors can examine their patients remotely.

1.4.3.4 Cloud Computing

Each city has different needs and each requirement need different ICT infrastructure. These varieties of requirements create such a massive cost for the city managers and companies. Cloud services are offering the reduction of initial costs and give flexibility to its owners to offer more services through online services. Novotný et al. (2014) said that the need for business infrastructure and the way they run their applications have radically changed by cloud computing. Cloud systems are grouped into different categories as *XaaS,* which this acronym refers to *X as a Service*. In general form, we can explain three main XaaS for smart cities.

Software as a Service (SaaS): Stakeholders of a city can gain access to any service online by a software application. There is no need for an extra infrastructure to run the application.

Platform as a Service (PaaS): Programmers or developers can lease operating systems or storage. Users do not need own or license the software. This is reducing the cost significantly for business or city leaders.

Infrastructure as a Service (IaaS): IaaS enable to the customer to lease any infrastructure from its provider. This is a great opportunity to reduce cost, access anywhere and operate efficiently the services.

1.5 Smart City Definitions by Region

Despite there are numerous research and studies about one unique smart city definition, there is still no unified definition for a smart city on a global scale. According to Neirotti et al. (2014) smart city studies from different cities throughout the world share commons and different characteristics. ICT is the essential instrument for the implementation of smart city, but the usage of ICT is shaped by cultures and needs of the cities' and by political choices of local authorities. In short, in this section how the foundation of a city is affected by culture, geographic position, economic situation, scientific and technological studies will be explained in detail.

Table 2: Smart City definitions by different regions

Definition	Reference
"A smart city in ASEAN harnesses technological and digital solutions as well as innovative non-technological means to address urban challenges, continuously improving people's lives and creating new opportunities. A smart city is also equivalent to a "smart sustainable city", promoting economic and social development alongside environmental protection through effective mechanisms to meet the current and future challenges of its people, while leaving no one behind."	**ASEAN SMART CITIES FRAMEWORK (2018)**
"A smart community is a community where various next-generation technologies and advanced social systems are effectively integrated and utilized, including the efficient use of energy, utilization of heat and unused energy sources, improvement of local transportation systems and transformation of the everyday lives of citizens."	**Japan Smart Community Alliance (JSCA) (2014)**

"In the approach to the Smart Cities Mission, the objective is to promote cities that provide core infrastructure and give a decent quality of life to its citizens, a clean and sustainable environment and application of 'Smart' Solutions. The focus is on sustainable and inclusive development and the idea is to look at compact areas, create a replicable model which will act like a light house to other aspiring cities."	**Smart Cities** **Mission Statement & Guidelines** **Government of India** **Ministry of Urban Development** **(2015)**
"Autonomous on-demand vehicles, high-speed public Wi-Fi, smart street lighting and augmented reality: no matter the technology, innovation or advancement, what we aim to do under the smart communities banner must be linked to and address community needs. A smart community should be working towards improving people's lives – their happiness and their health. The efficiency of critical infrastructure or data-driven decision-making are just part of the journey."	**A GUIDE TO CREATING A SMART COMMUNITY IN AUSTRALIA** **Australian Smart Community Association** **(2017)**
"Smart Cities have been characterized and defined by a number of factors including sustainability, economic development and a high quality of life. These factors can be achieved through infrastructure (physical capital), human capital, social capital and/or Information and Communication Technologies (ICT) infrastructure"	**European Commission** **(2013)**

"Smart cities approaches promise to reshape the lives of Canadians. By improving services and infrastructure through the use of innovation, data and connected technologies, this transformative approach to planning promises to make our communities more livable and environmentally-friendly."	**Smart Cities Community Support Program** **Government of Canada** **(2018)**
"A Smart City places people at the center of development, incorporates Information and Communication Technologies into urban management, and uses these elements as tools to stimulate the design of an effective government that includes collaborative planning and citizen participation. By promoting integrated and sustainable development, Smart Cities become more innovative, competitive, attractive, and resilient, thus improving lives. "	**Inter-American Development Bank** **The Road toward Smart Cities** **Bouskela et al. (2016)**
"The vision of "Smart Cities" is the urban center of the future, made safe, secure environmentally green, and efficient because all structures - whether for power, water, transportation, etc. are designed, constructed, and maintained making use of advanced, integrated materials, sensors, electronics, and networks which are interfaced with computerized systems comprised of databases, tracking, and decision-making algorithms."	**The U.S. Office of Scientific and Technical Information** **(2000)** **Hall R. et all (200)**

This literature review of smart city definition for each region carried out to find out common keywords among countries. As it is shown in the table, definitions are different because each country has different political, cultural, economic and social backgrounds. This results in different challenges and a variety of needs.

From eight definitions above, we derived some common objectives that later they will constitute the essential aspects of smart city. These essential keywords are the increasing quality of lives, development of infrastructure, sustainable growth which covers economic, social, and environmental pillars, and advanced technology. No matter what is the background of countries, each city must focus on these purposes. The other important element of smart city projects is that citizen must be in the center of the projects and also participate with their ideas and solutions about the challenges of the city.

Besides common keywords, some countries specify different aims in their definitions. Such as India is only one country to aim to create a replicable model to be a guideline for other new smart city projects in national and also international levels. Japan is the only country especially talks about energy and energy sources. Canada, the USA, and Australia underline the important role of data and how it fosters decision-making phases in projects. Although each country uses technology in its definition, Australia especially talks about autonomous vehicles, high-speed public wi-fi, smart street lighting and augmented reality. On the other side, ASEAN countries are the only one that mentions creating new opportunities for their citizens in their definitions.

As a conclusion, India and Brazil focus on sustainable development especially care about creating environmentally-friendly cities. On the other hand, Europe also aims to reach environmental targets but also focus on the development of social and human capital in their smart city projects. Australia and the USA especially want to improve their road infrastructures with the use of data-driven systems. While Canada, Japan, and ASEAN countries want to create a city which protects the environment and create sustainable development.

1.6 Programs to Accelarete Smart City Projects

Transforming a city into a smart city is long and challenging processes throughout the world. New technologies, know-how, funding, business models and roadmaps for a smart city are some of the difficulties almost every city faces in this transforming journey. Therefore, having approved smart city examples, statistical information and researches will accelerate the diffusion of smart cities. There are some initiatives by regional policymakers but also international non-profit organizations to guide the stakeholders of cities and open the way for successful projects. Horizon 2020 by European Union, Intelligent Communities Forum, Australian Smart Communities, Eco-Model City by Japan, Smart Cities Mission by India are some examples of these programs. Besides these programs, there is smart city exposition which held by several cities to spread the smart city concept, introducing new technologies, exchange ideas and build new relationships. For instance, Smart City Expo World Congress Barcelona, which after its success, it is exported to other countries such as Curitiba, Brazil, Casablanca, Morocco, Latam, Chile, Kyoto, Japan, and India. Next, each initiative will be explained in more detail to understand the main strategies of the organizations.

Horizon 2020 is an initiative supported by the European Union started from 2014 last 2020. It is the latest programme of *Framework Programmes for Research and Technological Development* that focus on governmental agencies to support economic growth, innovative projects, and development through the priority of climate change. According to European Commission Report (2016), the total budget is 77 million euro which a minimum 27% of this budget aim to invest climate-related research and innovation programs. 22% of the budget allocated on international cooperation topics. Horizon 2020 also a great supporter of small-medium enterprises such as 23.7% of the budget has given to small medium enterprises. Horizon 2020 has aimed to be long term success through three pillars. Firstly, scientists and researchers are an essential factor to create human capital for advanced infrastructure and knowledge capacity. Small-medium enterprises are another essential factor to foster the economic growth of Europe. Lastly, communities are so important to create resilient societies to challenge with new emerging issues. Such initiatives must be implemented in the fields of health, food, energy, transport, resource efficiency, and climate change. Consequently, these three pillars are bringing us to smart city concept. In this thesis, it is observed that most of the European projects are funded by the Horizon 2020 Programme.

Intelligent Community Forum (ICF) is a non-profit organization founded in New York City, United States of America. As we mentioned before ICT is the main enablers of a smart city and this community know this importance and work on it to spread the effective use of ICT among cities. According to their motto, ICF is a network community where the cities from five continents can exchange ideas, expertise, and information, and collaborate for economic development. ICF also researches how ICT can be used effectively to foster the development of cities, solve the problems that cities face and ensure the increased quality of life. Each year, researcher of ICF collect data from cities through the survey that ICF create, after processing those data, ICF choose 21 cities for *Smart21 Community*, then those cities shortlisted to *Top7 Intelligent Communities* and finally *Intelligent Community of the year.*

As shown in Table 3 concerning the projects under the Smart21 Community, the number of projects in Canada, the USA and Taiwan are higher than other countries. In particular, Australia has three projects, Russia, India, Brazil,and France from Europe have only one project in 2019. Furthermore, Adelaide, Chicago. Curitiba, Sunshine Coast,and Surat had chosen to be analyze for this thesis.

Table 3: Smart21 Community of 2019

Abbostford, BC, Canada	Issy-les-Moulineaux, France	Sushine Coast, Australia
Adelaide, Australia	Keelung City, Taiwan	Surat, Gujarat, India
Chiayi City, Taiwan	Moscow, Russia	Tainan City, Taiwan
Chiago, Illinois, USA	Nairobi County, Kenya	Taoyuan, Taiwan
Curitiba, Parana, Brazil	Prospect, Australia	Westervilla, Ohio, USA
Greater Victoria, BC, Canada	Rochester, New York, USA	Winnipeg, Manitoba, Canada
Hudson, Ohio, USA	Sarnia-Lambton County, Ontario, Canada	

Intelligent City of the year until 2012 can be seen in Table 4 with city and country name. Each city has a clear vision about smart city, long term strategic plan and efficient communications with its stakeholders.

Table 4: Intelligent City of the year between 2012-2018

Year	City	Country
2018	Espoo	Finland
2017	Melbourne	Australia
2016	Montreal	Canada
2015	Columbus	USA
2014	Toronto	Canada
2013	Taichung	Taiwan
2012	Riverside	USA

Australian Smart Communities founded to consultant city-leaders to cope with 21st-century challenges and guidance the smart city projects that are in different phases. It represents 150 local government from metro cities (150,000 +) to regions (below 20,000). The association ensures that each member cities are liveable, sustainable and workable with all the stakeholders of society through their core values such as community innovation, influence, knowledge, leadership, equity, and equality.

FutureCity Initiative is an initiative from the Government of Japan but it aims to create *world-leading cities* and spread the solution model not only in Japan but also around the world. Therefore, they create an international network where the participant can learn lessons from failures, can share experiences and best solutions and in this way, Japan will benefit the regeneration of its regions and successful cases from all around the world. *FutureCity* initiative mostly addresses environmental issues, the aging problem which is one the main challenges Japan face and regiınal specific issues if there is. For instance, some Japanese governments are chosen as *Eco-Model* city first and create the base for the initiative and then eleven cities are selected as a *FutureCity*. According to the FutureCity report (2016), Eleven FutureCity of Japan work based on three pillars. Firstly, create environmental value such as biodiversity, waste management, low carbon, secondly create social value such as healthcare and medical services, prevention of disaster and lastly

create economic value such as new business, cooperation between the public and private sectors. Consequently, Japanese cities will transform cities where *everybody wants to live*.

100 Smart City of India, is a public initiative of Government of India for urban renewal of 100 cities. As we said before there is no one common definition smart city, the Government of India is aware of this fact and create their strategies according to local needs, economies, and cultures. For instance, dwellers of India need retrofitting and better infrastructures. The project is implemented area based and will affect cities and towns around the state. Smart Cities Mission covers one hundred cities, where cities are competing for each other for funding and each city create its own special purpose vehicles (SPV) for investment management and the project lead by its own CEO. This project is launched in 2015 with a total budget of 14 billion USD$.

2 Methodology of Taxonomy

2.1 Methodology

Even though the efficiency of smart city projects (SCPs) has been improved in recent years, most improvements have been achieved by the advancement in the technologies especially in ICT infrastructures. Nonetheless, it is possible to further improve the efficiency of SCPs by introducing a taxonomy. With this goal, this thesis explores a taxonomy that is introduced by ICT Center for City Logistics and Enterprises (ICE Lab) of Politecnico di Torino in the paper of "*A new taxonomy of smart city projects*" (Perboli et al. 2014).

Taxonomy is a very important tool to examine the SCPs and detect the best practices; therefore, one SCP from a continent can be a guideline for another SCP in a different continent. In this way, it will help the diffusion of SCPs worldwide. One of the main problems is that the inappropriate use of ICT technologies. Because the investment of ICT technologies can be costly for local governments and even if they apply this infrastructure without understanding the requirements of its citizen and businesses led unsuccessful SCPs. On the other hand, there are some concerns about the more managerial side of the SCPs. Such as how economic value created? How technology will be implemented and will be controlled by private or by the public? What are the new value chains in the smart city concerning technology and ICT related services? To answer these questions, we obtain that the taxonomy will open the way of successful projects through identifying the right project context and components such as objectives and actors; scope the project management and finance such as finding right investment and funding plans. In addition, the taxonomy reveals trends of tools and will be a great example of further studies.

Before proposing a conclusion for successful smart city projects, we started by creating a database including all continents. For this thesis, Asia, Australia, Europe, Brazil, Canada and the United States of America (USA) were selected to study. After that, taxonomy used to discover a cluster analysis with the help of Business Canvas and Value Proposition.

Definition of the taxonomy proposed by Perboli et al (2014) will be explained in more detail with benchmarking analysis with other taxonomies introduced by Giffinger et al. (2010) and Cohen (2014). For now, in this chapter, the methodology will be explained through how the database was created and projects for each continent has chosen.

Creation of the SCPs database has been done by the previous studies of the ICE Lab. (Molino (2016) and Lopex (2017)) They selected the projects mainly according to the number of the

population is affected by the project which is cover the majority of the total population of that country and also based on their status that the projects are already started or financed. The geographic target of the projects usually cover more than one million people but it varies from 169 people with the project **Utility-Scale energy storage system** installed in the remote town of Field in British Columbia to 1.386.000.000 people with the project **China Ministry of Railways** that project cover all country. For instance, Figure 10 illustrates Canada has ten provinces but for our study, we selected only five provinces to examined that cover the 90% of the total population of Canada. As can be seen from Figure 11, for Europe, the projects have chosen according to the number of cities are covered with one project, consequently, its effect will reach more people in total. On the other hand, Asia is a varied continent that consists of China, Japan, India, South Korea, Malasia, Mongolia, Indonesia, Thailand and so on. Thus for Asia, we focus on China, Japan, India, and South Korea which contributes more projects than other countries. For the resulting plot, see Figure 12.

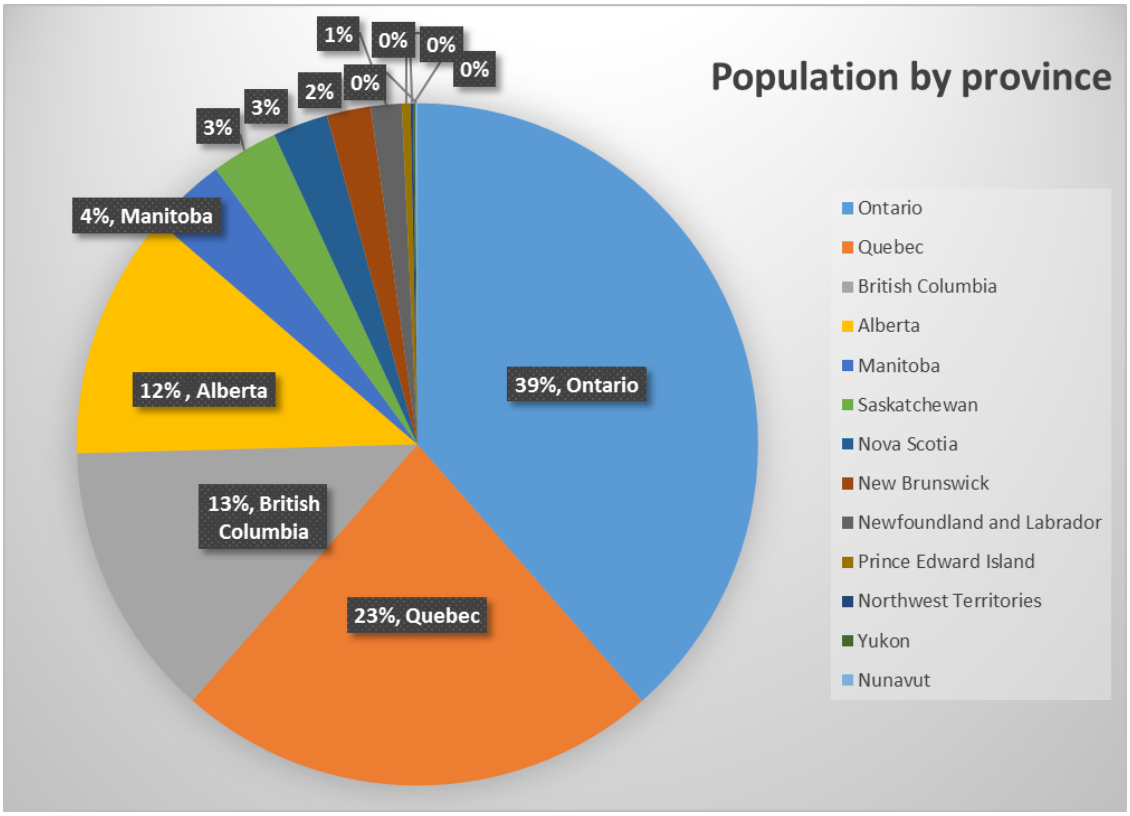


Figure 10: Population by Province for Canada

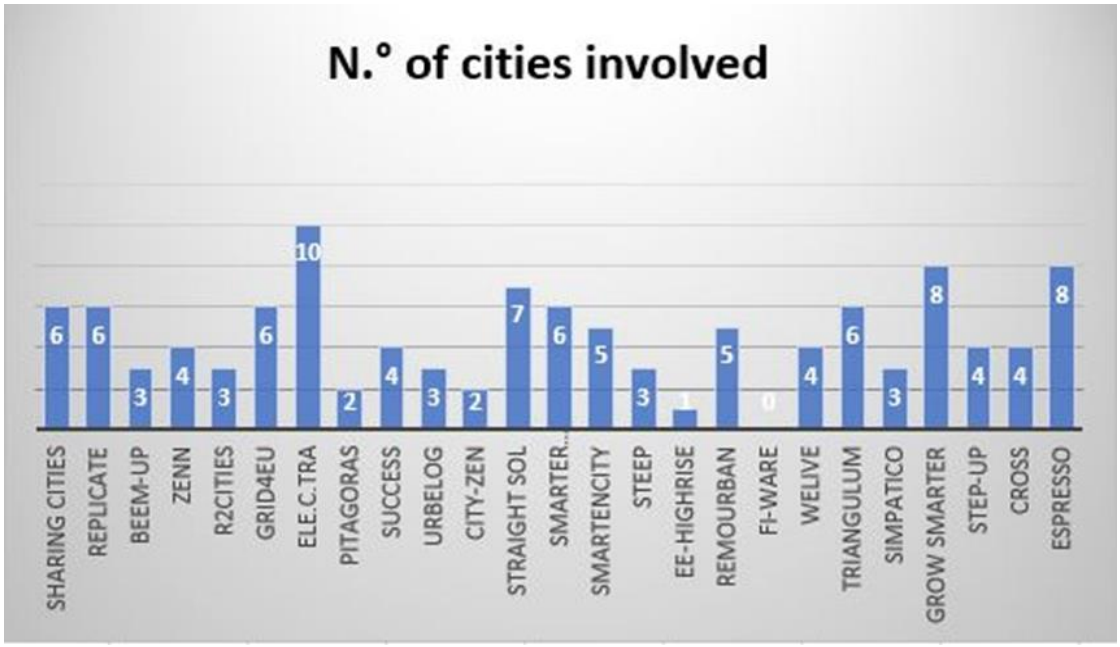


Figure 11: Number of cities involved in Europe

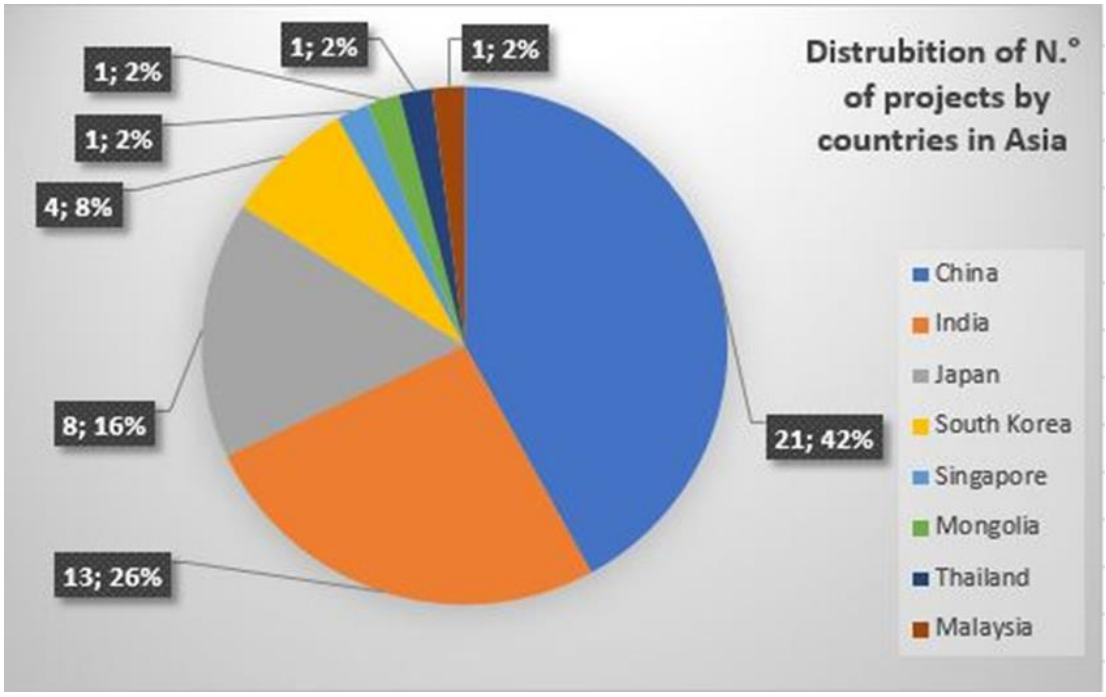


Figure 12: Distrubition of number of projects by countries in Asia

In conclusion, we have two hundred and one projects worldwide. Each region has a different number of projects, which were selected determined criteria before. Figure 13 illustrates the number of projects in each region. Fifty projects were selected for Asia, fifty-five were selected for Canada, twenty-five projects were selected for Europe, twenty projects were selected for Brazil, twenty-five projects were selected for USA and twenty-six projects were selected for Australia.

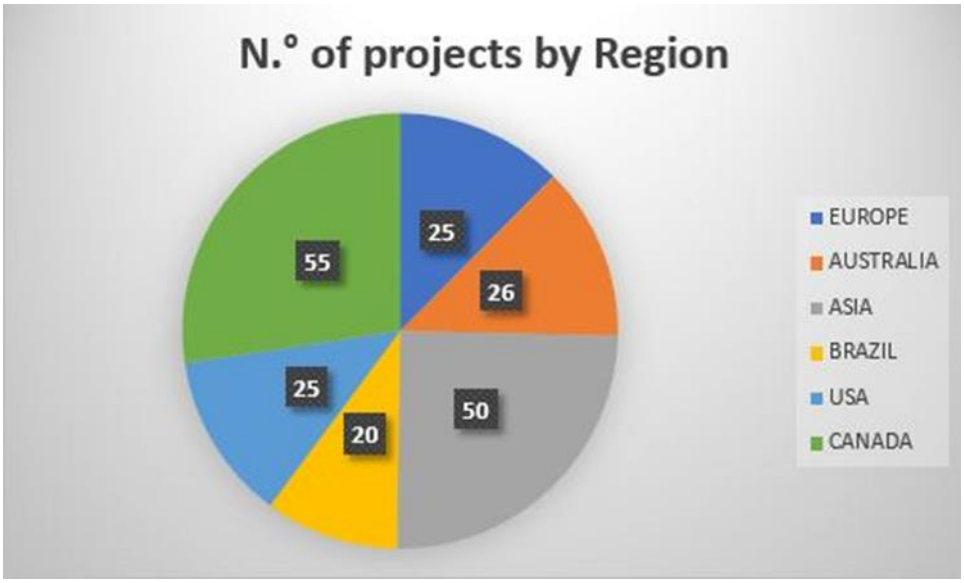


Figure 13: Number of projects by region

Once the projects were selected, we started to classify the projects according to taxonomy's criteria. In specific, all the information collected has been analyzed qualitatively by taxonomy. For each project, binary values were assigned to the taxonomy dimensions according to the characteristics of the projects. The sources of information that collected for the database were publicly available information, including projects, cities and provinces websites, published papers and presentations. After all the information has been completed, each region results are merged in one file to draw global analysis on the SCPs. This file is available in an Excel file called " Global Analysis.xls". As you can find individual regions, now you can find one global analysis and accordingly the charts for each tool of the taxonomy and we found significant results directed to differences and similarities between countries and relationships among the tools of the taxonomy. Beside we created a global analysis with regard to taxonomy, value propositions of each project were studied in depth. Business Model Canvas (BMC) and Value Proposition Canvas (VPC) proposed by Osterwalder, were used to identify the value that SCPs created for its cities. (These two tools will be explained in the next parts.) The results of this analysis can be found in an Excel file called " Global Cluster Analysis.xls". However, because of their extensive size, there are only a few graphs and examples of the database were included. Unlikely from the previous studies, for this thesis, investment analysis has done for each project and at the end; we have an idea about the average investment amount for each region. These findings will be explained in chapter three in detail with graphs.

2.2 Definition of Taxonomy

In the literature, too many articles explain the technology, innovation, and creative ideas to generate smart city projects. However, most of them focus on one subject or without understanding the interoperability of smart cities. Thus, it creates the main problem for city leaders to understand the whole design or replicate successful SCPs. The reason behind this confusion and challenge that there is no one common, well-defined taxonomy for SCPs. According to our literature review, the taxonomy introduced by Perboli et al. (2014) is the one that covers existing smart city concept with a managerial concept of the SCPs such as social inclusion, business and governance model and human and social relations. Thanks to this new taxonomy, smart city projects can be a guideline for further city planning and management. While many researchers have proposed various concept and taxonomy, none of them has the intention of comparison of multiple projects and finding results such as trend analysis, appropriate business models and so on. Therefore, Perboli et al. (2014) identify SCPs through three dimensions: description, business model and purpose. Each dimension has subcategories and each category has some criteria that are shown in Figure 14.

Description			
Objectives	Tools	Project initiator	Stakeholders
Water	*Cloud Computing*	*Private*	*City*
E-Governance	*Data Base*	*Public*	*Consumers / Citizens*
Buildings	*DSS*	*Mixed*	*Administration*
CO_2 Emissions	*ICT*		*SMEs*
Energy	*Innovative Sensors*		*University*
Security	*Legal and financial tools*		
Social Innovation	*Other new technologies*		
Transportation	*Portable Smart Devices*		
	Smart Grids		

Business Model			**Purpose**		
Management	Infrastructure financing	Financial Resources	Client	Product	Geographical target
Private	*Private*	*Private*	*Private*	*Specific*	*Urban*
Public	*Public*	*Public*	*Public*	*No Specific*	*National*
Mixed			*Mixed*		*International*

Figure 14: Dimensions and categories of the taxonomy by Perboli et al. (2014)

For the analysis, each dimension or category examined with its criteria individually. Later, the results of grouping a set of related criteria and merging all continents led us to identify relational trends. In the next section, each category with its criteria will be explained. However, for more details about the taxonomy, the interested reader could refer to the work by Perboli et al. (2014).

2.2.1 Description

Description allows the practitioner to identify project context and components. *Objectives*, *Tools*, *Project Initiator*, and *Stakeholders* generating the description part of the project. Each subcategory also has its own criteria that help to understand the project better.

2.2.1.1 Objectives

Successful smart city projects are the result of the tight relationship between city management and its citizens. To achieve this, each city has to define its strategy according to the objectives. For this aim, taxonomy proposes eight main objectives to implement and integrate ICT into urban solutions. The projects that point to improve or optimize more than one objective are called "multi-objective" projects.

- **Water:** Water is one of the most essential need for the human and nature. We need water for survive, agriculture, sanitation, and so on. However, now we are facing major problems because of the climate change. The countries have coastal cities are in danger of rise of the sea levels such as Holland, Maldives, Japan. Some countries face with severe droughts because of the less rainfall in same region. Such as Australia, record highest temperatures at the beginning of 2019. On the other hand, some countries face with intense rainfall and led to natural disaster such as tsunamis in East Asian Countries. In addition, most of the scientist indicate that fresh water on the decline, water quality on the decline, need for irrigation is on the rise because of the population growth; we need more foods then past. Cities also need to consider that infrastructures are aging and they need to replace with new infrastructures to work efficiently. Smart City solutions propose smart water meters, green water systems, and sensors to catch leaks, reduce cost, manage water consumption efficiently, recycle the rainfalls and serve predictive solutions.
- **E-Governance**: In this thesis, the importance of citizen participation has mentioned several times. ICT is not the only enabler for successful projects because the city is a multidisciplinary system in which humans play one of the essential roles. When people are not able to talk about the problems of their cities, not able to solve their

problem and live with different meaningless technologies, consequently, they start to feel living an artificial world. This results in the rejection of smart city projects by society. E-services create personalized solutions for citizen and give a chance to government be transparent. E-governance foster democratic participatory, efficient communication with each other, and decision-making process.

- **Buildings**, which are both private and city-owned, is the most essential part of our lives and the biggest source of energy consumption and consequently CO2 emissions. Therefore, we need smart buildings, which use sensors, meters, software to control and monitor a broad range of functions of a building. Thanks to ICT, we increase livability, workability, and sustainability of our buildings. Such as, tailoring the usage of energy, water, light, and heat and cooling with smart meters and thermostats. Fire and smoke alarms, video monitoring are enhancing the security of buildings. Remote control software is helping them reduce energy waste, increase the connectivity between buildings with communication.
- **CO2 Emission:** As it is mentioned in the previous part, cities are the main source of CO2 emissions. Kyoto Protocol, Paris Agreement, United Nation studies, Horizon 2020 initiatives are the main actors pointed out the emergency of climate change and its reason is CO2 emission. Therefore, many cities are developing strategies to reduce their CO2 emission footprints.
- **Transportation:** Transportation not only cause environmental damages such as greenhouse gas emissions, air pollution, noise but also cause the loss of money because of congestion, inefficient supply chain routes, unorganized transportation connections. To overcome these issues, we can introduce smart mobility, which is divided into three categories; mass transit, individual mobility and intelligent transport system and services (ITS). Smart mobility can feasible with the deployment of ICT. Video surveillance and GPS can inform drivers about congestion, synchronized traffic lights minimize travel time, car-sharing systems, or promoting the bike usage, mass transit with efficient connectivity of public transportation will help to reduce the number of vehicles in the city.
- **Energy:** Energy plays a critical role in city functions where almost everything powers with energy in a city. Smart Energy Management System (SEMS) is a wide range solution to cope with important issues in cities. Smart meters are creating two communication where clients and producer can arrange the consumption, a smart grid enables citizens to plug in their renewable systems and therefore, energy

consumption can be reduced. Automated outage management help to predict shortages and take prevention or solve a problem before. Besides, many cities all around the world support renewable energy systems such as solar panels, wind turbines, hydroelectric power plant, bioenergy and so on.

- **Security:** Public safety and security are probably one of the most visible outcomes for society. Security plans are long life-sustaining strategies starting from fire and emergencies, natural disasters, police departments, and courts and going soon. ICT plays a critical role to deploy security strategies and some of them are real-time information for police and emergency departments to prevent the city, data analysis to detect dangerous part of the city and keep safety on these part of the city, again collected data can use create criminal pool and detect criminals with the help of global connectivity.
- **Social Innovation**: One of the fundamental aims of smart city is increasing the quality of life of a citizen. The innovation and advancement in ICT enable companies and governments to ensure serving high-quality health and human services to its citizens. Digital education, smart government services, management of the road safety, transport-monitoring information, new job opportunities with the invention of new technologies, smart health devices, eldercare services are just some of the examples of social innovation citywide. For instance, doctors do not need to track patients' results on papers; integrated health history ensures doctors reach all patients results from 20 years ago until now.

2.2.1.2 Tools

Objectives of smart cities become applicable where new technologies are intelligently implemented. Most of SCPs mainly focus on infrastructures and technology enable to connect, combine and integrate all different phases of projects and make cities smart. Alongside most of the definitions of smart city indicate that ICT is an essential part of a smart city, taxonomy identified eight new technologies, which are the most widely used technologies to achieve successful SCPs. However, in this part of the thesis, these eight tools will be explained shortly because, in chapter 1, some of these technologies are explained in more detail under the title of Smart City Development Aspects.

- **Cloud Computing:** It is a service where users can access it anywhere and anytime over the internet and ensure high security, high reliability at the low cost of ownership.
- **Database:** Data is everything for a smart city then database and database management systems allows storing, structuring, and sharing data between different actors of a system.
- **Decision Support System (DSS):** DSS is an information system allows a person to identify and solve problems then make the best decision or choose the suitable solution between alternatives.
- **ICT:** It is an essential part of designing a smart city. ICT has a wide range of implementation examples in daily lives such as it can enable better use of energy, high speed of internet, enable e-governance and e-business, digital education, multipurpose card and so on.
- **Innovative Sensors:** Nowadays sensors are everywhere in a smart city. They collect useful data such as humidity, temperature, CO2 emissions, and the flow of people or cars and so on. They measure the actions around them and enable new solutions.
- **Portable Smart Devices:** These are phones, tablets, laptops, and wearable technologies, home appliances, which now they become smart and allow users to exchange information.
- **Smart Grids:** Increasing demand for electricity, the aim of decreasing shortages and losses cause the invention of smart grids. Because a smart grid allows consumers and producers to manage electricity by improving energy conservation, enable coordination between users and producers, increasing efficiency of distribution.

2.2.1.3 Project Initiator

Respectively, smart city roadmap has been developed, required technologies and tools are selected to implement smart city project but still, there are missing dimensions to accomplish smart city projects. Determining the project initiator is the next step for a successful smart city project. According to taxonomy, project initiator classified into three actors.

- **Public Initiator:** City councils, different levels of government entities, the academic sector are some of the project initiators. Public entities offer incentives such as federal laws, tax incentives, rationalize infrastructures to support SCPs. The most of the public sector plays an important role to foster SCPs.

- **Private Initiator**: Small-Medium enterprises (SMEs), corporations, a group of enterprises, and start-ups are the second type of actors of SCPs initiators. These entities are finding the solutions for smart city problems because they want to gain a competitive advantage over the market as first movers, or gain a market reputation as a sustainable company or improving their efficiencies.
- **Mixed:** It is a combination of public and private entities. They are coming together and work together to improve existing processes.

2.2.1.4 Stakeholders

SCPs are interoperability projects therefore; various parties involved in projects with its own responsibilities and requirements. For taxonomy, five different stakeholders are identified.

- **City:** Cities always play an active role in smart city decision. Online platforms for making decisions, an organization that covers the improvement of all city are some of the examples.
- **Government:** Government plays a crucial role in the management of the city and urban planning decisions. Such as national and regional governments analyze the problems, being the initiator of the projects, to aim to increase the quality of life of citizens and stay competitive among other countries.
- **SMEs:** As a whole city, catching new technological trends may be costly and difficult. Therefore, SMEs are playing an important role such as suppliers of infrastructures, as a financier of the project. Because high participation of SMEs is the indicator of successful and long term projects. SMEs' innovative solutions, marketing tools, and the advantage of being local enterprises foster the SCPs.
- **Universities:** Researchers and students are developing and creating innovative tools and ideas. Especially universities give insight about the local environment. Furthermore, universities are good test-bed for these ideas and implementations of projetcs. In addition, the research papers are helping the diffusion of Smart City idea worldwide.
- **Citizen:** Several types of researches about Smart City indicates that understanding the requirements of citizens, having a close relationship with them is very important to make long-term strategy and being successful. Citizens are involving directly in the design phase of the project with open data platforms or indirectly involve as an end-users. Technology fosters the participation processes of citizens thus, city leaders or enterprises pay attention to involve citizen in different steps of SCPs.

2.2.2 Business Model

Until this part of the thesis, it is noticed that smart city has many actors, different objectives, required different tools to implement and integrated these objectives, also we will see in the next part that it aims to satisfy different types of clients at the different level of geographic targets. Thus, we can easily say that smart city is a complex, interoperability and long-term project to transit our existence life of style. This complex and multi-level projects with the usage of ICT deliver new solutions. Some of these new solutions may be defined as a radical innovation that definitely brings a new business model to sustain the success of the project. For instance, e-governance applications or *Fab Labs* around the world are changing the organization from top-down to bottom-up style. Perboli et al. (2014) introduce business model dimensions to taxonomy differently from previous studies. At the same year, Peek et al. (2014) have also demonstrated that traditional models fail under the new economic circumstances and are not able to answer the demand of population growth and new resources for energy production and challenges of climate change.

The literature on the classification of SCPs shows a variety of approaches, but two of these studies are widely accepted to classify SCPs: Giffinger (2010) introduced six characteristics and thirty-four factors to rank smart cities and Cohen (2014) offered smart city wheel, which consists of six characteristics and eighteen factors. However, it is better to highlight that focusing only on smart city characteristics is not enough to sustain the SCP. We need to identify who manage, who provide infrastructure and who support the SCPs.

Figure 15 and 16 show that both authors grouped smart city solutions under six categories: smart economy, smart people, smart governance, smart mobility, smart environment, and smart living. It is an efficient tool for benchmarking different SCPs under general concepts. However, as reported by Giffinger et al. (2010), this type of rankings lean on a generalistic approach while investors are asking clear results not just finding the best or least attractive city.

Eventually, taxonomy proposes three subcategories as *management*, *infrastructure and equipment financing,* and *financial resources*.

SMART ECONOMY (Competitiveness)

- Innovative spirit
- Entrepreneurship
- Economic image & trademarks
- Productivity
- Flexibility of labour market
- International embeddedness
- *Ability to transform*

SMART PEOPLE (Social and Human Capital)

- Level of qualification
- Affinity to life long learning
- Social and ethnic plurality
- Flexibility
- Creativity
- Cosmopolitanism/Open-mindedness
- Participation in public life

SMART GOVERNANCE (Participation)

- Participation in decision-making
- Public and social services
- Transparent governance
- *Political strategies & perspectives*

SMART MOBILITY (Transport and ICT)

- Local accessibility
- (Inter-)national accessibility
- Availability of ICT-infrastructure
- Sustainable, innovative and safe transport systems

SMART ENVIRONMENT (Natural resources)

- Attractivity of natural conditions
- Pollution
- Environmental protection
- Sustainable resource management

SMART LIVING (Quality of life)

- Cultural facilities
- Health conditions
- Individual safety
- Housing quality
- Education facilities
- Touristic attractivity
- Social cohesion

Figure 15: A typology of Smart City Functions by Giffinger et al. (2010)

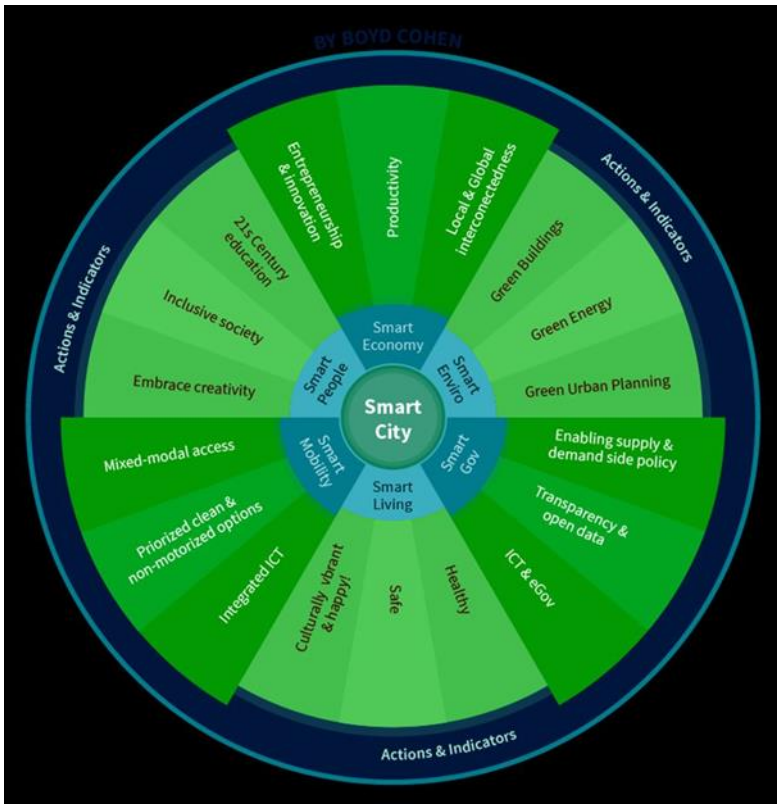


Figure 16: Smart City Wheel by B. Cohen (2014)

2.2.2.1 Management

Identifying business needs, setting the goals, planning the project, establishing strategies, make financial analysis are essential for the implementation of the project. Later, identifying who is going to manage, how risk allocates led us to classify management into three axes. When SCPs strategies aim to increase the quality of life, provide better services for its citizen, "public partnership" dominates the management. Because public entities are responsible to answer the requirements of its citizen. Secondly, a collaboration of two or more SMEs and companies can be grouped under "Private partnership". When public and private companies come together and create a special partnership, it is called "Private Public Partnership (PPP)" which is the most ascendant and desired type of partnership.

2.2.2.2 Infrastructure and Equipment Financing

Depends on the objectives of the projects, infrastructure, facilities, equipment, vehicles, and devices are needed. These requirements can be provided by public entities or private entities such as companies and SMEs or a mix of private and public entities. When there is high capital cost, private companies can invest into a project while they gain market share and reputation. On the other hand, sometimes public entities do not want to lose control over their infrastructure and we witnessed public infrastructure and equipment financing. While public and private ownership is again the best solution for all countries because it is reducing the stress both on private and public sector shoulders.

2.2.2.3 Financial Resources

Smart City Projects are long-term projects that they need financial resources for the realization and continuation of the project. Here again, taxonomy introduces three types of financial resources. In the case of large city infrastructure, "Private Financial Resources" is required because of high initial investment costs. While the predominance of government in the energy and transportation sector "Public Financial Resources" seems more suitable. However, collaboration of public and private investment more applicable and thus most-widely accepted type of funding. It gives to both side flexibility, to be able to introduce an innovative solution and manage the implementation processes in a better way.

2.2.3 Purpose

The last dimension of the taxonomy is identifying the final target of SCPs. It is important to classify *clients*, *product* and *geographic target*.

2.2.3.1 Clients

Clients are the end-users of the products of SCPs who use it and benefit from the product. According to taxonomy, clients classified as *public clients* and *private clients*. Public entities such as local governments, universities, city are grouped under *public clients*. Citizens, SMEs, private firms are constituting *private clients*.

2.2.3.2 Product

Classification of products has done "*specific product*" and "*non-specific product*" according to taxonomy. This classification depends on the technology, authorization, or any delay according to the planning process. Some of SCPs are set the target and plan their product at the beginning of projects but sometimes it is not possible. For example, during the planning phase, technology is not enough for implementation or the targets are so general that at the end it does not specify a purpose.

2.2.3.3 Geographic Target

As understood from the title "Smart City Projects", projects usually developed for that specific city. On the other hand, sometimes according to governance style of the country, projects aims to reach the national level or smart city leaders concerning special areas such as supply chain channel that covers more than one cities sometimes. However, sometimes SCPs are developing projects with the aim to reach an international level. Therefore, taxonomy classifies geographic targets as "city", "national" and "international" level. For the analysis instead of using "city level", we used " urban level" that means the same.

2.3 Managerial Analysis

Taxonomy helps to identify the project context, scope, and purpose. Even this taxonomy gives detailed information about projects and is a guideline for adopters and followers, we introduce *Business Model Canvas* and *Value Proposition Canvas* proposed by Osterwalder for managerial analysis of our study. As it is mentioned in the previous chapter, new technologies and innovations cause births of new business models. Business model canvas introduced by Osterwalder help companies stay competitive in the market and be agile to react to any radical innovation. In this part of the thesis *Value Proposition Canvas, Business Model Canvas* and how we make cluster anlaysis of business model will be explained with the examples from our analysis.

2.3.1 Value Proposition and Business Model

Osterwalder et al. introduced the Business Model Canvas (BMC) in 2010 but further, they needed to provide Value Proposition Canvas (VPC) in 2014 to demonstrate the adjacent relationship between BMC and VPC.

For any kind of business, understanding customer requirements is key to open all the doors for success and sustainability. The aim of VPC is helping practitioners to investigate customer requirements with all negative and positive aspects. We use VPC for this analysis because the city has five stakeholders who have different requirements. In that point, understanding customer requirements of each segment is a multi-level stage and consequently led the practitioners to create mistakes about project features. When the manager of SCPs perceives customer needs wrongly, they will fail. Therefore, VPC allows the city manager to zoom-in the value proposition and customer segment in one canvas. VPC comprises of two blocks: left side explore value proposition with *product and services*, *gain creators* and *pain relievers*, on the right side customer segment gives detail about *customer jobs*, *gains,* and *pains*. This is illustrated in Figure 17.

Firstly, SCPs managers must focus on each part of the customer segment block and value proposition block. In this way, VPC will help you understand stakeholders requirements simply and create a strong relationship between requirements and value. For our methodology, we have already defined the customer segment such as city, citizen, administration, universities, and SMEs. As can be seen from Table 5, each of them illustrated with a different color because in one canvas, we identified gain and pain relevant to the color easily.

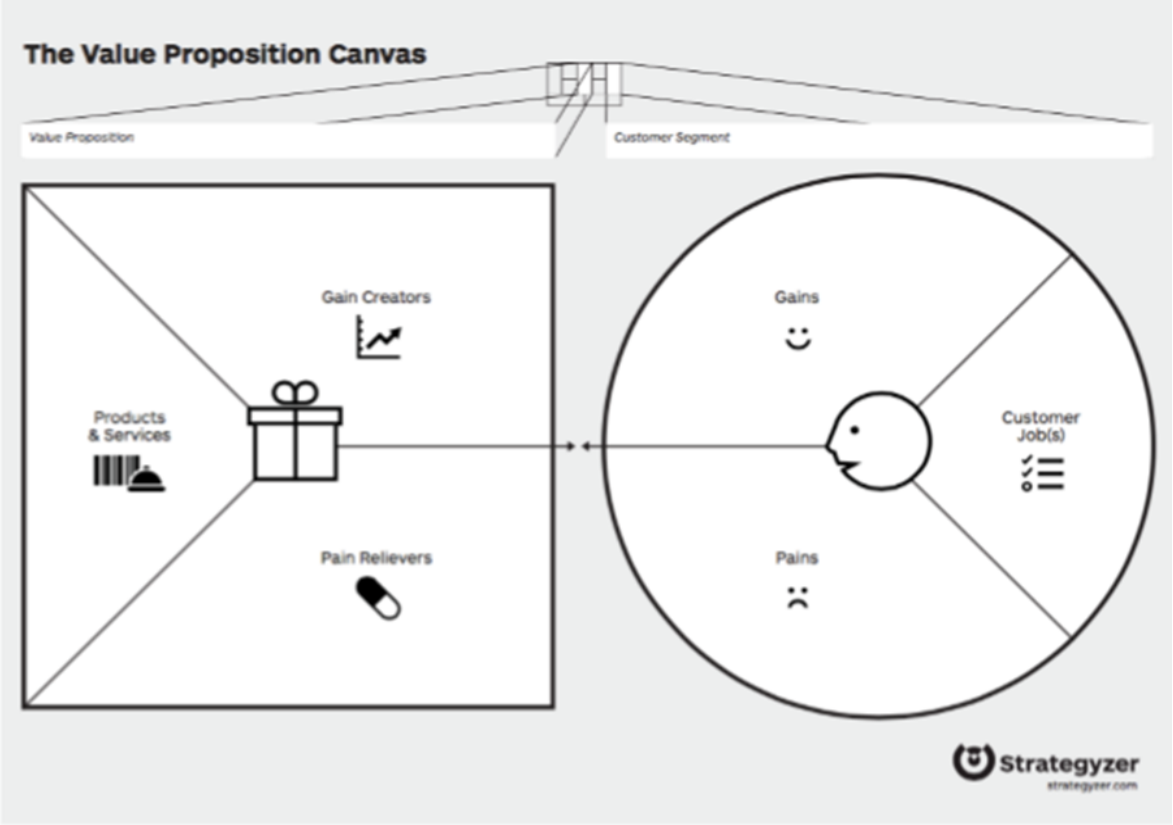


Figure 17: Value Proposition Canvas by Osterwalder et al. (2014)

Table 5: Customer segment of SCP and its color assignation for case study

Citizen
Administration
City
SME
Universities

- **Customer jobs:** Describe what are stakeholders' functional, emotional, social and basic needs.
- **Pain:** Describe what are stakeholders' fears, negative feelings, challenges, undesired results or possible risks that restrain stakeholders to do the related job.
- **Gain:** Describe what are the outcomes that stakeholder will desire, be happy and satisfied.

These constitute the customer segment part. Now we know our stakeholders and we can create value for them.

- **Product and Services**: These are the products and services that cover your stakeholders' needs. Product and services could be concrete products, digital services, or financial services.
- **Pain Relievers:** Describe how the projects mitigate stakeholders' pains.
- **Gain Creator:** Describe how the projects create gain for stakeholders.

The final step of VPC is *''FIT''*. The practitioner has to perfectly match the features of the value proposition to the characteristic of the customer segment. To sum up, VPC points out how to solve stakeholders' problems with features of value proposition and create awareness instead of explaining the project characteristics.

Once the value proposition perfectly fit, we have to define other parts of the project such as activities, cost structures, revenue streams and so on to deliver value to the stakeholders. Before VPC, Osterwalder et al. introduce Business Model Canvas in 2010. The main aim of the BMC allows managers to see everything together. It is a very easy tool and helps you make minor changes during the design phases instead of changing all the project when technology or innovation try to disrupt the current situation. BMC is a method to outline how value is generated, how this value reaches to stakeholders and in return how to collect value from customer to run the project. Osterwalder et al. (2010) create a common language with nine blocks to analyze different projects. This is illustrated in Figure 18.

- **Key Partners:** Describe the partners of projects who come together to develop a business model and reduce risk. For our case studies, key partners are such as construction companies, international cooperations, industrial suppliers, local governments, universities, and consultancies.
- **Key Activities:** They are the most important activities to represent value proposition, reach a different market, keep alive the customer relationship and generate an income. Key activities highly depend on the purpose of the projects, therefore, key activities could be the maintenance of infrastructure or developing an online platform.
- **Value Proposition:** It is a group of product or services, which create value to customer segments. This block also depends on project type such as reducing pollution, creating world-class infrastructure or ease of use could be some particular examples for that city.

- **Customer Relationships:** Describe the type of relationship with each customer segment and explain how customers acquired and retained. For our case studies contract, community, networks of people or organizations are some of the examples.
- **Customer Segment:** It describes the most essential part of the project. For the case studies of SCPs, customer segments are the stakeholders that managers create value for each stakeholder.
- **Key Resources:** Describe assets that an organization needs to run the project. There are four types of assets which are physical, intellectual, financial and human resources. In our case, some of the key resources are electric vehicles, infrastructures, renewable energy systems, smart grids and so on.
- **Channels:** It is the interface between project and stakeholders through communication, distribution and sales. It plays an important role in customer experiences. For example, networks, websites, conferences, guidelines, and so on.
- **Cost Structure:** Describe all cost incurred during the operation of the project. Such as infrastructure cost, maintenance cost, salary cost and so on.
- **Revenue Stream:** Once value perceived by stakeholders, they are willing to pay with a determined price. For our case studies saving money on bills, gaining reputation, private investments are some of the examples.

In conclusion, the value proposition canvas focuses on how to create value for customers while the business model canvas focuses on how to create value for business/projects. Thus, both analyses help us to generate value propositions for stakeholders with common language even projects are from five different continents with different purposes. Value propositions generated for VPC and BMC are clustered in value proposition with micro and macro categories, next part cluster analysis will be clarified and the results of cluster analysis will be explained in chapter 3 with global results.

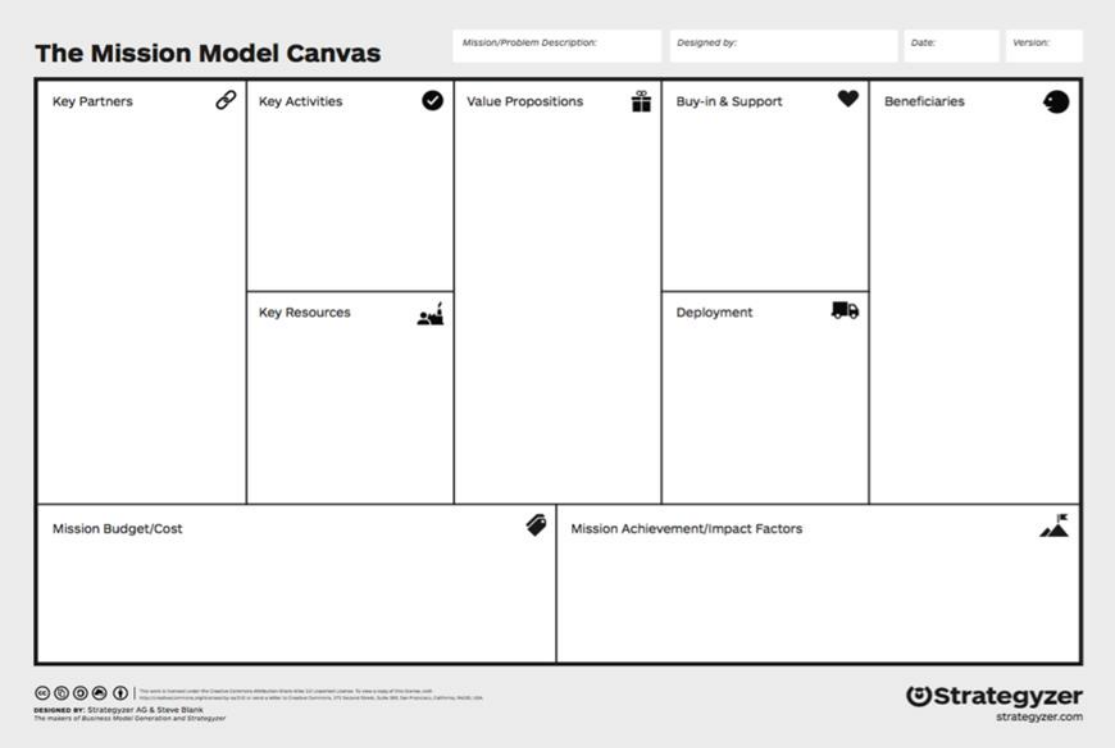


Figure 18: Business Model Canvas by Osterwalder et al. (2010)

2.3.2 Cluster Analysis of Business Model

Taxonomy, VPC, and BMC help us to identify common and different characteristics of SCPs from five continents. We identified a variety of value propositions according to the different purpose of projects. For this thesis, value propositions identified according to the best solutions of each country. There are forty different value propositions and each of them has matched with a project. Sometimes projects have more than one value propositions. Furthermore, we follow the clustering methodology to understand better results from our global analysis. Figure 19 represents a general snapshot of cluster analysis. Firstly, similar value propositions grouped under micro-category then again similar micro-categories merged under one macro-category. At the end, we end up with five macro categories which are *behavioral, economic, environmental, operational and technological* and *social*. Under the behavioral category, projects focus on how stakeholders are interacting with each other and how projects can improve this interaction between each other or cross-sectional. Economic category cluster the value proposition about the reduction of cost, investment and funding, sustainability or how raises economic growth. The environmental macro category is interested in how SCPs deliver a solution for better environmental conditions. Under operational and technological macro categories, intelligent systems and innovations are

clustered. Lastly, social macro category represents value propositions which increases the quality of lives.

Two-hundred projects are analyzed under the cluster analysis. Some projects represent only one value propositions while some others deliver more than one value proposition because most of SCPs are multi-objective means that they aim to deliver more than one objective. Cluster analysis allows us to make statistical data analysis.

Value Proposition	Micro-category	Macro-category
Implementation of Green Areas	City's Landscape improvement incentives	Behavioral
Participatory Democracy	Free Access to Information	
Food and Drug Management System	Healthy life	
Urban monitoring system Sensibilization	Public and Road Safety Education	
Smart street lighting	Optimization of Energy Consumption	Economic
Scalability of the project	Potential for Economic Growth	
Management of Energy Consumption	Reduction of Costs	
Management of Water Consumption		
Saving in transportation cost		
Zero Energy Building	Refurbishment of Infrastructure	
Project Funding	Investment&Funding	
Integrated Transport Network	Sustainability of production	
Electric Vehicles (Evs)	Clean Environment	Environmental
Waste Separate Collection	Reduce, Reuse and Recycle of Waste	
Reduction of Emission	Reduction Emission Effect	
Renewable Energy	Renewable Energy	
Big Data Solution	Data Collection	Operational and Technological
Reliable Management of the Grid System	Electric Power Management	
Logistics Management	Freight Transportation	
Geographic Information System (GIS)	Geographic Data Management	
Wireless city project	Telecommunications	
Modern Transportation Service	Transportation System	
Smart Parking		
Smart Vehicles		
Sensorized Garbage Collection Car	Waste Management	
Sensors on street bins		
Diversity of Housing Type in the City	Availability of Affordable Housing	Social
Digital Education Management System	Education System	
Smart Services for Citizens	E-Governance	
Taxation Management Platform		
Efficient Management of Data	Healthcare Service	
Efficient water supply system	High Availability of Drinkable Water	
Improvement of Employability and job inclusion	High Employment Rate	
Transport Monitoring Info	Information Availability	
Emergency Warning System	Public Safety	
New Infrastructures	Retrain New Area	
Management of the Road Network	Road Safety	
Work safety emergency management system	Work safety	

Figure 19: Cluster of Value Proposition

3 Regional Analysis: Qualitative Data Analysis, Processes, Findings

The goal of the thesis comparing the various characteristics of SCPs with the use of taxonomy and showing the good practices from different regions. At the best of our knowledge, there is no organization or entities collected data and benchmarking SCPs yet. Thus, in this chapter of the thesis, each region will be analyzed according to the dimensions and subcategories of the taxonomy with visual and business model results. Besides only focusing on data analysis, political, economic and social backgrounds of countries will be connected with the results.

3.1 Asia

Asia is the biggest and most crowded continent in the world. China, Japan, India, South, and North Korea, Thailand, Mongolia, Malaysia, Russia, Turkey, Indonesia, Singapore are just some of the countries have territories in Asia. However, countries like Russia and Turkey are transcontinental countries that have some territories also on other continents. Therefore, for this thesis, we include China, India, Japan, South Korea, Singapore, Mongolia, Thailand and Malaysia for our smart city analysis. Because these countries have significant smart city initiatives and examples but also their geographic position is located in central and East Asia. Figure 20 represents the number of projects distributed between countries. China has the leader position with twenty projects, India is following China with twelve projects and Japan has eight projects. These three countries are dominating 84% of the total projects. Number of projects selected for thesis is proportional to number of SCPs in these countries.

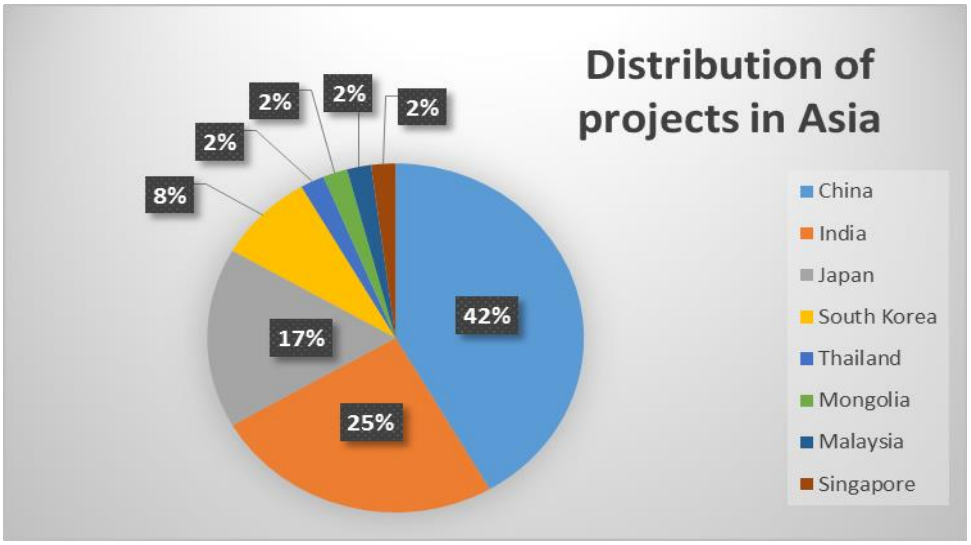


Figure 20: Distribution of projects in Asia

Firstly, the regime in each country is different and as a result, the development of smart city projects are varied.

China has one powerful central government and its administration is divided into three levels. The first level is provincial level include four municipalities such as Beijing, Chongqing, Shanghai, and Tianjin, and Special Administrative Regions such as Hong Kong and Macau, the second level is sub-provincial-level and lastly prefectural-level cities. According to World Population Review (2019), "*China has 662 cities totally. China has 65 cities with more than a million people, 360 cities with between 100.000 and 1 million people, and 387 cities with between 10.000 and 100.000 people."* The largest city in China in Shanghai, with a population of 22.315.474 people. Thus, smart city projects in China affects so many people. As can be seen from Table 6, the number of potential population affected by projects ranges from 430.000 with the project on **Korla** to 1.386.000.000 with the project of **China Ministry of Railways** which affects 662 cities in total.

Table 6: Number of potential citizen affected by projects

Country	Min N.° of population affected	Max N.° of population affected
China	430.000	1.386.000.000
India	364.532	62.700.000
Japan	230.000	126.659.683
South Korea	55.000	10.010.000

Although Japan is an island nation in East Asia, Japan is the tenth most-crowded country in the world with the population of 126.659.683. Differently from China, Japan is governed by constitutional monarchy where there is an emporer with limited power and a central government control everything. However, local governments are playing important role in decision making about management of urban areas. As reported by Britannica, cities are called as *prefecture* and Japan is divided by 47 prefectures. 43 of these prefectures are *ken* that is government unit, two of them are *fu* that urban prefectures such as *Osaka and Kyoto,* one of them is *to* which means that metropolitan in Japanese and *Tokyo* is the metropolitan of Japan. Lastly one of these prefectures is called *dō* that means district such as *Hokkaido.* All prefectures are administrated by their own governors. Table 6 shows that Japan affects minimum 230.000 people with projects on **Green Crossover in Tsukuba** and maximum

126.659.683 with the project on **Emergency Response and Coordination** which covers all country.

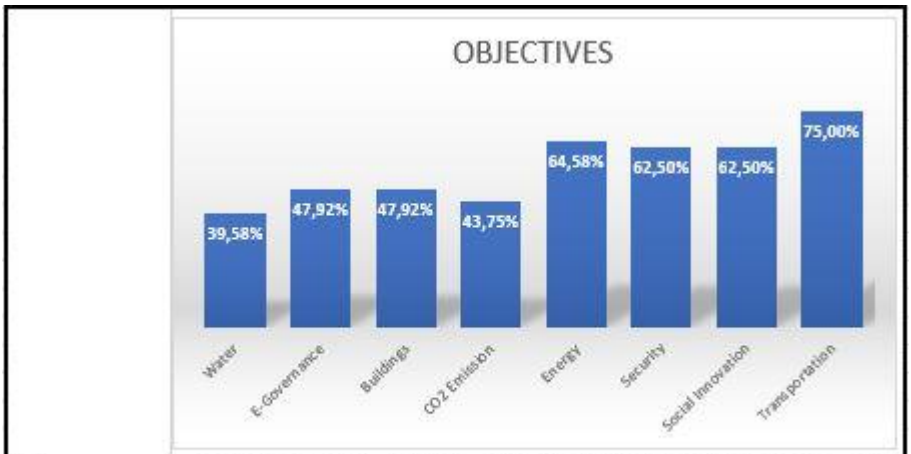
On the other hand, the Government of India describes itself as a Union of States, which is "*a Sovereign Socialist Secular Democratic Republic with a parliamentary system of government*. " Constitution of India provides a parliamentary form of government, which is federal in structure with certain unitary features. According to Constitution of India, "*the administration consists of The President of India is the head of state, The Prime minister is the head of the executive, and two Houses are known as the Council of States (Rajya Sabha) and the House of the People (Lok Sabha)*." Municipal Governance in India divided into three systems. First one is called *Nagar Nigam* which means that municipal corporation with the population more than one million. The second type of cities has a population between 100.000 and one million which is called *Nagar Palika* or Municipality. Lastly, *Nagar Panchayat*, which means that Notified Area Council has a population between 11.000 and 25.000. India is the second most populous country in the world after China with 1.3 billion population. Several publications say that India surpasses China by 2022. As shown in Table 6, India has affected a minimum of 364.532 people with a project in **Davanagere** and has affected a maximum of 62.700.000 people with a project in the state of **Gujarat**.

After analyzing governmental and population characteristics of Asia, India, and Japan, now the applied taxonomy dimensions with their subcategories and their results will be summarized.

Starting from Description axis, we don't notice significant prosperity between objectives but transportation with 75% and energy with 64,58% has the highest weight in Asia. As can be seen from Figure 21, energy and transportation is one of the core objectives but especially in China and India. The result is not a surprise for us because two most populous countries in the world is in Asia, (China and India.) One of the most important problem in crowded cities is the development and higher efficiency in transportation systems. Thus, projects like **China Ministry of Railways, Ningbo, Jiaxing, Solarpur, Kochi, Belgavi, Bhopal** are focusing on improving efficiency, security, safety, viability and environmental sustainability of urban transportation systems. On the other hand, energy is the crucial element to empower cities functions. Considering the developing industries in those countries but also the population, it is an expected result that efficient management of energy demand is the core objectives of SCPs in Asia. New cities in China like **Binhai, iPudong** or **Jeju Island Smart**

Grid Test in South Korea, or cities in India such as **Chennai, Pune** implementing solar energy systems to produce energy from renewable sources.

Water is important objectives of Indian SCPs. More than half of the projects are aiming to increase the availability of drinkable water or improving the water infrastructures to prohibit the water leaks. (57,89%) Surprisingly, Japan has no water objective in selected projects.



China	26,32%	65,22%	34,78%	28,57%	35,48%	50,00%	50,00%	36%
India	57,89%	17,39%	34,78%	23,81%	35,48%	30,00%	26,67%	33%
Japan	0,00%	0,00%	17,39%	28,57%	16,13%	3,33%	6,67%	14%

Figure 21: Objectives in Asia

Another surprising result comes from security and social innovation which they are considerably higher than e-governance and CO2 emissions. Especially, China has innovative developments and cheap production in video surveillance market. These cause 50% of domination among all Asian countries. For instance, **Li River video surveillance** aims to improve security along the river for its citizen but also for tourists. Lastly, E-Governance has a significant percentage in China than other countries. Even if we look at the name of China is **People's Republic of China**, thus the main objective of SCPs should be transparent, efficient and accountable communication between government and public administration, citizen and businesses.

Furthermore, 92% of the projects in Asia shares more than one objectives. Table 7 summarize the results of multi-objective projects. 82% of the multi-objective projects include transportation. Therefore, we also analyzed the most frequent combination with transportation. Energy and transportation with 82%, transportation and social innovation follows with 64% and lastly building and CO2 emission is seen most frequent combination with transportation with more than 50% score.

Table 7: Multi-Objective projects in Asia

Multi Objective	44	92%
Transportation	36	82%
Transportation+Energy	28	78%
Transportation+Social Innovation	23	64%
Transportation+Buildings	20	56%
Transportation+CO2 Emissions	18	50%

Regarding Tools, ICT has the highest contribution with 98% among other tools. The essential role of ICT in SCPs support this result. Besides ICT, in chapter 1, ICT enablers technologies are explained and as can be seen from Figure 22, database is at second place with 56,25%, cloud computing follows with 47,92% and smart grid is an another major tool with 43,75% in Asia. According to Websell (2016), the 90% of the World's digital gadgets produced by China, Japan, South Korea, and Taiwan. Another obvious result is that China is the leader of the production and manufacturing industry in the world. However, in the recent year, thanks to government initiatives China has steady and rapid growth in ICT and internet related sectors. According to International Trade Administration of U.S Department of Commerce report (2017), the market of Big Data, Cloud Computing, 5G, IoT, Augmented Reality, Virtual Reality, and smart appliances are growing each year with the help of regulation and standardization studies by the government. Another reason for developing technology in China is low labor cost. It brings international companies to China and local companies are learning know-how and thanks to their natural resources they are leading market of semi-conductor market in the world. For example, some projects like **eGOVERNMENT, Smart Haidain District, Yangzhou, Nantong of Jiangsu, Nantong of Jiangsu, Jiaxing, and Smart city for Yinchuan** use ICT, cloud computing, database,and decision support system coherently. Most of smart city projects in China use big data for the management of city. These cities are using cloud computing and database to share collected data. This allows the transparency of cities and fostering the implementation of projects.

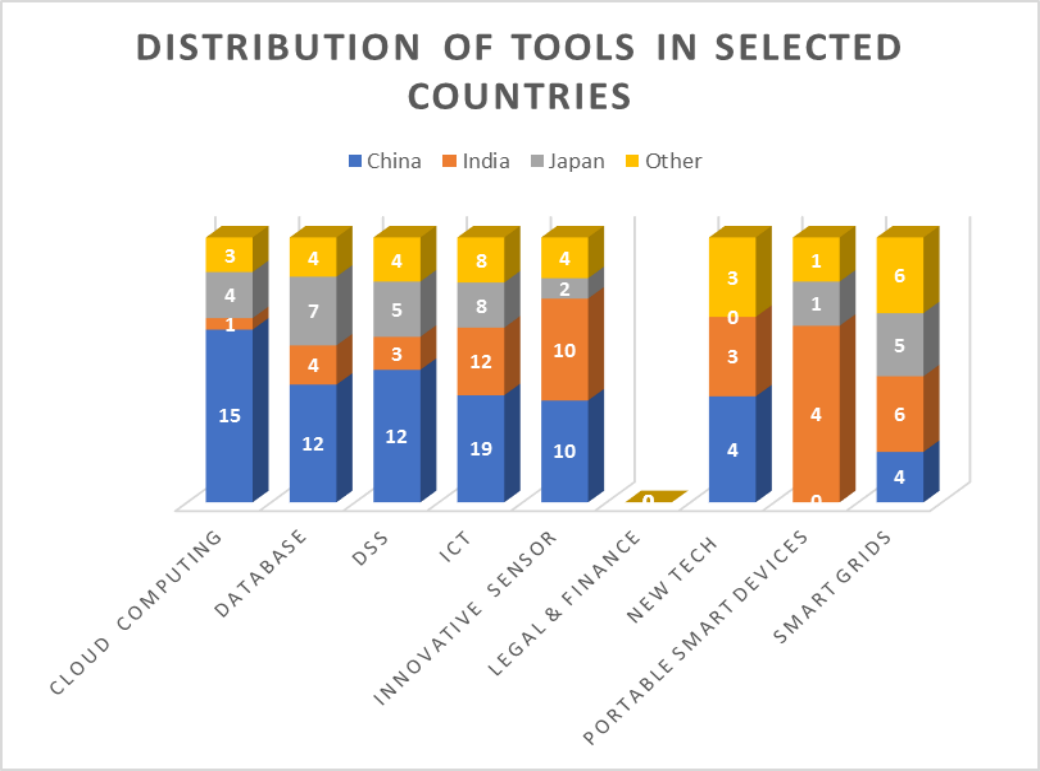


Figure 22: Distribution of Tools in selected countries

Other actors like Japan and India are also playing important roles in the World's technology market. For instance, Japan is famous for its durable products in the past. Since technology shifts to software technologies such as cloud computing and big data, Japanese companies have difficulties to answer this changing demand. One of the reasons behind it is traditional Japanese group consensus decision-making processes retain Japan to be agile to adapt to new technologies. Another reason comes from strong foreign competitors like China, the USA, and Europe. Japan use mostly ICT and database for their projects. For example, **Keihanna Smart Community Project, Green Crossover Project, and Kitakyushu Smart Community Creation Project.** Surprisingly, the smart grid technology is also used in these projects. This proves that those projects are multi-objectives and aim to create eco-cities. In the case of India, technological developments are not about software or computer-related technologies. India has the plan to develop its technology for changing its energy production plan and become a leader in the pharmaceutical industry. The reasons behind this route for India, first of vaccines and other sundry drugs are cheap in India. Secondly, a high level of health problems in India pushes the government to take precaution to change dependency on coal to renewable energy systems. Lastly, the computer literacy and utilization rate of phones are very low. The use of portable smart devices is increasing by India such as projects like **Belagavi, Jaipur, Coimbatore**, and **Kochi** has initiatives to improve computer literacy of citizen and create awareness about SCPs.

Still considering the description axis, the project initiator attributes described in Figure 23. Government and public entities initiate 60% of SCPs in Asia. This result is dominated by China because of its governance style. On the other hand, the cooperation between government and private companies are considerable with 40% participation. The surprising result there is no direct private initiative in Asia.

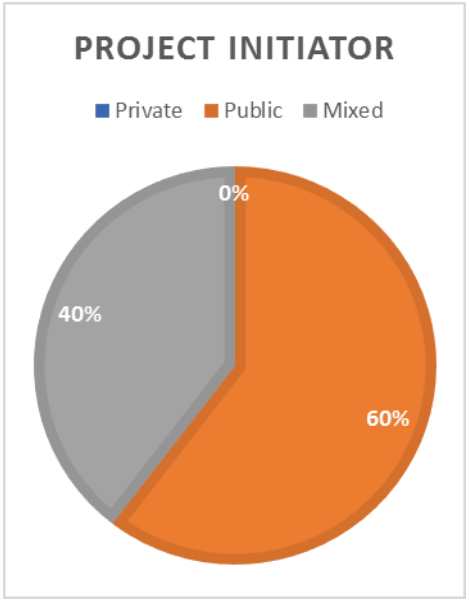


Figure 23: Projects Initiator in Asia

Finally, to close the description axis, the results for the stakeholders illustrated in Figure 24. As it is mentioned in chapter 1, one of the common keywords of the different description of Smart Cities is the high quality of lives of the citizen. Thus, citizen plays an essential role in SCPs as an end-user or participant in the design phase. The result proves this argument that all of the SCPs in Asia has 100% participation of citizen and city. Undoubtedly, the administration and SMEs have high participation. Their participation is important to develop new technologies and replicate successful projects. Regretfully, university participation is very low especially in India. Contrarily, university participation fosters new technological development and innovation with low cost and gives a chance to test smart city technologies.

Considering the Business Model axis, the dominance of PPP is noticeable from Figure 25. Perboli (2014) proved the important place of public entities in the Business Model and the result is confirmed that public entities issues policies, financing mechanism such as bonds, increase effective communication between society, while public entities need collaboration with private entities to foster development, catch new technological innovation and export SCPs to abroad. Thus, PPP has the highest share in the partnership, infrastructure financing, and financial resources as an expected result.

Figure 24: Stakeholders in Asia

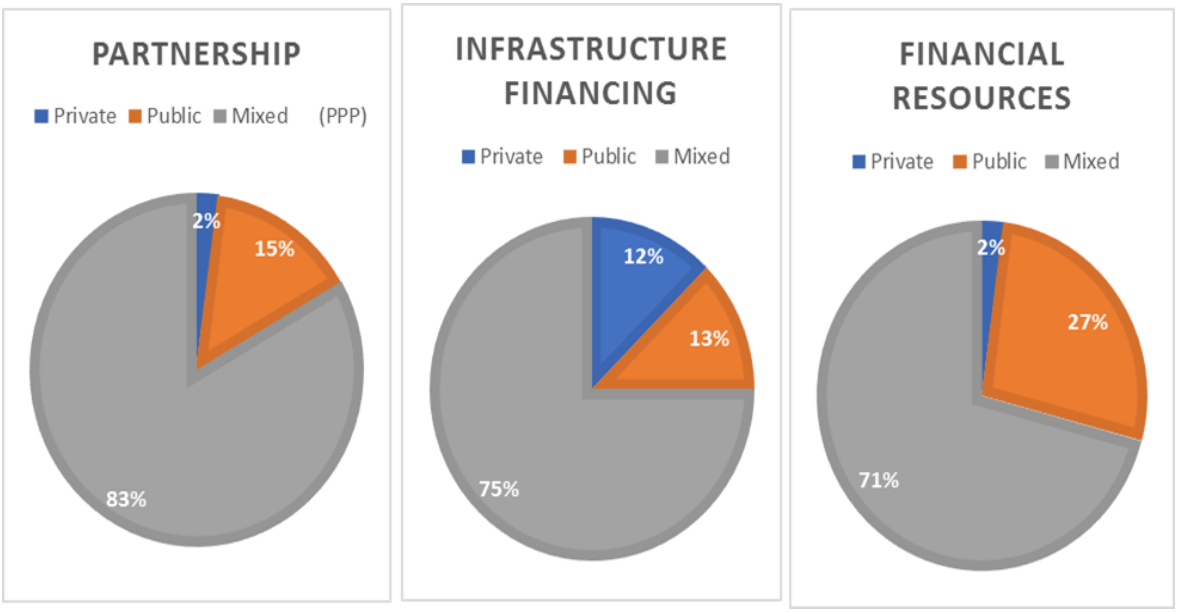


Figure 25: Business Model in Asia

In China, the Ministry of Industry and Information Technology (MIIT) has published several Five-year plans in a number of different areas. Lately, 13th Five-Year plan (2016-2020) published and it supports the developments in smart city, smart manufacturing and so on. Ministry of Housing and Urban-Rural Development (MOHURD) focus on especially smart Cities and released the *Notice on Carrying Out National Pilot Smart Cities* and issued the *Interim Measures for the Administration of National Smart Cities and the Pilor Index System for National Smart Cities (District and Towns)* in 2012. Most of the Chinese SCPs, these ministries fund and operate but outsourced the design and consultancy by private companies. However, Build-Operate-Transfer (BOT) or only private governance systems are also observed. Pham discussed in SMART CITIES IN JAPAN (2014), smart city initiated by the central government, local government, and private sectors. Ministry of

Economy, Trade, and Industry (METI) subsidized many projects in Japan by different entities. Such as urban planning, promoting sustainability, and so on. However not only METI plays an important role, but also local government initiatives have to be considered in Japan. SCPs are not only initiated by the government but also private sector funds SCPs. Companies like LG, Sharp, Hitachi, Toshiba and so on are grouped to foster smart city development in both national and international level. However, investments from only the private sector make SCPs as a showcase of advanced technology. Thus, PPP is the best solution for successful and sustainable smart city projects. India follows different processes than other Asian countries but in the end, its business model is also based on PPP. Mallick et al. (2015) said 100 smart city projects in India are initiated by the central government with the total investment amount of $7.5 billion in five years. In this time, the local government will compete to become a shortlisted smart city. For the management of SCPs in India, a Special Purpose Vehicle(SPV) formed to implement initiatives. These SPVs are incorporated as a public company to implement, manage, operate, control and evaluate SCPs. SPV funding additional resources through market or government which government initiatives only use for public infrastructures.

For case studies in Asia, investment for SCPs in Asia found and analyzed. Countries use their own currency thus each investment currency exchange to USD for the analysis. As can be seen from Figure 26, the range of investment is between $16.000.000 and $8.000.000.000. Average investment amount is between $100.000.000 and $500.000.000.

Figure 26: Investment analysis of Asia

The last dimension of the taxonomy is Purpose and gives information about the output of projects. As can be seen from Figure 27, the client of Asian SCPs is dominated by a mixed type of client by 82% which both private and public entities are targeted. On the other hand,

8% of SCPs have targeted only private entities while public entities are targeted by 10%. More than half of the SCPs' products are defined at the beginning of the project. The no-specific product is not desired because it means that the project is still under test phases or technology has not developed yet and in Asia, 38% of the SCPs' product is not specified. For instance, China is still working on the standardization of 5G network.

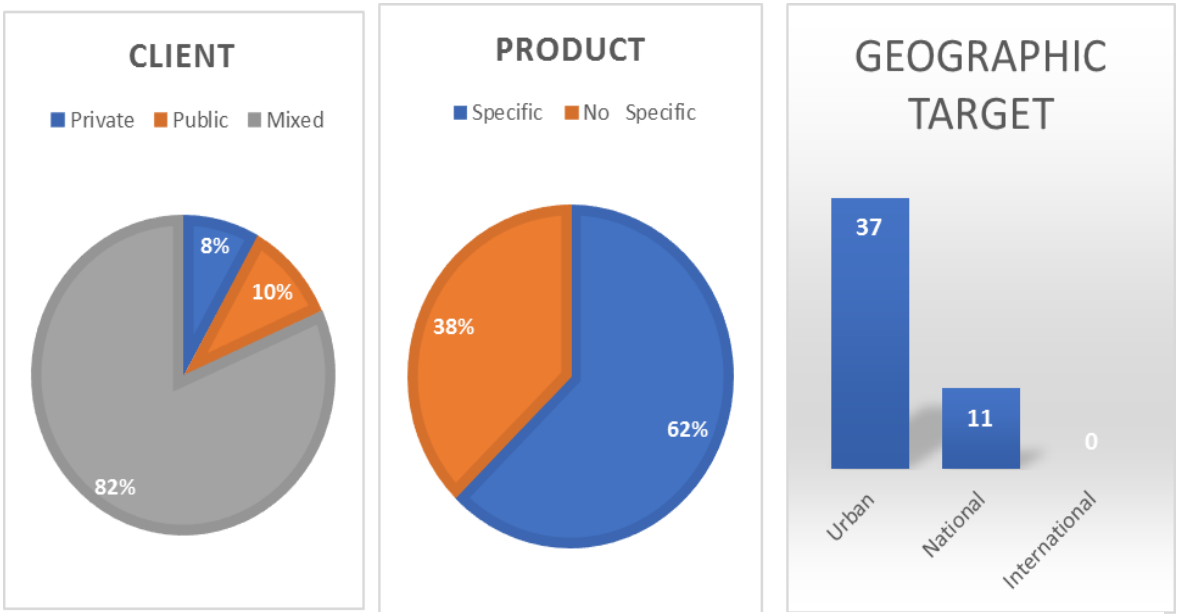


Figure 27: Purpose in Asia

3.2 Australia

Australia is an island located in Oceania and its population consists of local community and other ethnic groups especially there was a significant change in the population because of increasing immigration after European investigation on the island around the 17th century. After the arrivals of European especially English, the island demography has changed and the urbanization starts on the coastal side of the island by increasing in time. As a demographic analysis, Australia has the least density population in the World. While it is the sixth largest territory, it has a population of around 26 million which most of these population lives in the city located on the coast sides. Now, Australia has five federal states such as New South Wales, Queensland, South Australia, Tasmania, Victoria, and Western Australia. According to the Australian Government, "*these six states form the Commonwealth of Australia and each state has its own state constitution. The monarch's powers over state matters are exercised by a Governor in each state. The head of each state government is known as the Premier.*" Local governments have a great influence on the individuals' lives through health and education systems, property and civil rights, and so on. Therefore, this federal government policy affects the results of potential people involved by each project.

Figure 28 presents the number of people affected by each project at the urban level. Metropolitan cities of Australia are the target of SCPs because of their high population. However, as it is mentioned before Australian population density is lower than other countries and therefore, we observed most of the cities population are around 200.000.

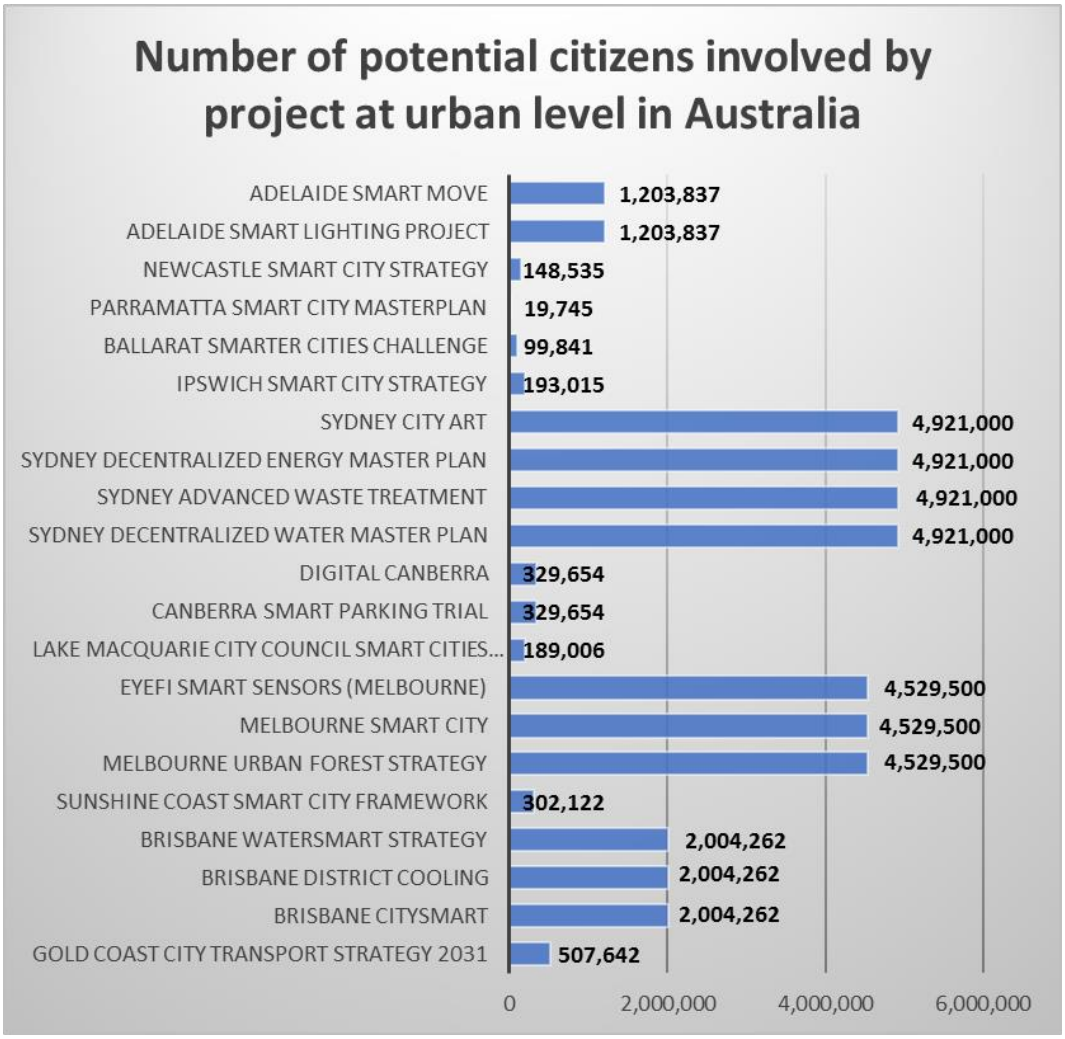


Figure 28: Number of potential citizen involved by project at urban level in Australia

Starting from description, Australian Smart City case studies will be analyzed by each axis with their subcategories. The results will show us trends in Australian Smart Cities and how this trend drive practitioners to build a new business model.

Figure 29 illustrates the distribution of objectives in Australia. It is easy to notice the prosperity of social innovation with 61,54%. Most of the smart city master plans of Australian cities such as **Brisbane CitySmart, Sunshine Coast Smart City Framework, Melbourne Smart City, Ipswich Smart City Strategy** include the aim of the high quality of lives for its citizen. High coverage and high-speed network connection, better health services, e-government, information availability about transportation, digital education, and

so on are the priorities for Australian governments. On the other hand, **Melbourne Urban Forest Strategy** aims to manage urban growth while protecting the urban forest in the city of Melbourne. Energy is following social innovation with 50% priority. Australia is constituted of existing cities from its early history. Thus, at this moment, buildings have to be considered as a common solution with energy. Because new efficient energy systems, smart grids, retrofitting for buildings are highly demanded. Infrastructures in cities are not capable to answer demand in near future. Therefore, local governments have to consider solutions correlated with energy and buildings. In the same way with energy, CO2 emission is another important challenge for Australian cities. **Sydney Decentralized Energy Master Plan** offers new renewable energy sources such as solar panels on the buildings and with the smart grid solutions, each household enables to enter the energy market and reduce the dependency on fossil fuel. On the other hand, one of the most important economic instrument in Australia is tourism. Thus, environmental problems have significantly affected the climate of Australia. Transportation is another crucial objective with 46,15%. As it is discussed before, the Australian population is increasing and this population chooses to live in cities. Thus, increasing population put challenging pressure on transportation systems of Australian cities. Local governments, especially in **Sydney, Melbourne and Adelaide** think about solutions for traffic congestion, multimodality, intelligent mobility systems, electric vehicles and so on. Another objective has to point out in the case of Australia is water. It is considerably higher than in other countries because as it is mentioned before, people live in the coastal side and climate change cause extreme weathers. Floods, increasing sea levels or in the center area light rainfall push governments to find efficient water management systems. Projects like **Ipswich Smart City Strategy, Parramatta Smart City Masterplan,** and **Sydney Decentralized Water Master Plan** are putting important efforts to overcome problems related to water.

After analyzing the objectives of SCPs, it is easy to note that projects do not focus only on one objective to create smart city. Table 8 shows 69% of projects are multi-objective. Between those projects, social innovation is placed as the most critical objectives for Australian SCPs with 89% score. The most frequent combinations are social innovation and energy, 56%, social innovation and transportation, and social innovation with the aim of reduction of CO2 emission, 50%. Thus we can conclude that Australia wants to focus on the well-being of its citizen and improve the transportation systems with the aim of protecting the environment.

Table 8: Multi-Objective projects in Australia

Multi-Objective	18	69%
Social Innovation	16	89%
Social Innovation+Energy	9	56%
Social Innovation+Transportation	8	50%
Social Innovation+CO2 Emission	8	50%

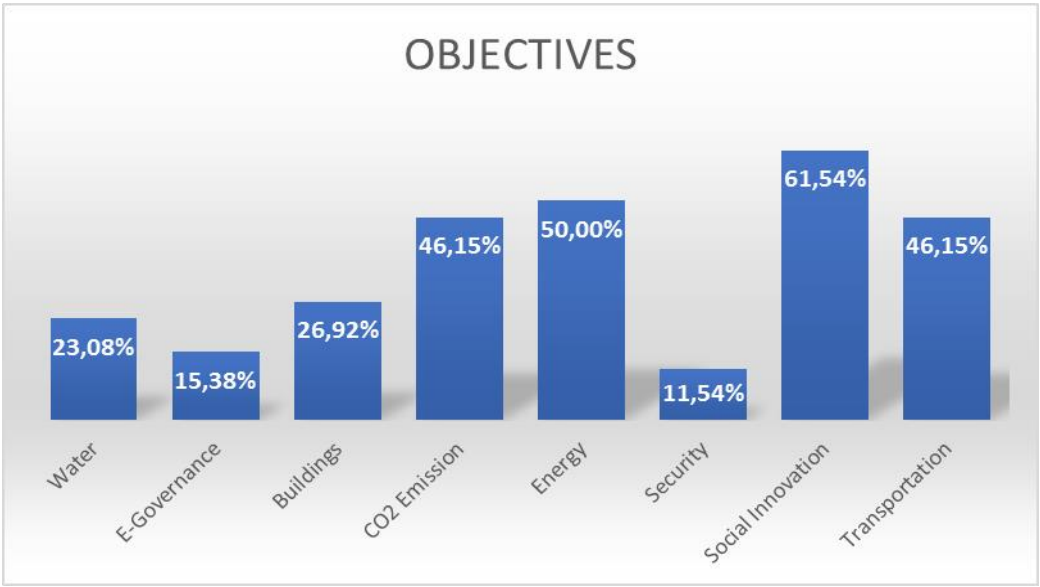


Figure 29: Objectives in Australia

Figure 30 proves that the tools needed to demonstrate the most demanded objectives also have high weights. Such as innovative sensors and database are needed to apply the energy system, water system, and smart mobility. Thus, database with 57,69% and innovative sensors with 50% are frequently used in SCPs. Unsurprisingly, ICT has the highest score in Australian SCPs because of its essential role to implement ideas.

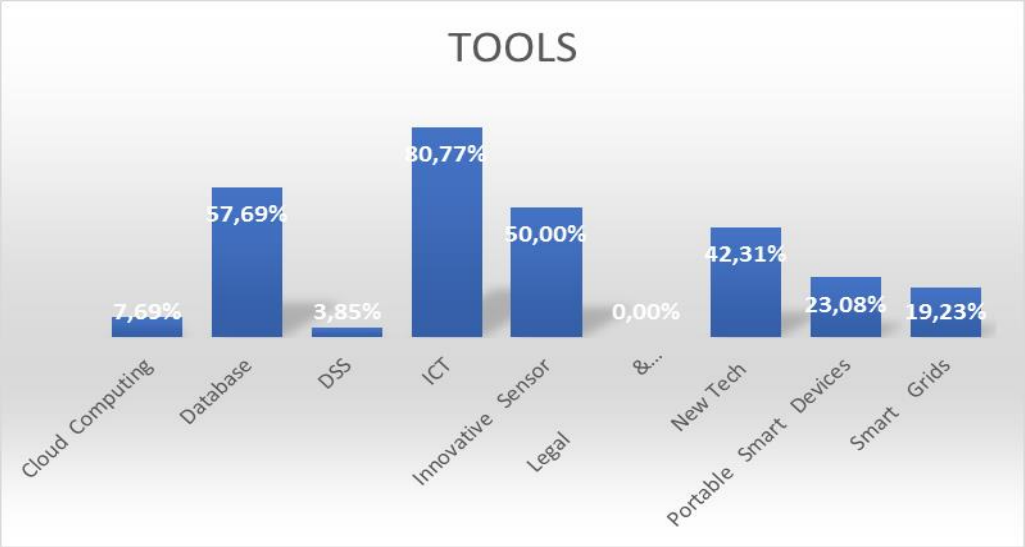


Figure 30: Tools in Australia

From Figure 31, it's easy to note the remarkable participation of the city and citizens. SMEs are following this trend with 73.08% which their participation is important to accelerate SCPs. Unlikely from Asia, universities higher participation rate than in Asia while it is disappointingly lower than other stakeholders. The role of the Australian government to fund scientific and R&D studies affect to get this result in Australia.

Figure 32: Stakeholders in Australia

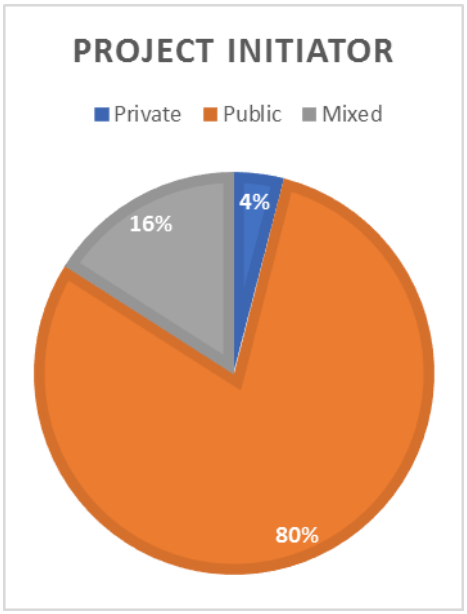


Figure 31: Project Initiator in Australia

Considering project initiator, 80% of selected projects tend to initiate by the government. Figure 32 shows that public entities dominated the initiative phase of the projects, while 16% of projects have the partnership with the private sector and only 4% of projects have only private entities as an initiator. As it is mentioned before, the government has a crucial role

on analyzing the public requirements and in the case of Australia, most of the local governments are working on their smart city plan and initiate different solutions under the SCPs initiatives.

Regarding business model axis, it is noticeable from Figure 33, public entities dominate in three cases, while public entities doing a partnership with SMEs, start-ups or international companies to implement SCPs. According to Smart Cities Plan by Australian Government (2016), Commonwealth will provide $50 million to plan and develop only infrastructure projects including rail projects. However, thinking about local governments plan, commonwealth fund is not enough to implement these projects. Therefore, we notice public and private partnership with 88%. **Brisbane District Cooling** is the only project initiated by private companies. For infrastrurcture financing, the Australian government found **Infrastructure Financing Unit** to increase the share of the private sector in funding and financing problems. Thus, fifty-fifty participation of infrastructure financing is remarked. Lastly, the Australian government perceives the investment of SCPs as national objectives and long-term economic returns. Therefore, most of the projects are funded by Commonwealth of Australia with 77% or with cooperation with the private sector by 23%. According to investment analysis, as can be noticed from Figure 34, most of Australian SCPs need huge investment. The range is starting from $25.000 until $3 billion. The medium of the projects is between $100 million and $1 billion. Therefore, Australia has to focus on the development of a clear business model to identify who create economic value and what is the win-win relationship.

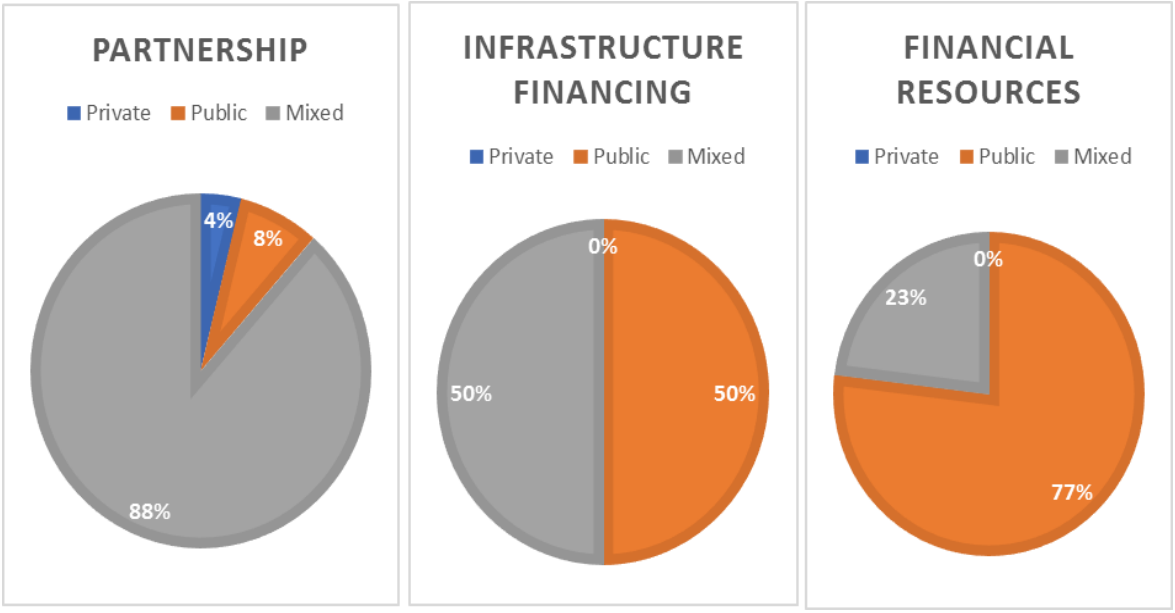


Figure 33: Business Model in Australia

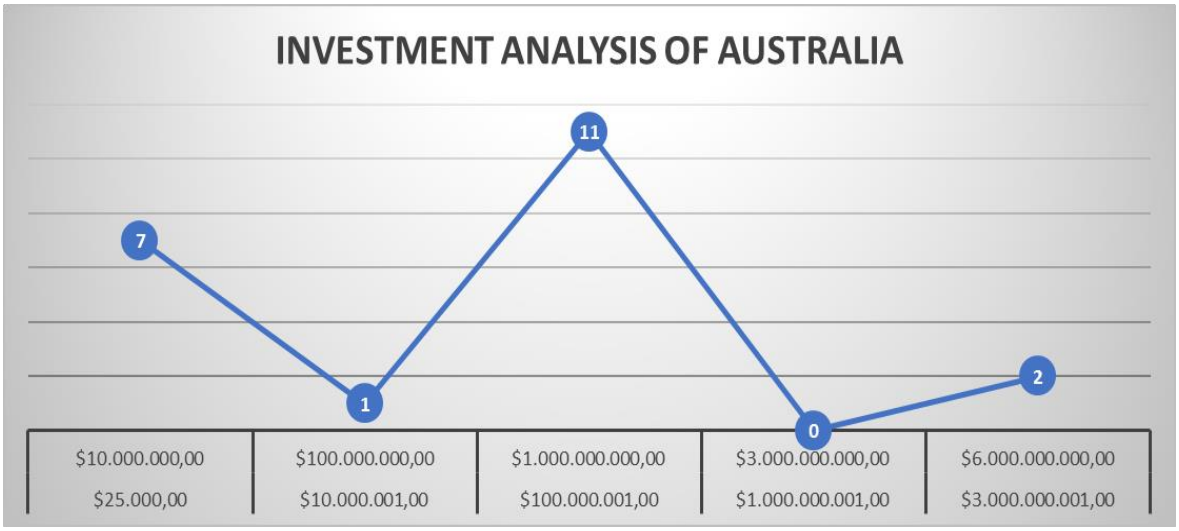


Figure 34: Investment analysis of Australia

Regarding the last axis of taxonomy, Australian SCPs have a clear purpose about the client, product and geographical target. 88% of Australian client consist of private and public entities. Following 85% of projects, the output is identified from the beginning. For example, some projects in **Parramatta Smart City Masterplan** are still testing and that's why outputs of this project is considered as non-specific like in the case of other projects. Lastly, there is no international project developed by Australia. Opposite of Europe or the USA, they are not the innovators of smart cities, they prefer to follow examples from other continents and apply the best case studies in their cities. As can be seen from Figure 35, 84, 62% of SCPs are implemented in urban areas.

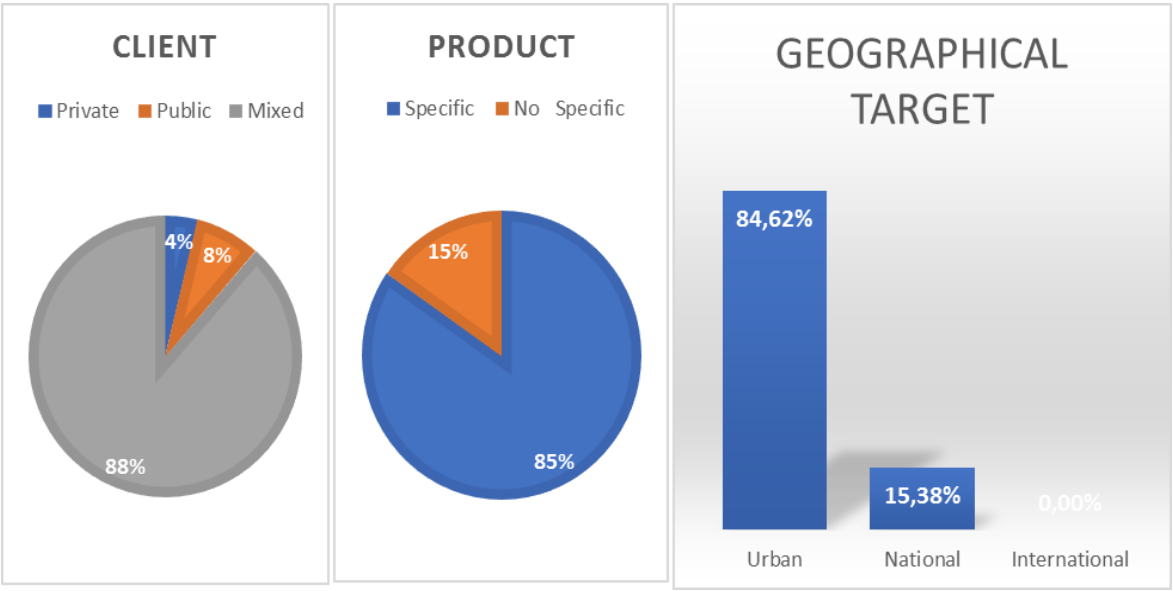


Figure 35: Purpose in Australia

3.3 Europe

Europe is one of the oldest continents where people settled and founded cities. Since from the early history of Europe, Europeans were the pioneer of the main inventions in the area of health, governance, science and so on. Europeans explore new continents and brought natural resources or other inventions to their countries and gave birth new inventions. All of these inventions, interactions with other cultures created a strong wealth for Europeans. In the next history, Europe becomes a union with all of these different countries. European Union (EU) allowed cohesiveness, social inclusion, and powerful monetary governance among the members of the EU. Thus, it is easy to note that welfare of Europe is higher than other countries, infrastructure is well established in almost all European cities, the education system is well organized and consequently, the rate of literacy is high.

European Union is founded in 1992 and now it consists of 28 countries. All member countries have to follow economic and legislative regulation by the EU. This also can be seen in smart city applications in Europe. One of the first initiatives of smart city is proposed by the European Commission under the 7th Framework Programme. After this programme, smart city becomes popular and its applications have increased. As it is mentioned in chapter one, Horizon 2020 especially foster smart city projects. Another important initiative of the European Commission is the foundation of The European Innovation Partnership on Smart Cities and Communities (EIP-SCC). Under this initiative, local governments prioritize sustainable urban mobility, sustainably built environment, integrated infrastructures and processes in energy, ICT, and transport, open data governance, knowledge sharing, citizen focus, business model, funding and procurements. This unity brings integration between countries. All of these initiatives support the integration of data, sharing technologies and knowledge among countries. This is also distinctly visible 92% of the analysis is applied at the international level, where more than two countries involved in SCP. As can be seen in Figure 36, projects that focus on an international level that covered number of citizens from 454.581 to cover the whole EU with more than 500 millions as the case of **Espresso** and **Fi-Ware**. **EE-Highrise** is the only project at an urban level that affects 272.140 people. The project was the pilot to test new energy solutions, technologies and concepts. On the other hand, **Urbelog** is another example of focusing national level. The project areas cover Milan and Turin and Genova with the aim of developing sustainable and cost-effective transportation system of goods.

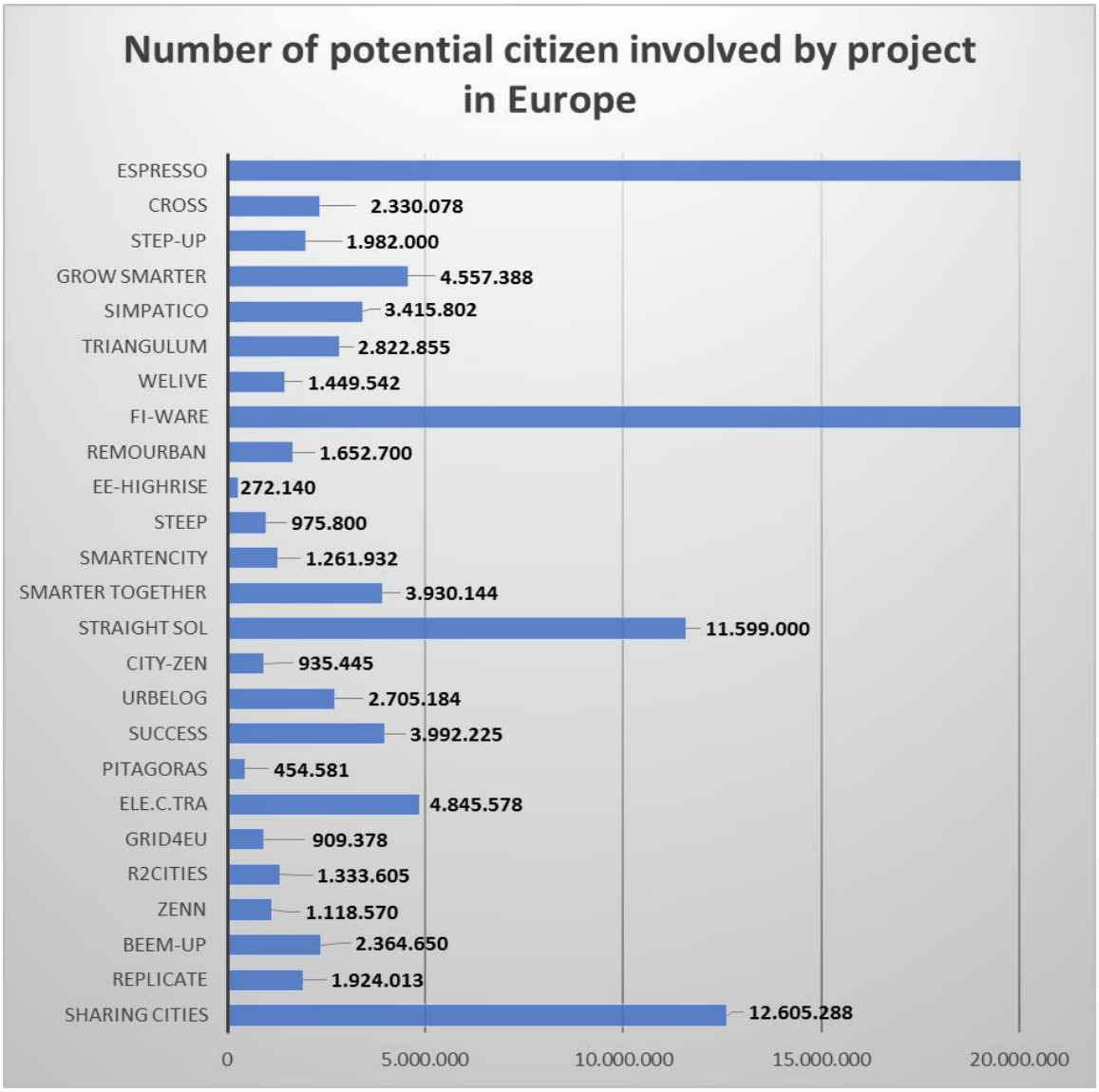


Figure 36: Number of potential citizen involved by project in Europe

Considering description axis, the first objectives of SCPs is analyzed. Firstly it is important to underline that the European Economy is one of the strongest economies in the world where Europe produce one-third of world GDP. The industry is the backbone of the European economy. Therefore, it is not surprising to see energy and CO2 emission with the highest score on the graph. Energy consumption is one of the recent topic in the urban area and if we consider that cities responsible of CO2 emissions, cities have focused to find renewable energy solutions, efficient control of energy distribution, smart grids, and environmental solutions. For example, **GRID4EU** is one of the largest solar panel implementations in Europe and aimed to reach around 273 million people. As can be seen from Figure 37, building and transportation are following the trend. As it is mentioned above, Europe has established cities and consequently, buildings and infrastructures are becoming old and

cause some main problems such as water leak, power outage or isolation. On the other hand, as in the case of the world population, the European population also moves to urban areas. Therefore, most of SCPs put retrofitting strategies, availability of affordable housing, smart grid and solar energy solutions for heating and cooling in their smart city frameworks. For example, **Remourban, Step Up, and Smarter Together** have strategic sustainable city planning.

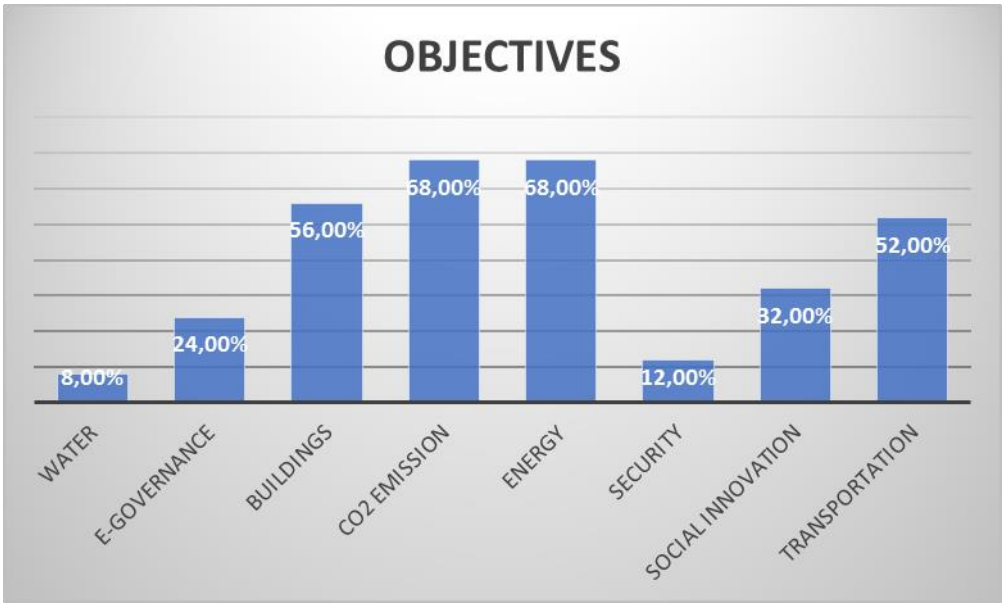


Figure 37: Objectives in Europe

Transportation is another challenge which Europe has to overcome with innovative and intelligent solutions. Since Europe has one single market where people, goods, and services can move freely without borders, governments have to focus on the international, efficient, sustainable, and safe transportation system. In brief energy, CO2 emissions, transportation, and buildings are usually integrated and share a common purpose to achieve. For instance **Sharing Cities** bring Milan, Lisbon, and London to find a solution where cities integrate the area of energy, transportation, and ICT. Lastly, high quality of life, social cohesion are the main strategies for governments but unlikely from other countries social innovation involved elder care smart city solutions in Europe because of increasing aging problems.

Differently, from other countries, European SCPs aims to cover more than one cities but also aims to cope with more than one problems of cities. Table 9 represents 92% of projects are multi-objective. Energy and CO2 are the most critical objectives between those projects. The most frequent combination for energy is with buildings, 76%. As it is explained before Europe has existed cities and retrofitting is an emerging solution for energy efficiency. Another combination of energy is with transportation where Europe has a target of CO2

emission reduction of 40%. On the other hand, CO2 is another critical objectives by itself but not surprisingly the combinations are the same with energy. Therefore, we can sum up the objectives of Europe as having the most sustainable cities around the world.

Table 9: Multi-Objective projects in Europe

Multi-Objective	23	92%
Energy	17	74%
CO2 Emission	17	74%
Energy+Buildings	13	76%
Energy+Transportation	10	59%
CO2 Emission+Buildings	13	76%
CO2 Emission+Transportation	11	65%

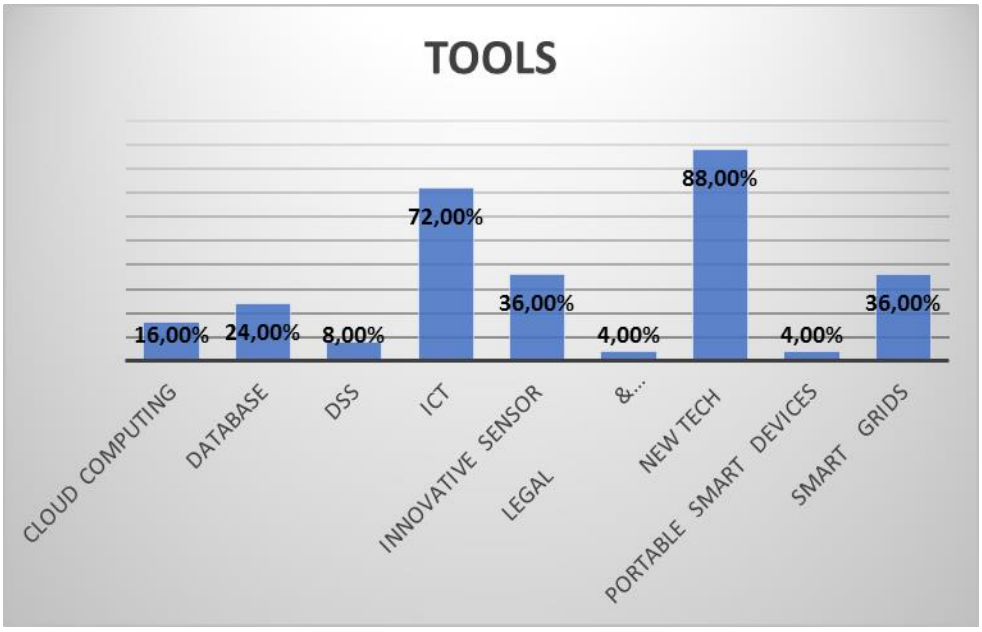


Figure 38: Tools in Europe

Figure 38 proves that ICT enables smart city projects through collecting, combining and crushing data. However, new technologies have 88% score which is more than ICT. Because selected projects propose innovative ideas to increase the quality of life and inclusive of the

citizen. For instance, **Cross (Citizen Reinforcing Open Smart Synergies)** bring different stakeholders into one platform to develop a sustainable society and non-monetary economic system. This project allows developers or any citizen to develop new digital solutions rather than using old technologies. All other tools are distributed equally according to the aim of the projects.

Concerning project initiator, Figure 39 illustrates a remarkable propensity to the public entities. One of the main reasons behind this result is that local governments focused to reach Horizon 2020 targets and developing strategies to implement these targets through smart city aspects. On the other hand, public entities want to improve infrastructures and economies of their cities, therefore, public entities have to work on developments of public infrastructure and provide high-quality life for its citizen. Analyzing stakeholder participation, it arises the importance of high participation. Each stakeholder has more than 80% score and these participations led innovative and succesful projects. Because stakeholders play a crucial role to plan, implement, develop, finance and control of the projects.

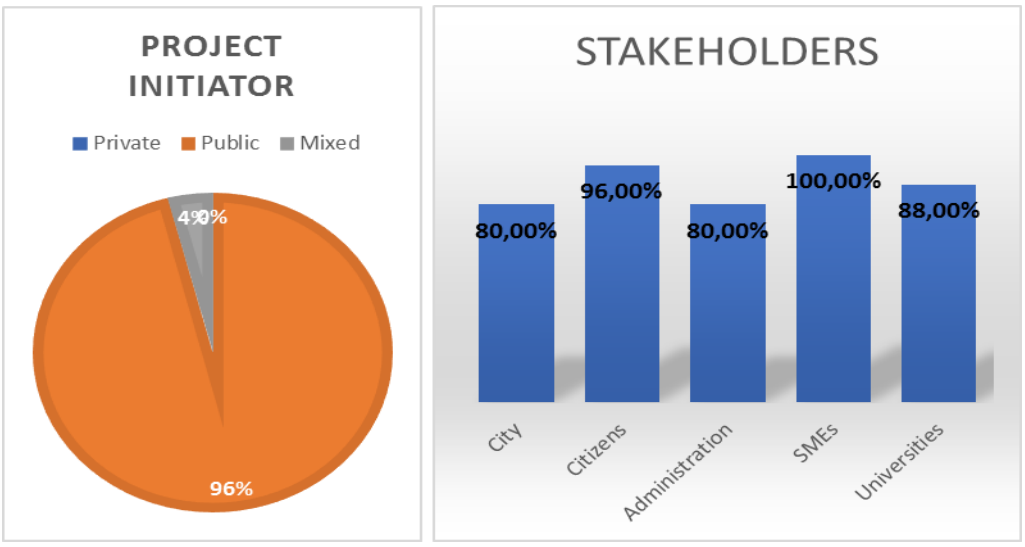


Figure 39: Project Initiator and Stakeholders in Europe

Business model innovation is necessary to have sustainable SCPs. We observed several successful smart cities around Europe because each actor role is defined clearly. There are smart city commissions to create a platform to bring governments, SMEs, universities or start-ups together. Integration of stakeholders ensures the smart city function as one actor, helps to find financial resources and accelerates the implementation phase of the projects. Figure 40 shows 100% of mixed partnership and 84% of mixed financial resources. However, the private sector dominated the infrastructure financing dimension. This can be

explained by innovative and high-quality solutions of the private sector. In addition, all European projects funded by the EU and the remaining part provided by the private sector or mixed.

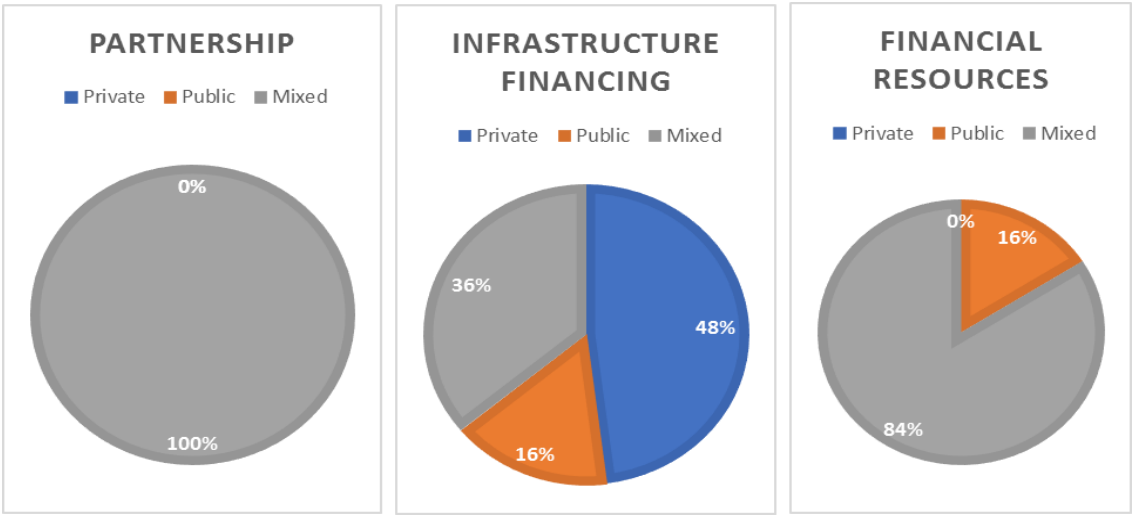


Figure 40: Business Model in Europe

Considering European SCPs, we notice most of the projects start smart city transformation with small initiatives. Such as **Electra** which aims to improve eco transportation or **Beem-Up** which aims to improve insulation of buildings and increase energy savings. Therefore, Figure 41 illustrates the investments concentrate at the range between $1 million and $16 million.

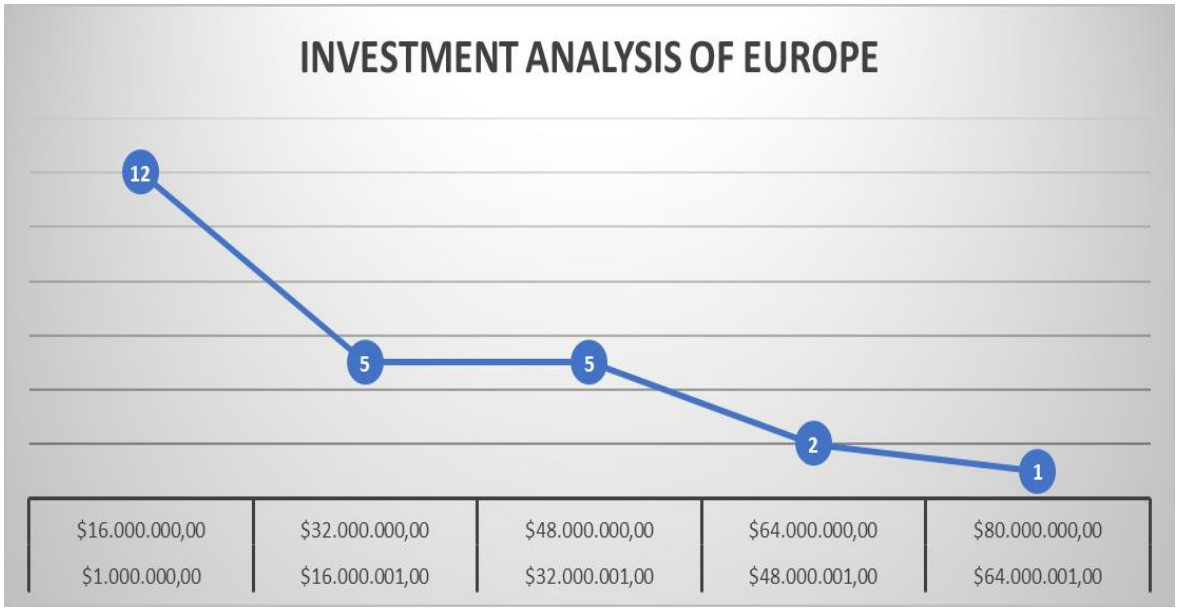


Figure 41: Investment analysis of Europe

Finally, to close the taxonomy analysis, the purpose of the projects will be analyzed. Figure 42 represents the output analysis of SCPs. Regarding client, the mix of the citizen, SMEs,

private firms and public entities benefit from project output with 60% score. However, both private and public client is observed with respectively 32% and 8%. Thanks to smart city frameworks and the European Commission target, products are specified from the beginning of projects. As it is explained at the beginning of the part, geographic target is international because Europe is one single market to enable participation of more than one country easy.

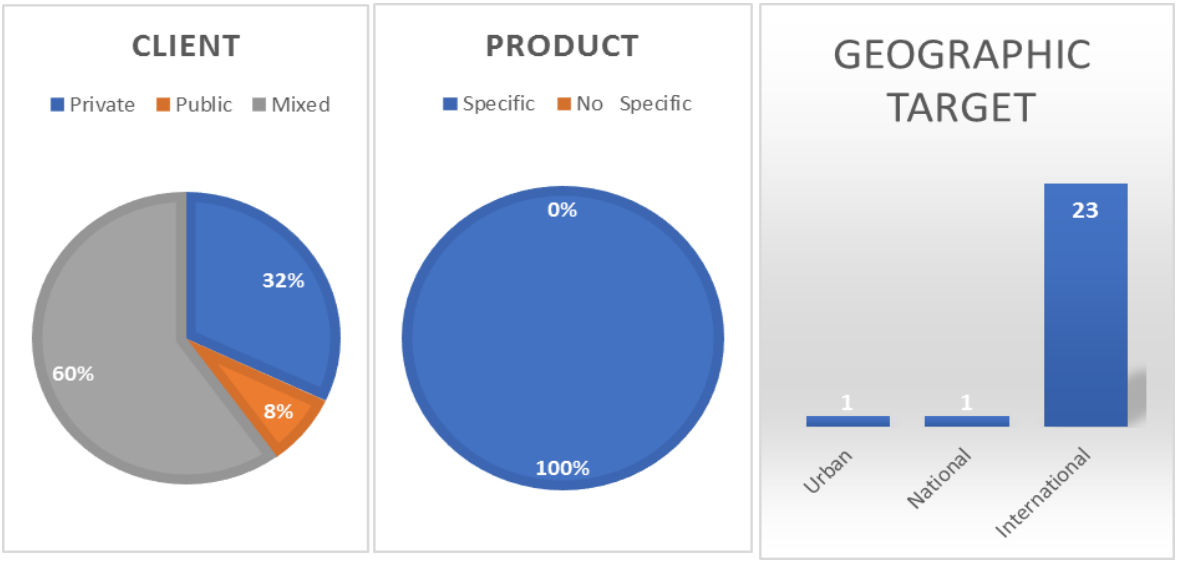


Figure 42: Purpose in Europe

3.4 Brazil

As can be understood from the official name of the country "Federative Republic of Brazil", the governance of Brazil is federalism like India or the USA. Therefore, Brazil is divided by states and it has 26 states. Brazil is the largest territory in South America and consequently has both demographic and climatic differences. Thus, there are significant differences also in North and South Brazil through the aspects of smart city. The quality of life is higher in the south because of the high literacy rate, developed industry, higher GDP growth, and higher digital literacy and consequently, the population density is also higher than north. Although, north part has rich natural resources, it is undeveloped and very dangerous to live because of uncontacted people in Amazons. Therefore, not surprisingly 90% of projects are in the South of Brazil. As can be seen from Figure 43, selected projects affect maximum of 10 million of people by project about **clean energy-Furnas** which aims to cover all Brazil. This graph illustrated the all geographic level such as urban, national and international. However, more than half of the projects are targeted at the national level especially in South because North is still not available to apply SCPs.

Figure 43: Number of potential citizen involved by projects in Brazil

Starting from description axis, Figure 44 shows a remarkable result that CO2 emission is the main objectives with 100% and energy is following it by 95%. Energy is the main crisis in Brazil. Unlikely than other countries Brazil produce energy from its hydroelectric power plants. Afonso, Ricardo Alexandre, et al. (2015) say that according to a survey conducted by the Ministry of Mines and Energy, Brazil needs to find new alternative energy resources and balance its energy mix. Dependency on water is critical for Brazil because of climate change and drought, it is going through a water crisis and it will significantly affect energy production. Besides the urgent needs of new renewable energy sources, Brazil witnessed massive power outages that affect millions of people in the country. Thus, federal and local government take serious strategies to improve Brazil's poor planning in the energy sector. New solar energy and wind energy solutions, smart grid systems are some of the actions of Brazilian SCPs. **Paraná Smart Grid, Cidade de Aquiraz, Alternative source of energy – COPEL, Projects about clean energy – Furnas, Alternative source of energy –**

PETROBRAS, Urban photovoltaic in Porto Alegre, Deployment of 3MW PV plant, and **Sol+ project** are just some of the examples of projects.

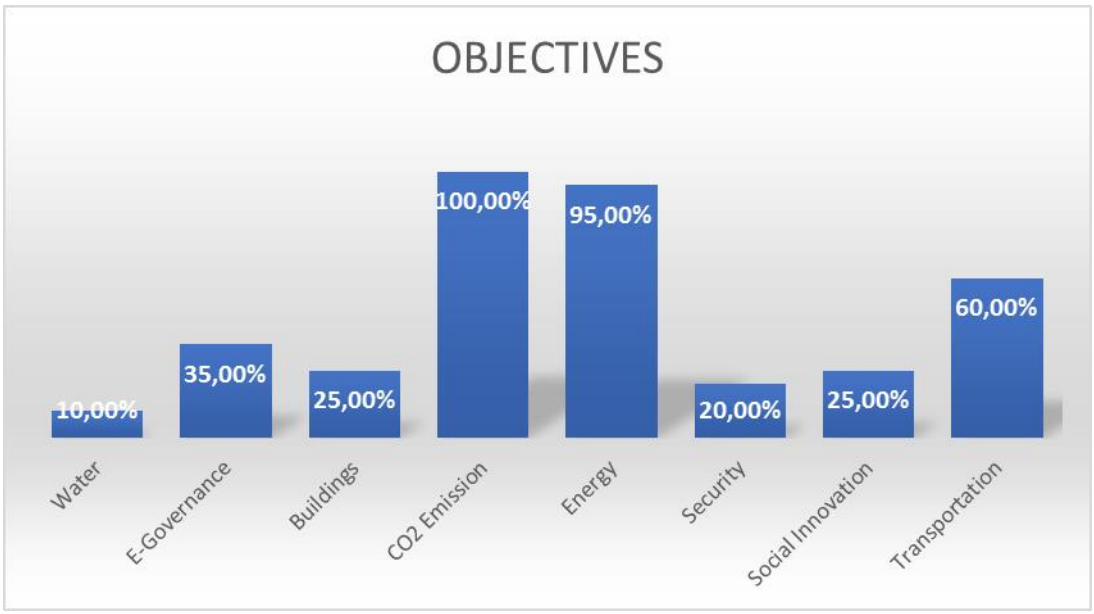


Figure 44: Objectives in Brazil

Electric vehicles are the next emerging strategies with 60% of SCPs. Governments focus to reduce fossil fuel dependency, rather than improving the road network or providing multi-modal transportation system. According to literature, the mobility in Brazil highly depends on road and the bus is the main vehicle for transportation. Therefore, along with the strategy of energy mix and reducing CO2 emission, replacing traditional vehicles with EVs will be an environmental-friendly and economic solution for Brazil. **Mobility project – Indra** and **Mobility project – KTH** are some of the examples to expand the urban traffic management solution in Brazilian cities.

In conclusion, alternative renewable solution and EV strategies have an indirect impact of CO2 emissions. Therefore even direct aim is not reducing CO2 emission, energy and transportation solution will help to reduce CO2 emissions in Brazil.

Table 10 illustrates the multi-objective projects in Brazil. All of the projects aim to cover more than one objectives and CO2 emission is the most critical objectives for the Brazilian government. Actually, CO2 emission is not the direct results of the projects, as can be seen from Table 10, energy and transportation is the most frequent combination. Renewable energy solutions, projects about EVs are the main strategies of energy, transportation and CO2 emissions.

Table 10: Multi-Objective projects in Brazil

Multi-Objective	20	100%
CO2 Emission	20	100%
CO2 Emission+Energy	19	95%
CO2 Emission+Transportation	12	60%

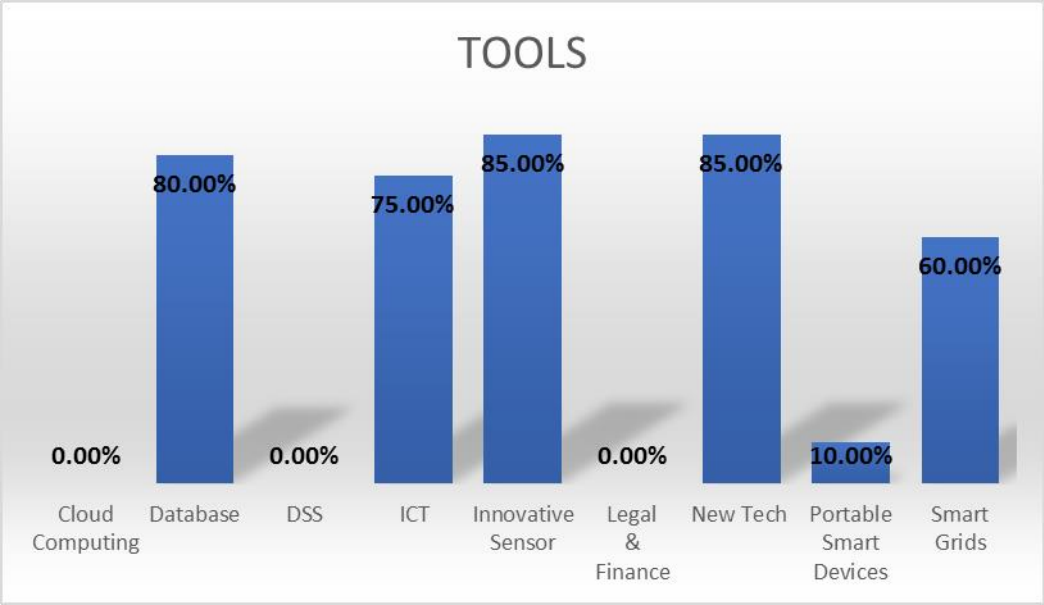


Figure 45: Tools in Brazil

Figure 45 shows consistency between objectives and tools. New technologies and innovative sensors are the most desired tools with 85% score. For instance, new technologies introducing EVs or vehicles with hydrogen fuel cells as in the case of the project **alternative source of energy- Petrobras**. Database follows innovative sensor and new tech with 80% because most of the project applies integration of smart grid projects or some of them have information technology strategies such as the project **Parintins** develop measurement center with the implementation of measurement data collection system (MDC). Unlikely from other projects, first time ICT fell behind of other tools. It can be explained by accessibility to technology is relatively lower than in other countries.

Regarding project initiator, 45% of the project initiated by public entities and 50% by mixed is given in Figure 46. This is not a surprising result when you considered 95% of the project is about energy efficiency and energy is one of the most important tax instruments to have a strong economy. On the other hand, private companies introduced new technologies and innovative smart grid applications into the market.

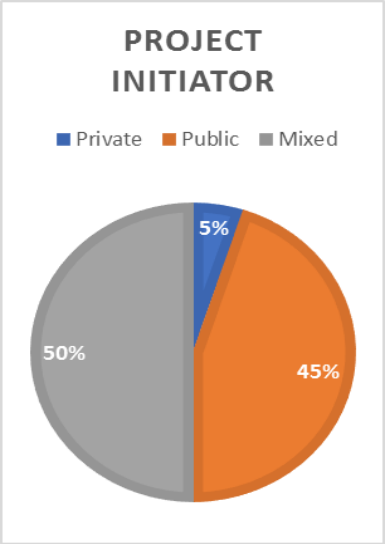


Figure 46: Project Initiator in Brazil

The last dimension of description part is stakeholder and Brazil is the most successful country to create a multi-stakeholder platform and 100% participation from its cities, citizen, administration, and SMEs. This is illustrated in Figure 47. Unfortunately, university participation is not higher than 85%. One of the reasons behind this result is Brazil still doesn't provide enough initiative to the education system and R&D studies. Therefore, even the participation of universities is considerably high, it fell behind other stakeholders because of the lack of initiatives.

Figure 47: Stakeholders in Brazil

Considering business model axis, partnership, infrastructure financing, and financial resources are formed as PPP respectively with %100, %95, and 95% scores are shown in Figure 48. Municipalities of Brazil, for whom PPPs make it possible to search more quickly

for new technologies and financing aiming at the implementation of smart grids, the efficiency of public lighting, the development of new renewable energies and the efficiency of EVs. For instance, **Cidades Intelligentes de Bùzios** receive $18 million from Aneel which is a public entity and $22 million from private sectors as sponsorship and equity. Furthermore, as can be seen in Figure 49, more than half of the projects represents investments of the range between $1 million and $50 million. The prosperity of investment is about $20 million, only **Cidade de Aquiraz** has an investment of $1.660.000 which is a pilot project of smart grid implementation in the city of Aquiraz. Furthermore, Brazil is open to having international investments from countries like Italy, Spain or Swedish. For example, **Mobility project KHT** is running by a consortium between Swedish and Brazilian stakeholders and they are exploring the deployment of transport and IT-based technologies together with new concepts for urban planning in Curitiba.

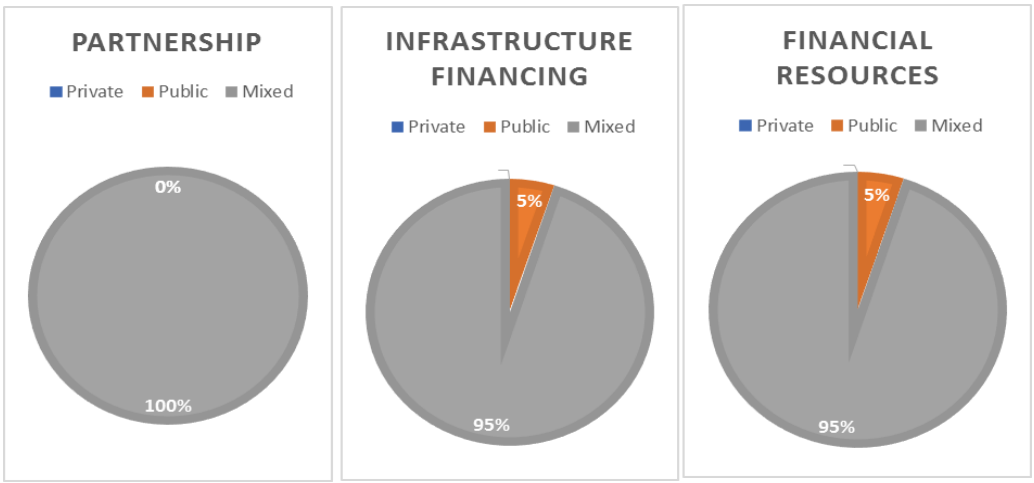


Figure 48: Business Model in Brazil

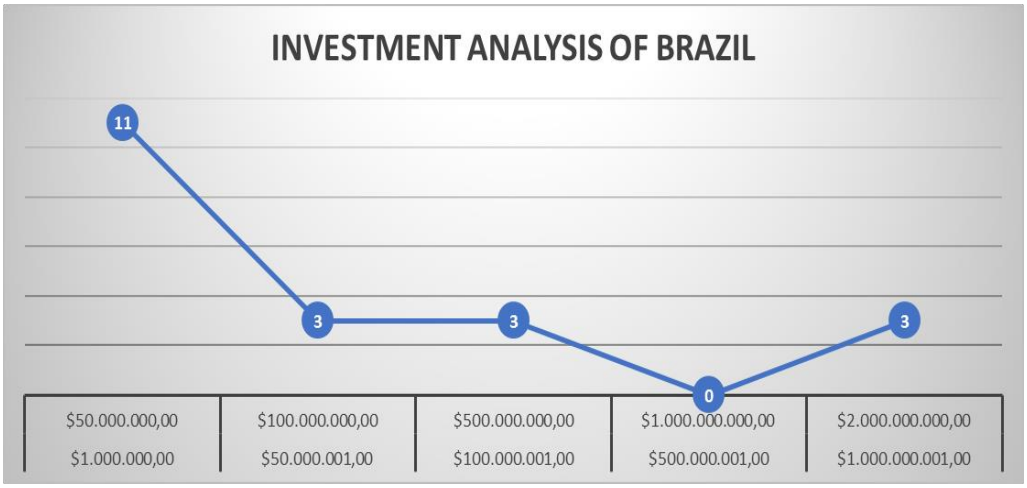


Figure 49: Investment analysis of Brazil

As shown in Figure 50, the final analysis of taxonomy is giving information about the client, product and geographic target of the projects. Definitely, the client of the SCPs is public entities in Brazil. Regarding products, 85% of projects defined their product, on the other hand, 15% of projects has no-specific products because these projects are pilot projects and they still need the approval of the technology.

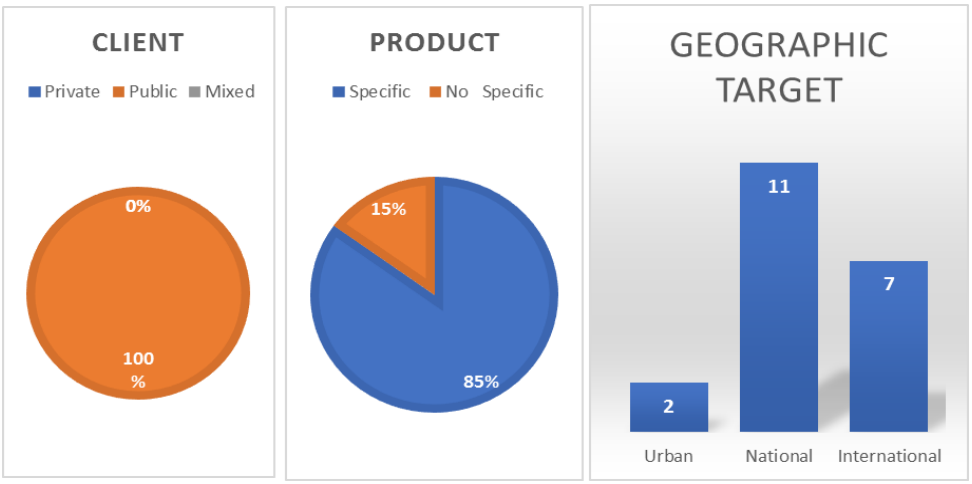


Figure 50: Purpose in Brazil

3.5 United States of America

United States of America (USA) is the most known example of the federal government. Governance consists of the different level of power and they are federal, state and local governments. Political power is divided by the federal government and local governments and constitution is the backbone of the system. The federal government holds executive, legislative and judicial powers while state governments have great influence on the individuals lives. They are controlling taxes, health and education systems, property and crime according to their own constitutional law. Therefore, each state has a different government style which is the most relevant issues of their citizens. The USA has one federal district and 50 states, and the total population is 328.238.020 in 2019. United States holds some of the records such as California is the most populous states which its GDP is equal to Italy, and New York City is the largest and most financially powerful city in the world. (World Population Review, 2019) Therefore, it is easy to note that America is one of the attracted countries to live because of its high quality of life, job opportunities, financial power, and technological and scientific advancements. Cities are getting larger every year because of immigration, consequently, infrastructures are getting old, transportation is

becoming a crucial problem. Therefore, the government has to consider smart city strategies to stay competitive, improve the quality of life and protect the environment.

The first results come from the description axis and it splits projects by sector. As can be seen from Figure 51, state governments give their attention by 60% to solve problems in the transportation sector. Then, CO2 Emission, energy, security, and social innovation follows transportation respectively 52%, 44%, 40%, and 40%.

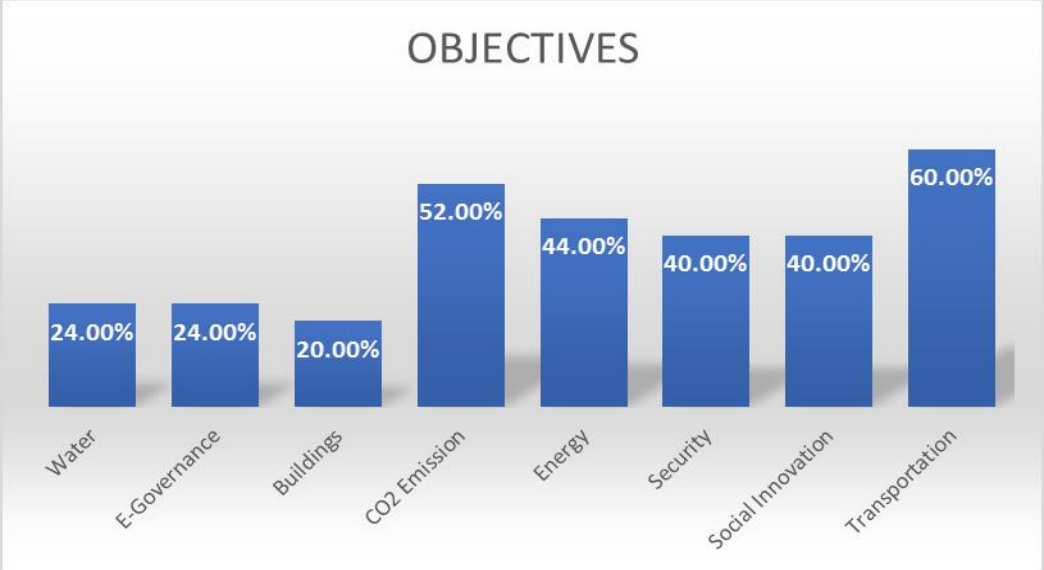


Figure 51: Objectives in the USA

Each state face the challenges about transportation. For instance, traffic congestion has serious results about cost, time and the environment. The more car on the road, the more time spent on the road and consequently CO2 emission is increasing, traffic accidents are causing death and cost. Therefore, as in the case of **Miami Easy Card System** or **Cisco Connected Rail** project, the government propose to citizen more connected public transportation system and increase the quality of citizen journeys. On the other hand, **Kansas City** or **RoadX** focus on whole transportation and logistic problems and with use of ICT, they create efficient, resilient and comfortable transportation system. **Olli**, **Bullit Center**, **Transit Hub** introduce intelligent transportation network and EVs. Lastly, parking is another problem for large cities and **PA2040** and **Array of Things** are offers smart parking system to their citizens.

Even the United States has been working on reducing crime rates, intelligent solutions give a chance to be an efficient and safe city. The increasing number of population brings together the crime and some cities offer solution with real-time data. For example, **MARTA See&Say** is an application proposed by the Atlanta Police Department. When people see

something, they simply use their phone and report the police officers. **LinkNYC** is another successful project in New York City which give information about the emergency situation in the city with digital kiosks. As it is mentioned before, increasing safety on road has great importance in the USA and most of the security objectives developed to improve road safety for drivers by real-time data.

Energy has a 40% score in the USA and most of them introduce renewable energy solutions for buildings**. Kahuku wind farm project** is implemented by the Hawaiin government to decrease its dependency on fossil fuel and protect the island environment. **Bullit Center in Seattle** is one of the first successful green buildings in the world.

Regarding social innovation, unlikely from other countries USA projects are not related to social inclusion of citizen but focus on improvement of the standard of living. **Smart Hospital Terminals** advanced the traditional health system with the use of smart health systems or **City 24/7** inform their citizen about city news and **LinkNYC** provide free wifi and charging station to its citizen.

Lastly, efficient water management systems, more transparent and digital government services, and environmental-friendly buildings are also seen as other strategies in United States SCPs.

As can be seen in Table 11, 72% of projects are multi-objective. Transportation is the most critical objective because 83% of these multi-objective projects have transportation as a strategy. The most frequent combination of transportation is with CO2 emission and security with 60% score. Most of these projects not only improve the transportation system but also introduce EVs and traffic monitoring system to protect the environment and safer travel for citizens.

Table 11: Multi-Objective projects in the USA

Multi-Objective	18	72%
Transportation	15	83%
Transportation+CO2 Emission	9	60%
Transportation+Security	9	60%
Transportation+Energy	6	40%

Transportation+Social Innovation	6	40%

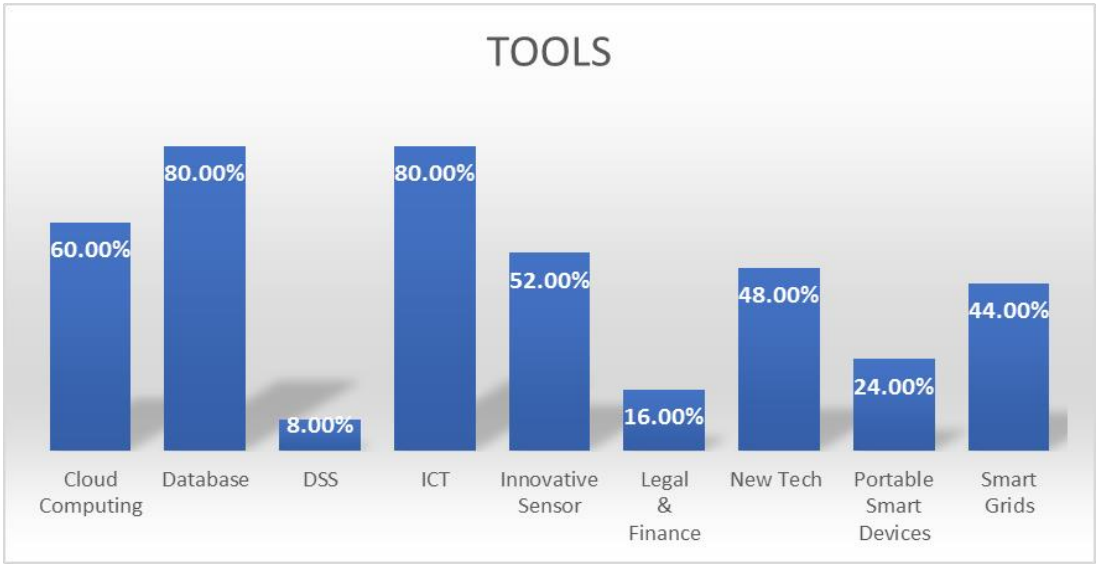


Figure 52: Tools in the USA

The United States is the center of innovation. From Boston to Silicon Valley in California, the advancement in cloud computing, ICT, sensors and database are changing our era and affect the technological advancement all around the world. As it is represented in Figure 52, ICT and database have the highest score with 80%. Cloud computing is following the trend and it is mostly used in a project like real-time data is important. Big Data and data mining are so important and with the use of innovative sensors, several states improve city management in a variety of area. Surprisingly, legal and finance instrument has a %16 score for the first time. It can be explained by the entrepreneurial characteristics of the USA. Projects such as **City Hall to Go in Boston** is one of the successful examples in smart government area where government brings serviced to underserved areas.

Regarding project initiator, we notice a remarkable result of great participation of the private sector. Because in the United States, the private sector is powerful and made significant studies about Smart cities. Such as **IBM Smarter Cities** is one of the first company to bring smart city definitions into the market. Along with the public sector, private sector in the USA such as IBM, Cisco, and AT&T initiate projects with their smart solutions. For example, Smart Hospital Terminals is initiated by Intel. Furthermore, the collaboration between the public and private sector is also noticed in Figure 53.

Figure 54 illustrates the stakeholder participation for SCPs. Citizen is the core of the project and they are actively participating with 100% score. City, administration SMEs are involved as service providers, financiers, and industry collaborators, and are also defining standards.

Unfortunately, universities are not as high as other stakeholders while they are bringing cost-efficient and innovative solutions.

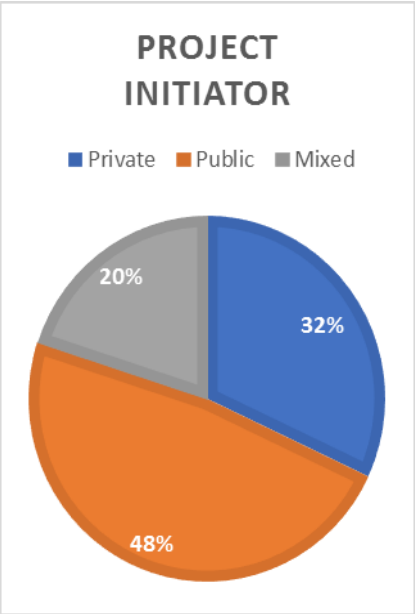


Figure 54: Project Initiator in the USA

Figure 53: Stakeholders in the USA

Next axis gives insights about business model. According to Summers (2016), all politicians agree on the improvement of infrastructure in the United States. The studies show that the investment expands the economy's capacity in mid-term and therefore, the issue is how the policy framework take form. According to her, the private sector should be part of the modernization of the US cities. Figure 55 proves her idea, in US collaboration of public and private model, is dominating partnership, infrastructure financing, and financial resources models respectively 72%, 40%, and 40%. However, in some cases, both the public and private sector are the pioneer of the SCPs. Such as **City Hall to Go** and **MARTA See&Say** are related to public services and local governments initiate, develop and implement the projects. On the other hand, **WheatherTRAK** is managed by solely private entities.

Besides business model analysis, investment analysis shows us how much money is invested by projects. As can be seen in Figure 56, the range of average investments spend on projects is between $1 million and $200 million. The reason of the enormous range is that projects like **Green Vision San Jose** ($8 billion), **Olli** ($1 billion) and **Antelope Valley Solar Ranch** ($6.4 billion) needed huge investment. Therefore, we took very large range to be able to insert all project into a specific range.

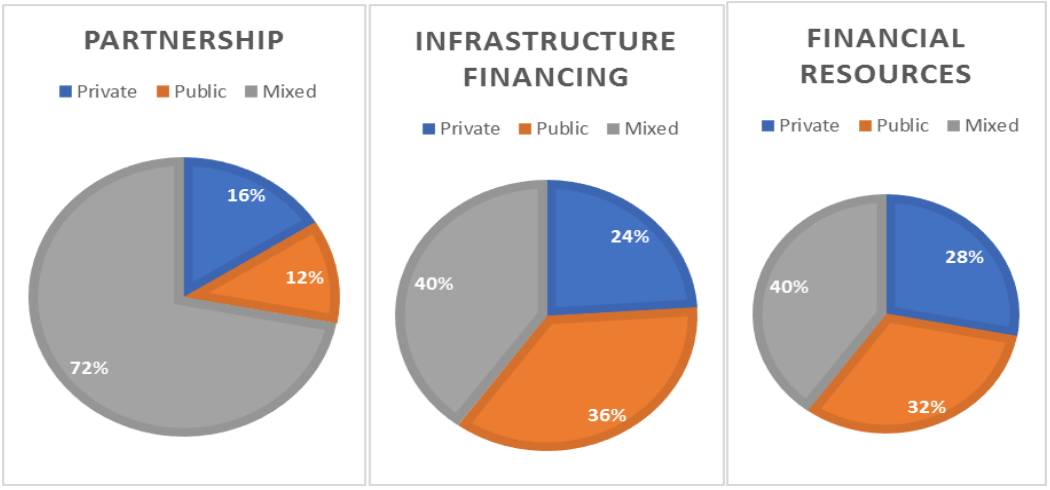


Figure 55: Business Models in the USA

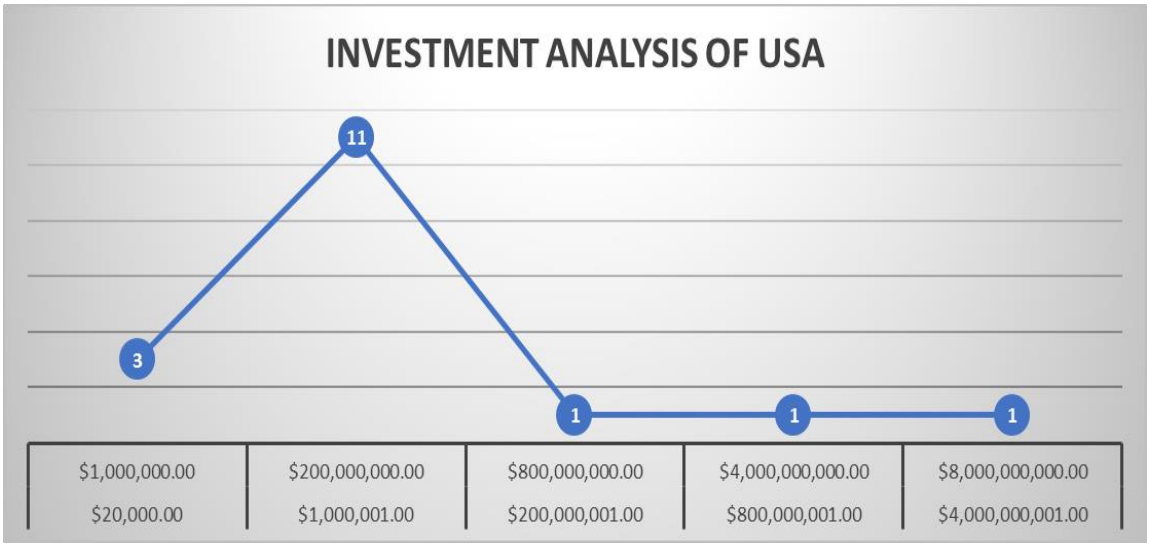


Figure 56: Investment analysis of the USA

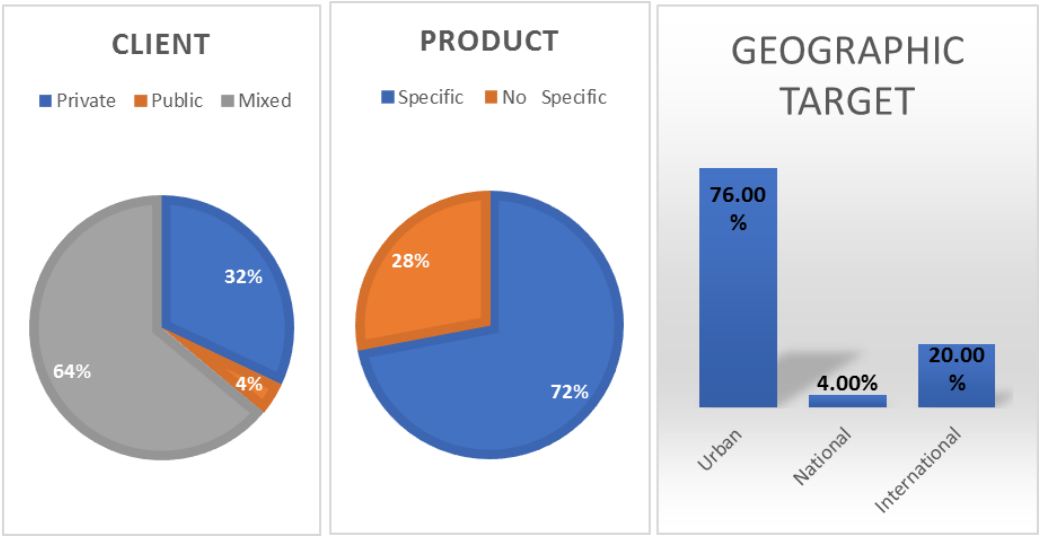


Figure 57: Purpose in the USA

Lastly, purpose analysis in the US gives detailed information about clients, products and geographic targets. As can be seen from Figure 57, 64% of projects targeted to affect citizen, cities, public entities, and private companies. 76% of projects are implemented at the urban level and Figure 58 illustrates the number of potential people affected by projects at the urban level and it increases until 8 million people with the project **Hudson Yards NYC**. Considering the product characteristics, while 72% of the product is specified, 28% of products are still under testing processes. For instance, the project **RoadX** contains **Hyperloop** project which its technology is still developing and tested by engineers.

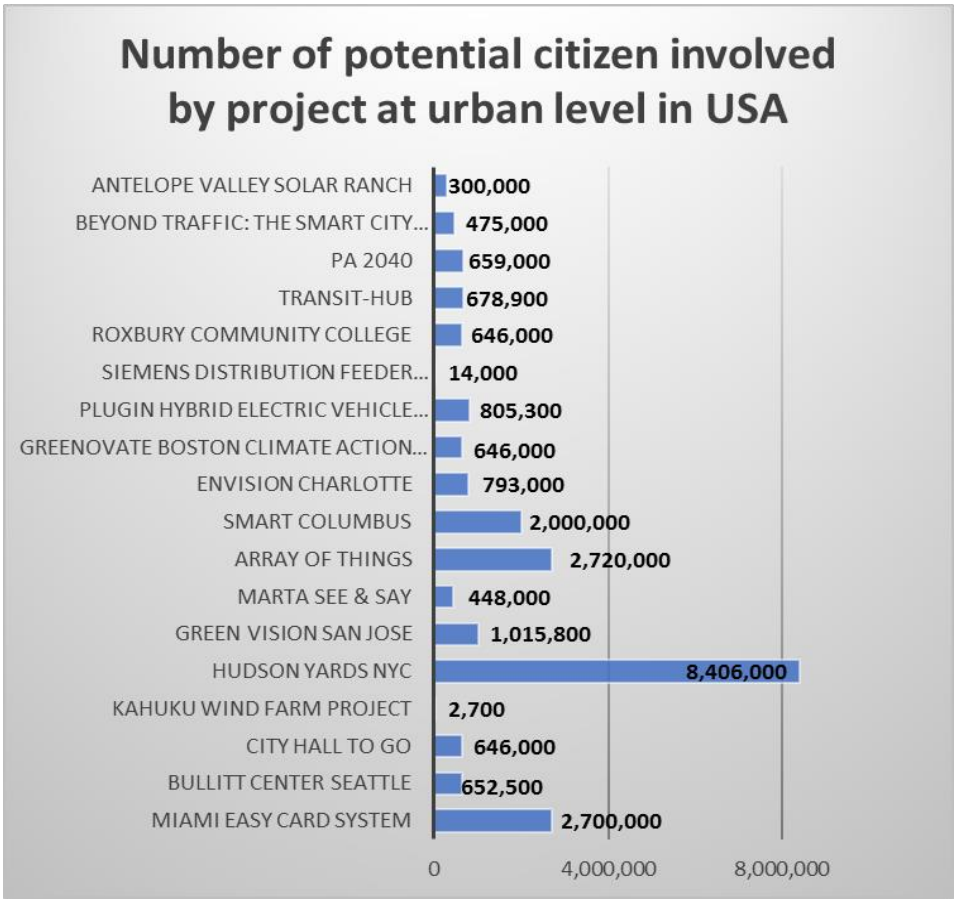


Figure 58: Number of potential citizen involved by project at Urban level in the USA

3.6 Canada

Canada is a constitutional monarchy like Japan, Australia and some countries in Europe. Canada is the second largest country in the world and because of its size, the federal structure is suitable for Canada. After the monarch (the formal head of state), the government system in Canada divided by federal government, state/territorial governments and local governments. Thanks to the federal system, like in the case of America, each state apply its own constitutions according to their own population. Each province has its own power to

control systems such as education, property, civil rights, direct taxes, hospitals, marriage, and prisons. The Canadian population is around 37 million and consists of 10 provinces and 3 territories. Most of this population live in the southern part of the country because the north is not hospitable. (World Population Review) The most crowded province is Ontario which hosts around 40% of the population and obviously the most crowded city is Toronto in province Ontario with a population of 6 million people. Thanks to its political interventions on business development and high literacy level, Canada well understand the whole aspects of smart city concept and implementing innovative solutions in their cities. For instance, Canada is one of the most successful candidates of ICF- Smart Communities contest and won the smartest city award in 2014 with Toronto and in 2016 with Montreal. Therefore, Canada gives interesting results about taxonomy analysis and can be a good guideline for other SCPs.

Starting with the first axis of taxonomy, description, there are no critical objectives that Canada focused on the most. Figure 59 proves an equal distribution among objectives.

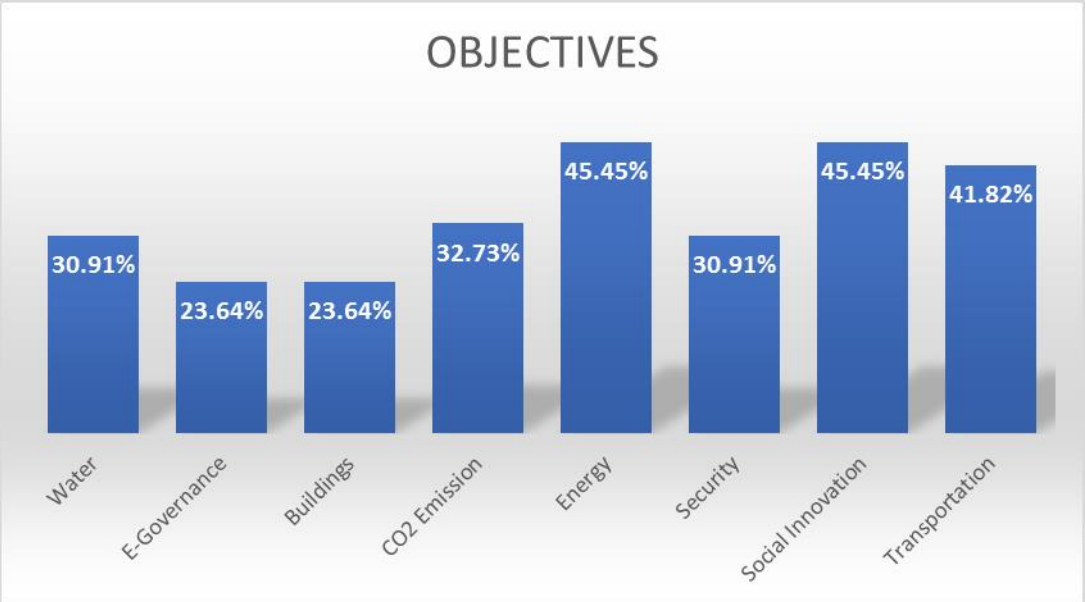


Figure 59: Objectives in Canada

Energy and social innovation have the highest score with 45,45%. Canada is searching for alternative energy sources. Projects like **Ontario wind energy**, **Manitoba Hydroelectric power plant**, or **World Renowned Waste Management Facilities** give a chance to reduce fossil fuel dependency with energy mix. When you started to use different energy sources you need to implement a smart grid to increase the efficiency of energy distribution and therefore, Canada introduce smart grid projects like **Advanced Metering Infrastructure in Saskatoon**. On the other hand, Canada offer projects that make them feel pleased in the city

and increase their quality of life**. "O Net" gigabit fiber-optic** introduce high-speed internet in Towns of Olds, Alberta, **InnoParc** in Quebec creates job opportunity and increase economy of the region, and mobile applications for the citizens like **Ask Watson** in Surrey, British Columbia, give chance to citizen to exploit public services.

Transportation is following the trends with 41,82% score. Generally, cities put transportation strategies on their frameworks like **St Albert Smart city** and **Vancouver greenest city in the world**. On the other hand, projects like **Edmonton SmartTravel app** or **Quebec electric vehicle law** offer eco-friendly mobility alternatives. These projects cover also CO2 emission objectives. Canada also works on improvements of its rails system like in the case of **Canadian Rail Portal**.

Most of the Canadian projects cover more than one objectives and their results are accompanied by other objectives. Table 12 proves that 69% of projects are multi-objective and as it is explained before energy and social innovation have the highest score among projects. The most frequent partners of energy are the objectives of the reduction of CO2 emissions and water. On the other hand, social innovation has seen with transportation and security mostly. Therefore, it is possible to conclude that Canada is showing an interest in the development of sustainable or "green" energies.

Table 12: Multi-Objective projects in Canada

Multi-Objective	38	69%
Energy	25	66%
Social Innovation	25	66%
Energy+Trasnportation	10	40%
Energy+CO2 Emission	14	56%
Energy+Water	14	56%
Energy+Buildings	10	40%
Social Innovation+Transportation	12	48%
Social Innovation+Security	11	44%

Social Innovation+E-Governance	10	40%
Social Innovation+Buildings	10	40%

Considering tool dimension, Figure 60 illustrates, ICT is the most commonly used technology as it has to be because it is one of the first tools to enable smart city projects. New technologies is another predominant tools in Canada with 58,18% score. Canada is searching for new energy sources and ways to reduce fossil fuel dependency. Therefore, solar panel systems, wind farms, or biomass energy facilities use new technologies. In spite of technological advancement in Canada, it is surprising to see cloud computing, decision support system or smart grids are the least used technologies. This can be explained by the selected projects are focusing on the development of renewable energy facilities to produce more energy and then maybe for the next step, building energy system will be placed in the Canadian SCPs strategies. Database and portable smart devices got high shares with respectively 49,09% and 32,73%. For instance, **Free ride for thoughts** and **Civic Innovation YYC** are great examples of digital communication between public entities and citizens. Citizens are writing their ideas through websites and develop projects together with government officials.

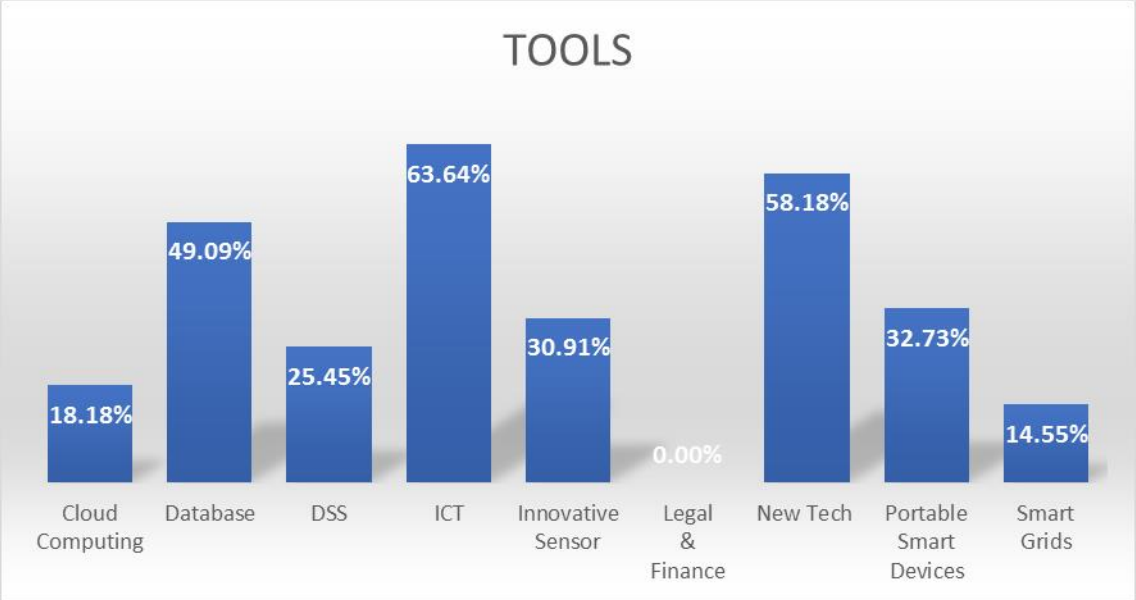


Figure 60: Tools in Canada

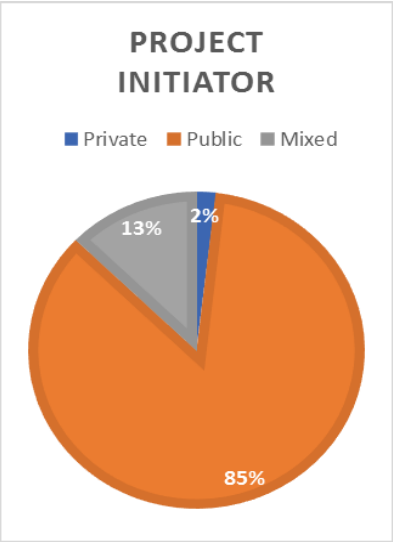


Figure 61: Project Initiator in Canada

Project initiator is illustrated in Figure 61. Like in almost all other countries governments and public entities initiate the projects. With 85% score, public entities dominate the results and 13% of projects initiated by both public and private entities. Only **Umbrela: All-in-one smart-home device** is a private initiative and also its target to enter the international smart home market.

The last dimension of description is stakeholders and it is illustrated in Figure 62. Even there is no common smart city definition, city and citizen participation are the common keywords in different definitions. Canada also proved this fact with the high participation rate of city and citizen, which are respectively 94,55% and 87,27%. Regrettably, university collaboration is very low compared with other stakeholders. As it is mentioned in chapter 2, university and city collaboration has benefits such as economic and scientific.

Figure 62: Stakeholders in Canada

Business model is the second axis of taxonomy. In this part, *partnership*, *infrastructure financing*, and *financial resources* will be explained. Investment amounts for each project

are also found for this thesis and analysis will give information about the investment range for Canada.

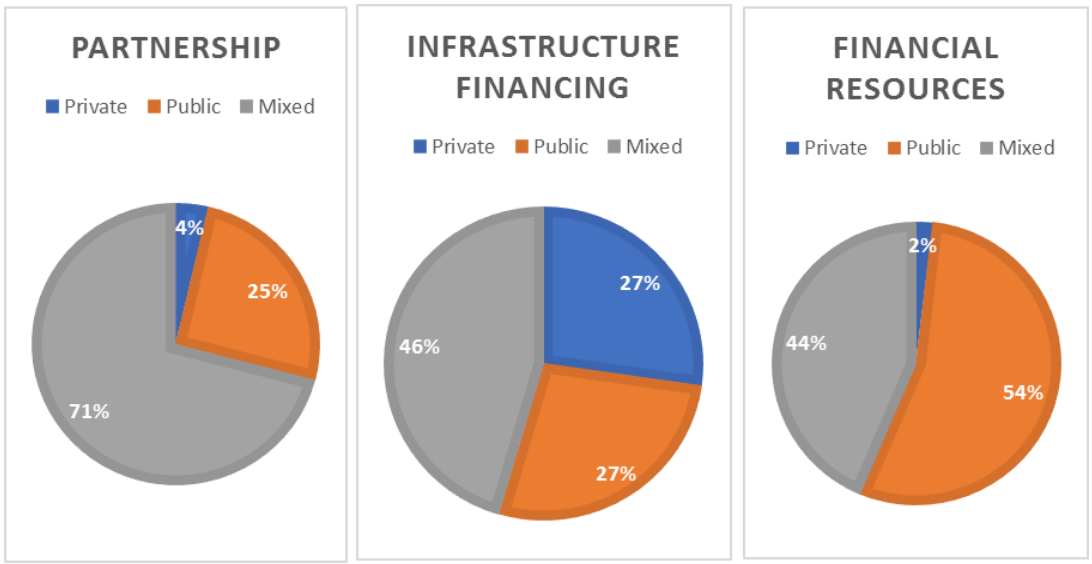


Figure 63: Business Model in Canada

As can be seen from Figure 63, a mix of private and public entities dominated the partnership with 71%. The partnership of public and private entities plays an important role in Canada such as different sectors allow the project to reach more people. For infrastructure financing, we observe equal distribution between private and public entities and a mix of both dominated the result. The federal government is not enough to fund all cities therefore, public entities such as local government funds and private sector financing instruments are very important to implement projects. Lastly, financial resources mostly come from public entities like green bonds. However, not only public entities can solve the realization phase of the projects, therefore, a mix of public and private entities also play an important role. Figure 64 shows the investment analysis of Canada, the average range is between $1 million and $100 million. The investment amount is increasing until the peak of $16 billion with the project **UP Express airport rail line.** Therefore, we can sum up business model analysis that Canada needs an enormous amount of investment and only federal and local government can't effort to fund projects. Planning, implementation, realization and controlling of projects need a new business model. As Figure 63 and 64 presents the government of Canada made a collaboration with the private sector and the lead to Canada one of the successful countries to actualize SCPs.

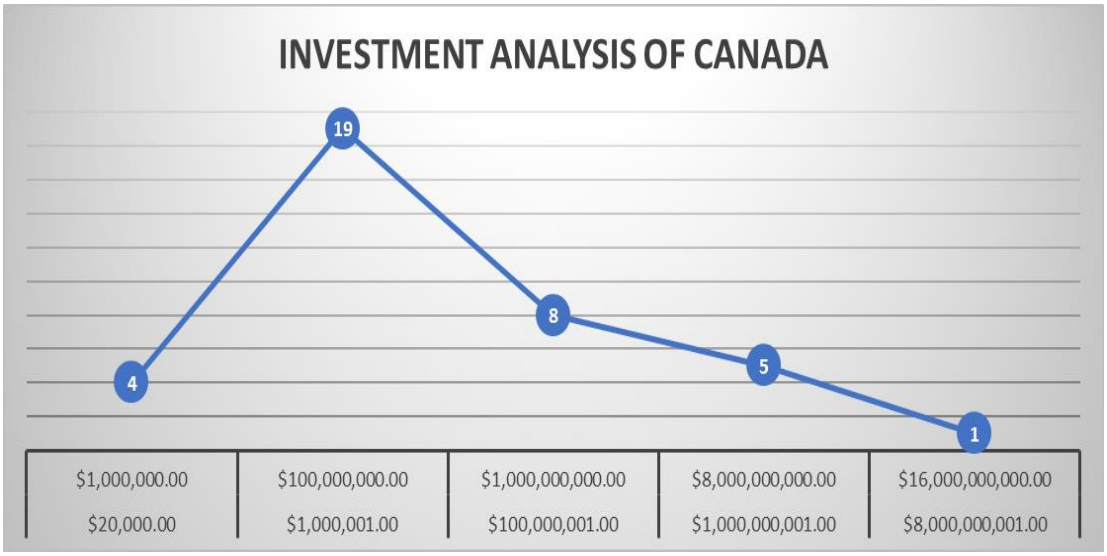


Figure 64: Investment analysis of Canada

The last axis of taxonomy, purpose, gives information about outputs of projects. Figure 65 illustrates the results of clients, products and geographic targets. Considering the client, 62% is mixed, 31% is public and 7% is the private client. Regarding product characteristics, more than half of the project, 73%, identify and test the characteristics of the products. 27% of products are still testing or technology is still under development.

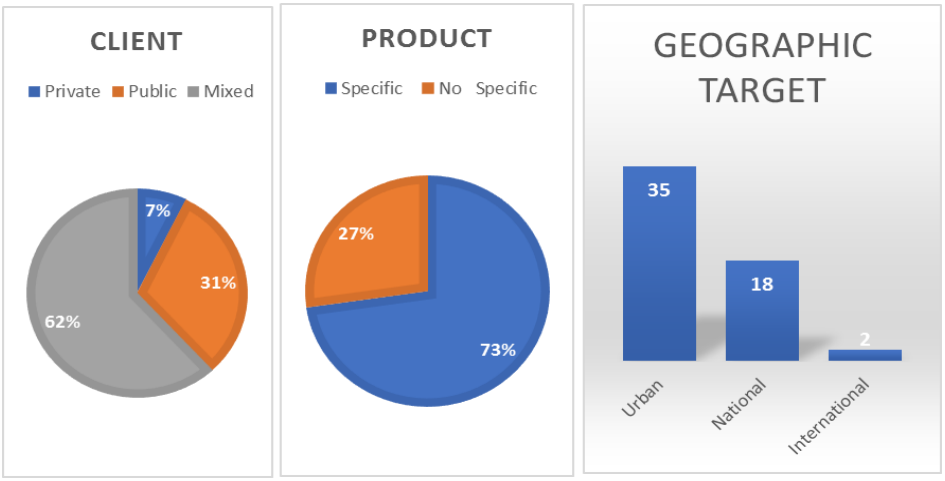


Figure 65: Purpose in Canada

Most of the Canadian projects are at the urban level. Because of political systems of Canada, local governments focus on the high quality of their own citizen. On the other hand, projects like **Smart corridor Ontario-Quebec** create a transportation corridor to foster trade between different provinces and increase the efficiency of the supply chain. Figure 66 illustrated the number of potential people affected by each project at an urban level. Most of the project is implemented in metropolitans of Canada such as Toronto, Montreal, and Edmonton.

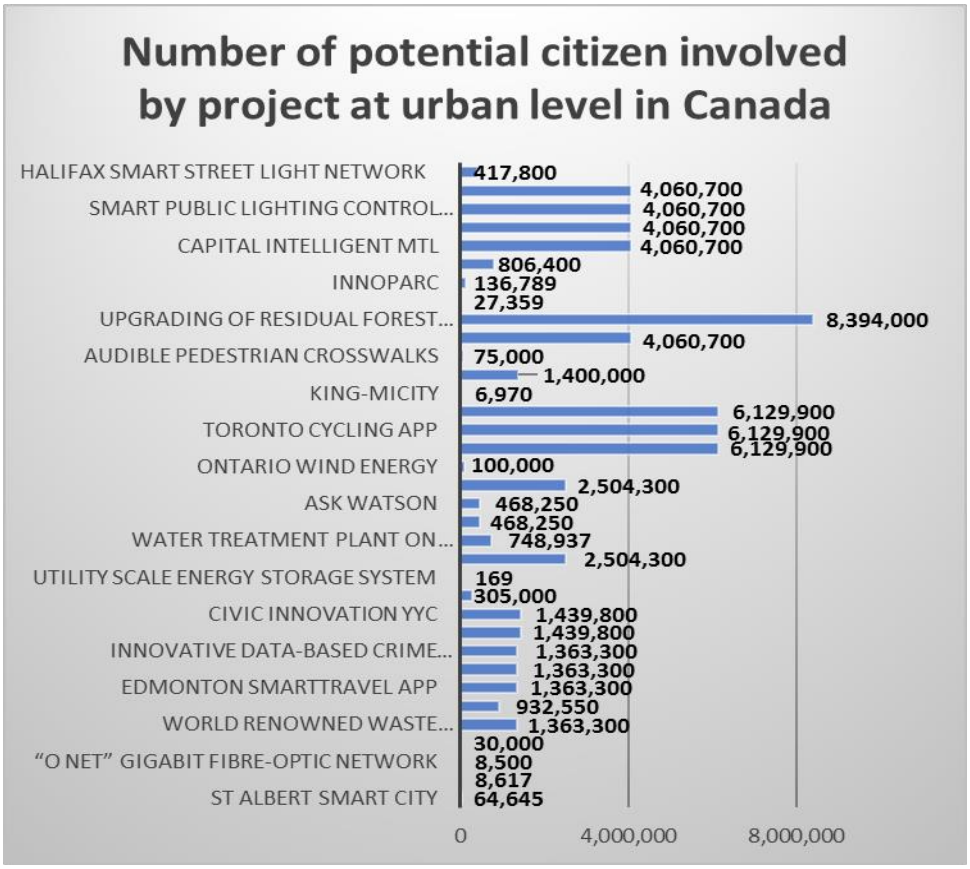


Figure 66: Number of potential citizen involved by projects at urban level in Canada

3.7 Statistical Analysis

During the research process, each collected data were identified on each case studies, then final results of each projects collected for each countries. Lastly, the results of each country merged in one file. In this part of the thesis, each dimension of taxonomy will be analyzed at global level by comparing the results of different countries. Further, qualitative data analysis and statistical correlations allow us to find better urban development within smart cities.

Objectives

- **Water**

Figure 67 shows 39,58% of Asian SCPs and 30,91% of Canadian SCPs are paying attention to water issues, while Brazil and Europe are focusing on other objectives more than water. In Asia, especially India mainly focuses on efficient water supply system. For example, **Smart City Challenge-Belagavi** has strategies to implement water metering, increase water quality, implement rain forest harvesting and improvement of lakes around the city. On the other hand, Canada focuses on hydroelectric power plants

construction. Projects like **Manitoba Hydroelectric power plant** aims to produce renewable energy from water. These two projects show that same objective has different SCPs according to requirements of the countries.

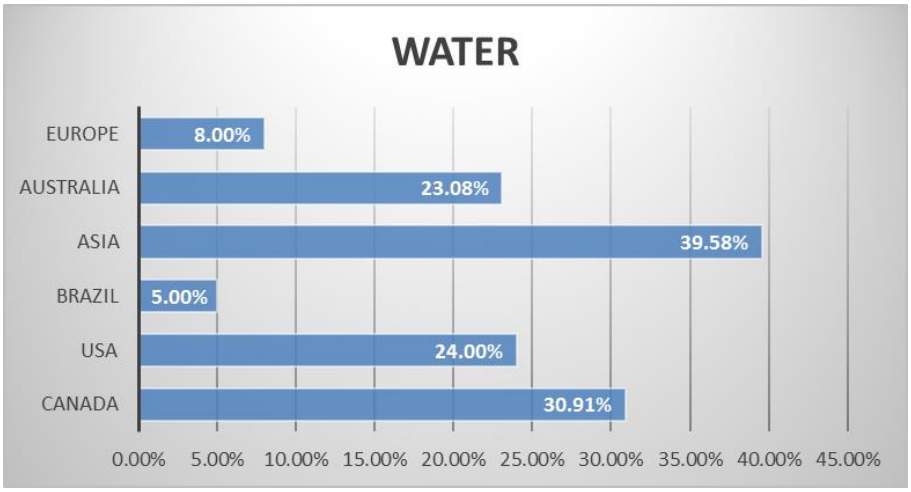


Figure 67: Distribution of "water" among regions

- **E-Government**

Figure 68 proves that each country is aware of the importance of e-governance and consider as one of their objectives. However, Asia is the leader of e-governance projects. Especially in China, transparency, data sharing and interconnection with the citizen are one of the key tasks and it is widely applied in the strategies of governments.

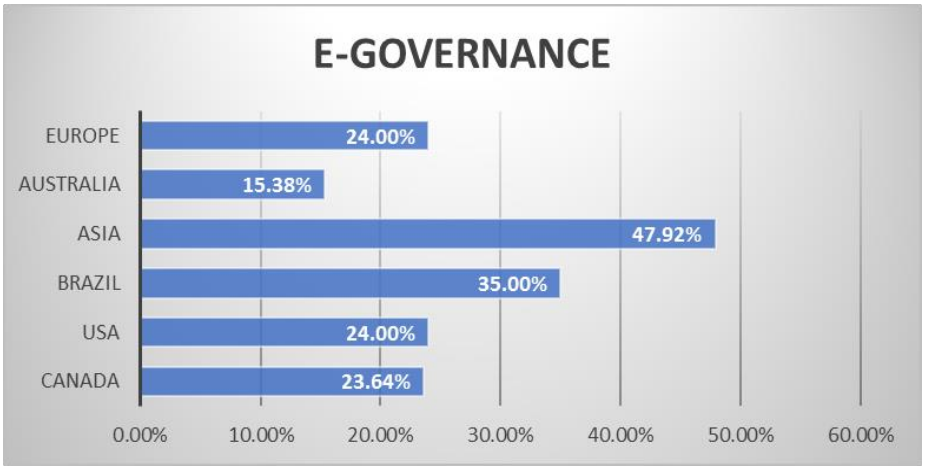


Figure 68: Distribution of "E-Governance" among regions

On the other hand, countries like Europe, Australia, Canada, and Europe has fallen behind Brazil and Asia. The reason behind this result, these countries started to use electronic means of communications between citizen and government for a long time ago. Therefore e-government services are well established and we do not witness it projects too much.

- **Buildings**

It can be seen from Figure 69, Europe focuses on retrofitting more than 50% and more than in other countries. This is because of the aim of reaching the target of Horizon 2020 which aims to reduce CO2 by 20% until 2020. Another reason behind this, European cities are already existing cities and local governments try to increase the energy efficiency by implementing retrofitting strategies or smart metering system into the buildings. However, smart metering systems, solar panels or smart home appliances are also seen as building strategies in other countries.

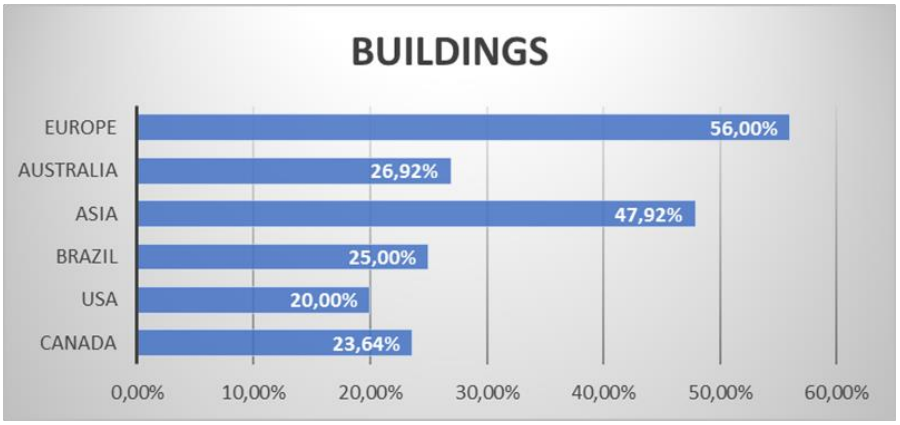


Figure 69: Distribution of "buildings" among regions

- **CO2 Emissions**

Figure 70 illustrates Brazil is 100% working on reducing CO2 emission by introducing smart grid or developing solar panels as an alternative energy source. Besides, transportation is the main source of CO2 emission, every country is introducing innovative alternatives to transportation. Therefore, we can find a trend between CO2 emission and transportation later.

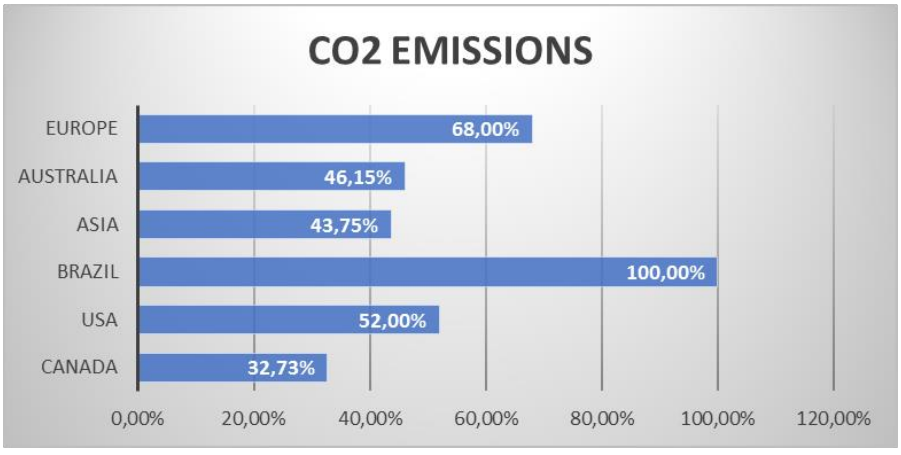


Figure 70: Distribution of "CO2 Emissions" among regions

- **Transportation**

Figure 71 represents each country implement serious strategies about transportation with more than 40% weight.

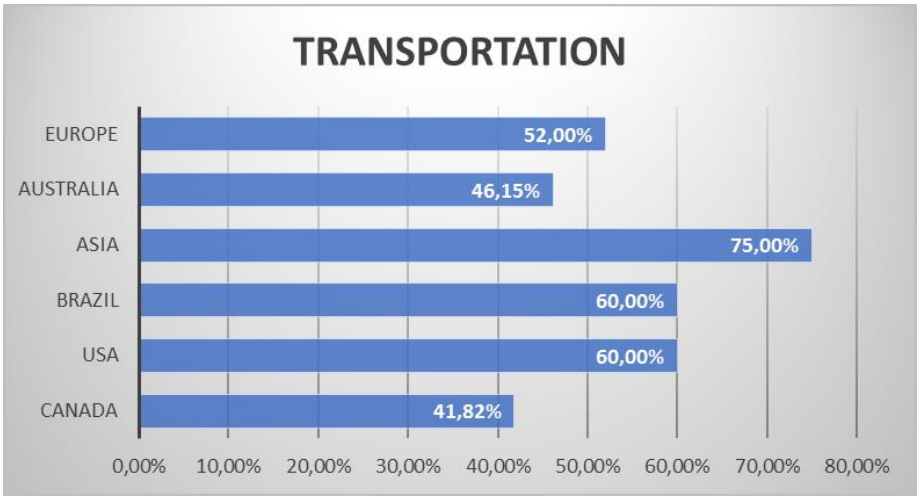


Figure 71: Distribution of "transportation" among regions

In Europe and Brazil, intelligent transportation systems such as EVs are widely used. On the other hand, Australia and the USA develop strategies to build the safest and most modern roads. The project **RoadX** in Colorado, create an integrated system where drivers will be informed about weather, traffic congestions, or accidents with the use of sensors, thanks to IoT technologies, driverless cars will communicate each other, **hyperloop** system will offer clean and fast transportation between long distances. While Australia, improve its rail systems between cities such as the project of **New South Wales Long Term Transport Masterplan** is building more than one rail system projects across the state.

- **Energy**

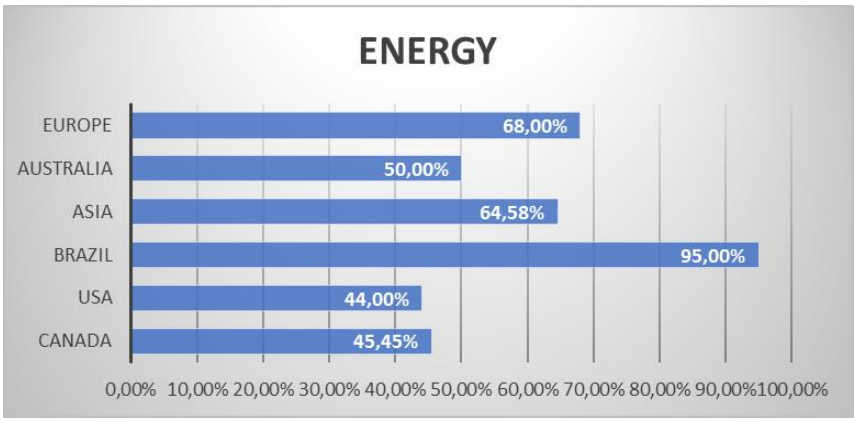


Figure 72: Distribution of "energy" among regions

As follows from Figure 72 shown above, energy has the highest distribution among other objectives until now. Because of the critical role of energy in a city, city leaders start their smart city strategies with energy projects. According to Worldbank report (2016), second largest infrastructure investment gap is for electricity which is $2.9 trillion. The majority of gap is coming from developing countries as it can be seen from the Figure 72, Brazil has the highest share for energy.

- **Security**

Asia is one of the prior countries to implement video surveillance all around the countries and try to achieve high public safety is shown in Figure 73. Increasing population growth brings safety problems. Therefore, Asian countries have to implement serious security projects by collecting data. On the other hand, other countries use data for security in other areas such as natural disaster. For example, ın the project **Smart Oceans BC**, scientists collect data from the ocean activities and proposing preventive solutions.

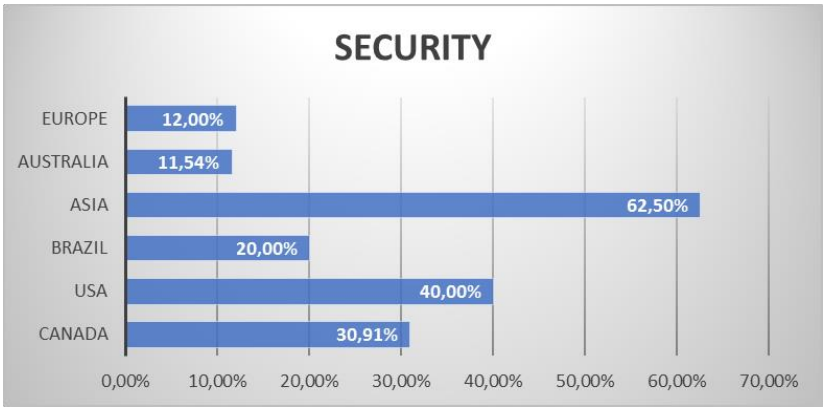


Figure 73: Distribution of "security" among regions

- **Social Innovation**

As shown in Figure 74, Asian countries are the first place of social innovation strategies. Because of the aging problem of several Asian countries, significant population growth in China, and increasing number of natural disasters around Asia drive the governments of these countries to ensure high quality of life of their citizens and make competitive their cities around worldwide.

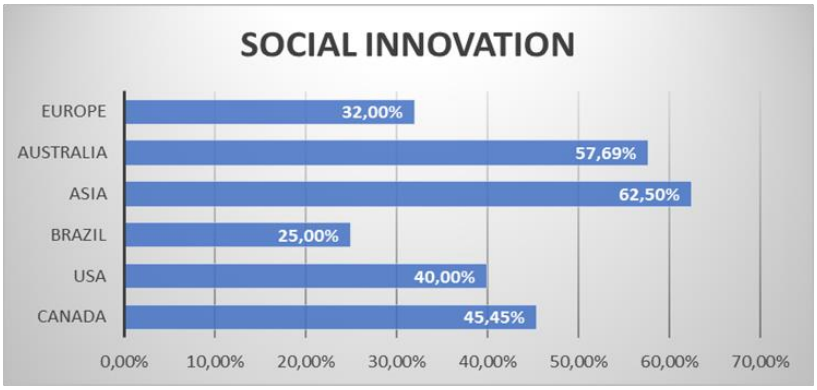


Figure 74: Distribution of "social innovation" among regions

Tools

Figure 75 proves ICT is the most important technology to build a smart city. According to the literature, both enabling the participatory governance, the management and interpretation of data require ICT. After ICT, new technologies are the second most widely used tools in Europe and Brazil. Because new technologies means innovative and particular solutions because of the specific needs of that city. Europe and Brazil focus on applying environmental solutions, therefore, they use new technologies such as solar panels, smart metering systems or wind turbines as well as traditional technologies.

The analysis of this thesis gives a chance to find positive correlations between objectives and tools. This is illustrated in Figure 76. New technologies such as smart meters, renewable energy systems are used to enhance improvement in energy management. The same relationship is found also between CO2 Emission and ICT, Transportation and Database.

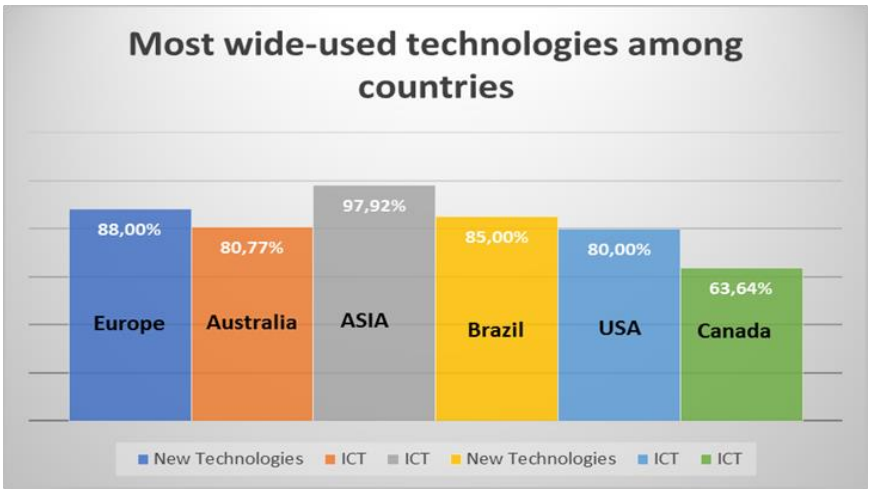


Figure 75: Most wide used technologies among countries

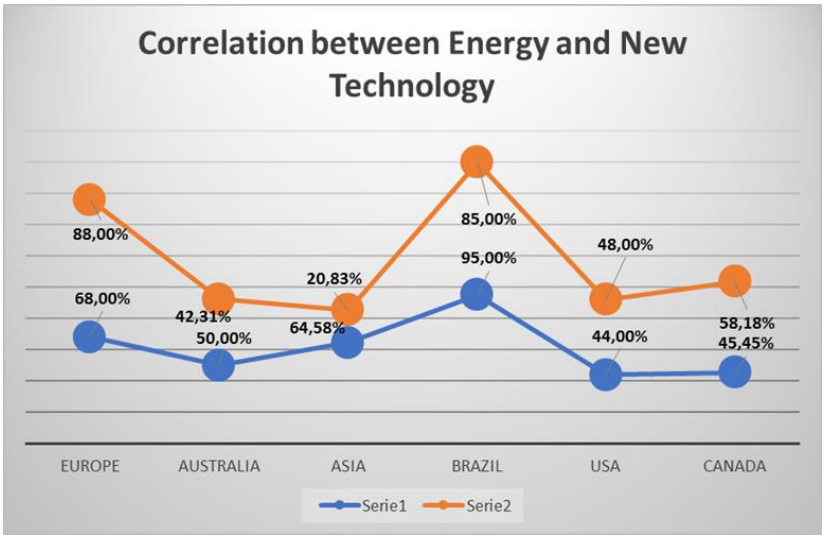


Figure 76: Correlation between "energy" and "new technology"

Stakeholders

Thinking only the technological part of the smart cities is one of the worst strategies could be undertaken. When developing a smart city project, all other stakeholders voice has to be listened and take into consideration during the different phases of the projects. Citizen participation is one the key point in smart cities to be appreciated and successful. On the other hand, SMEs participation fosters the implementation of the project and bring new technologies. Figure 77 and 78 illustrate high participation of SMEs, city, citizen, and administration with almost full participation. However, university participation is very low compared with other stakeholders. Especially in countries like Australia, Asia, the USA, and Canada.

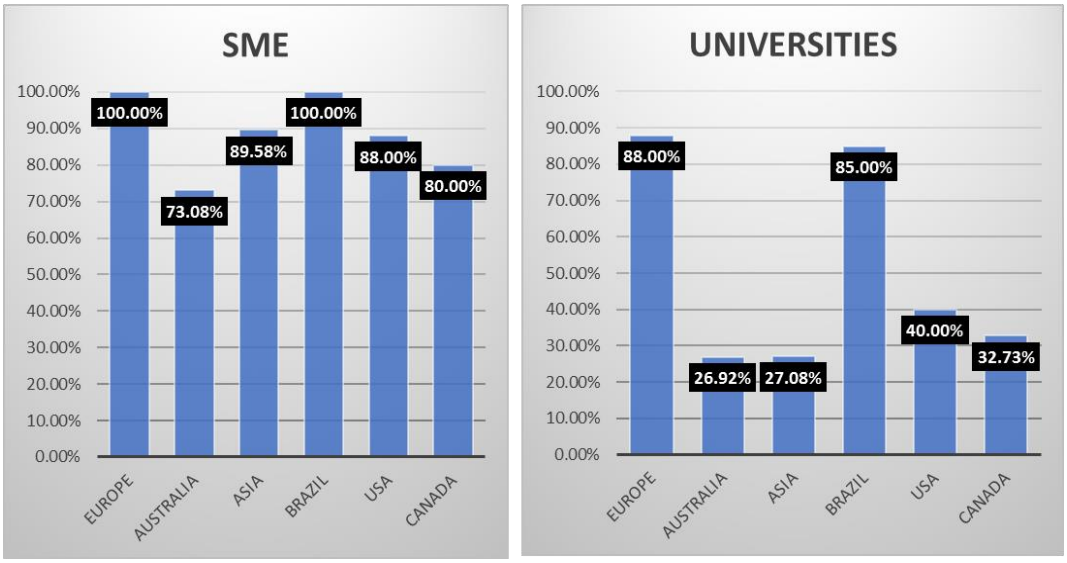


Figure 77: Distribution of SMEs and Universities among regions

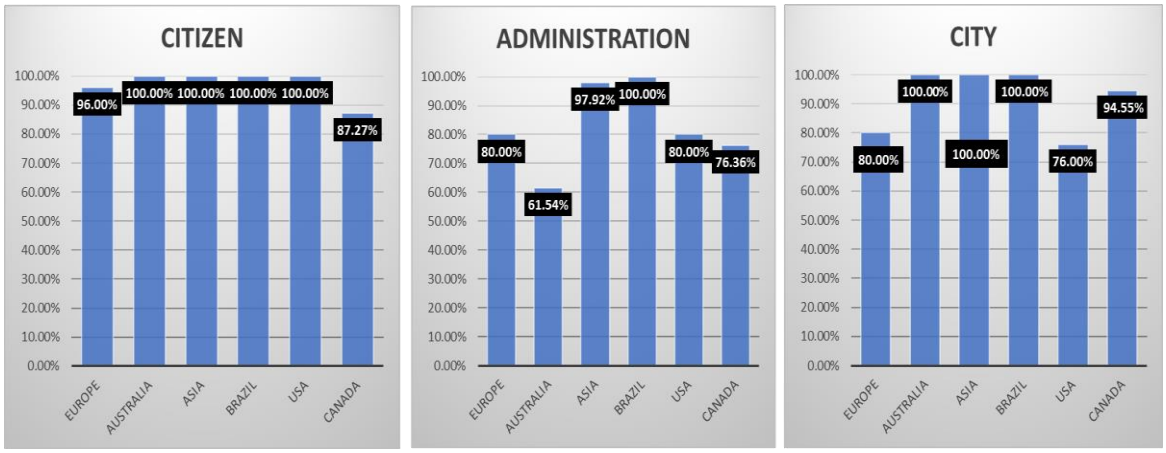


Figure 78: Distribution of Citizen, Administration and City among regions

Project Initiator

Private project initiator is not the common case at the global level except the USA. 32% of projects initiated by private companies. For instance, **Intel** presented a **Smart hospital terminal** to connect and intellectualize of the health system and provide better hospital experience.

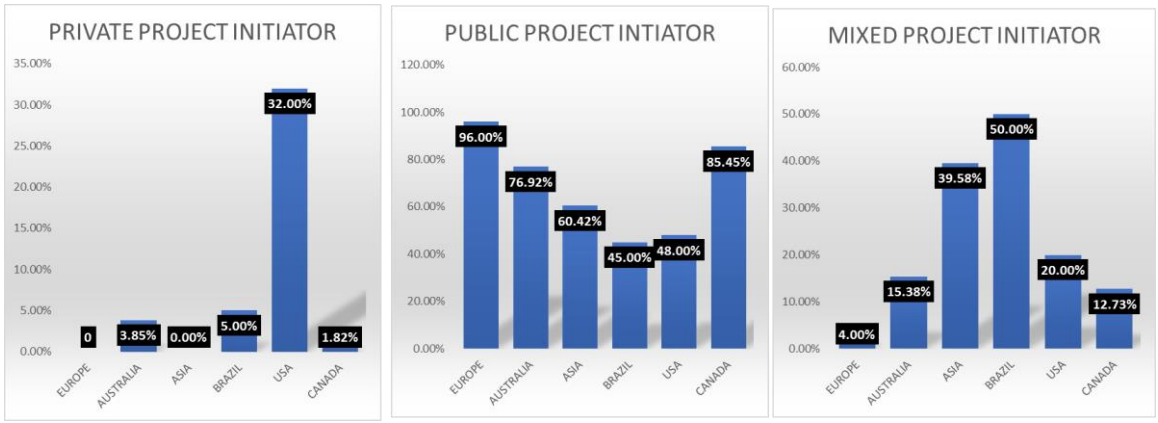


Figure 79: Distribution of "Project Initiator" among regions

Figure 79 presents most of Brazil projects choose mixed project initiator where the government works closely with the private sector. Relevant to the economic situation of Brazil, it is a good solution to achieve successful SCPs. While Europe, Australia, and Canada find its initiatives from public entities such as from the EU.

Business Model

- **Management/Partnership**

  As can be seen from Figure 80, in the case of America private partnership hold leadership of management of SCPs. Because there is powerful cooperation which they are leading

SCPs not only in the USA but also worldwide. On the other hand, Canada also trusts public partnership more than only having a private partnership. In conclusion, PPP is the best solution for each region because it also gives a chance to countries to become more competitive with using this own infrastructure to collaborate with local or international companies.

- **Infrastructure and Equipment Financing**

As shown in Figure 81, European companies are willing to pay the capital cost, on the other hand, half of the Australian projects have supported by the public and the other half has supported by mix. While mixed is seems a better option among countries where they mostly choose sharing the cost between public and private ownership.

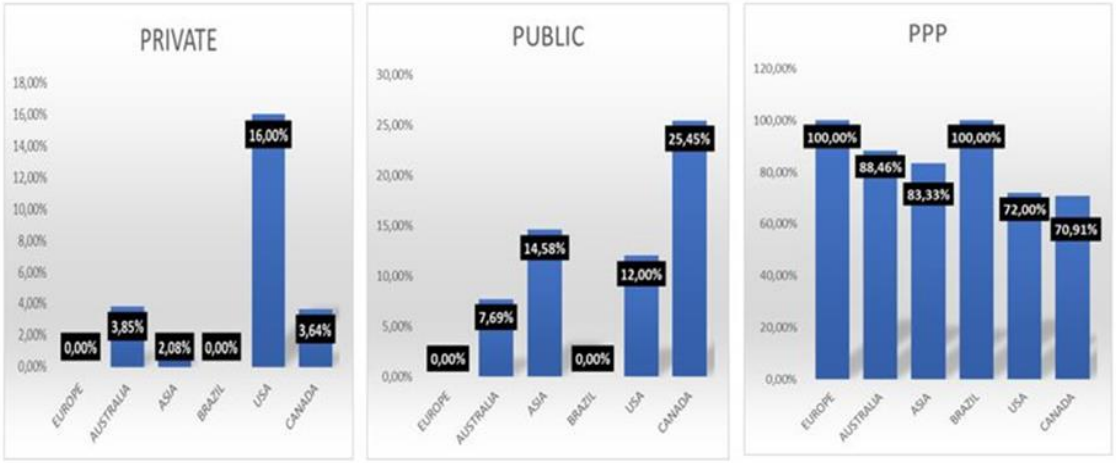


Figure 80: Distribution of "Management1 among regions

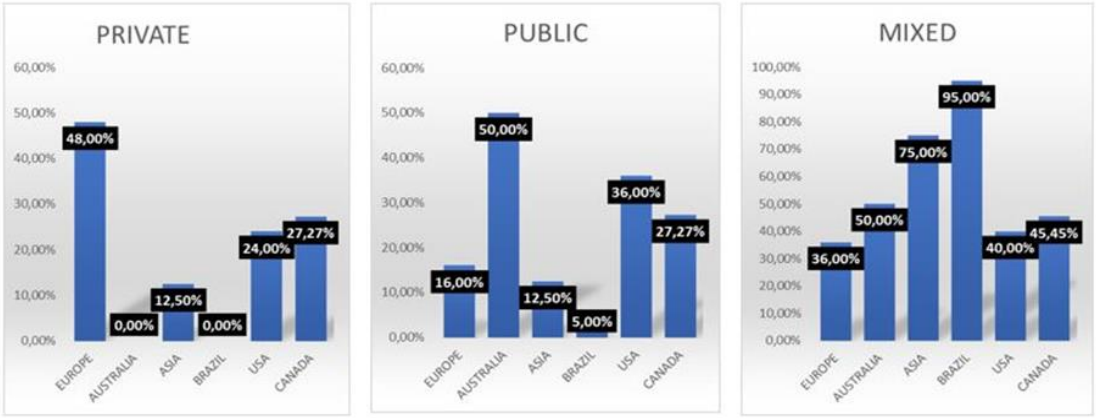


Figure 81: Distribution of "Infrastructure and Equipment Financing" among regions

- **Financial Resources**

Figure 82 illustrates that Europe, Asia, and Brazil choose to PPP funding methods for most of their projects while the USA funds its projects from private instruments and Australia use public funds.

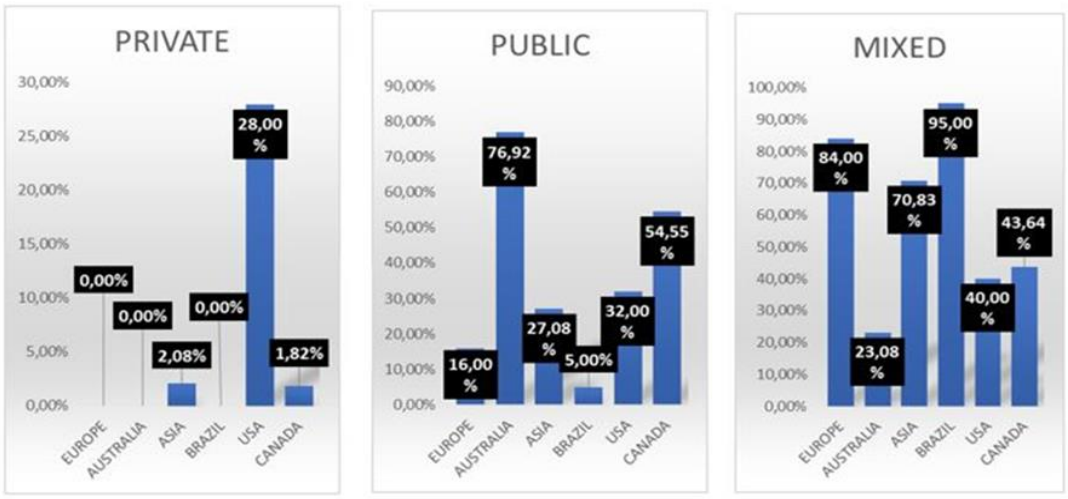


Figure 82: Distribution of "Financial Resources" among regions

Purpose

- **Clients**

Figure 83 outlines that governments are the main beneficiaries of SCPs with 100%, in USA and Europe citizen or SMEs, are important clients for SCPs but still, it has no significant results in the case of Brazil public clients or mixed clients. Lastly, most of the SCPs are aiming to reach a combination of public and private clients all around the world that they will ensure high efficiency.

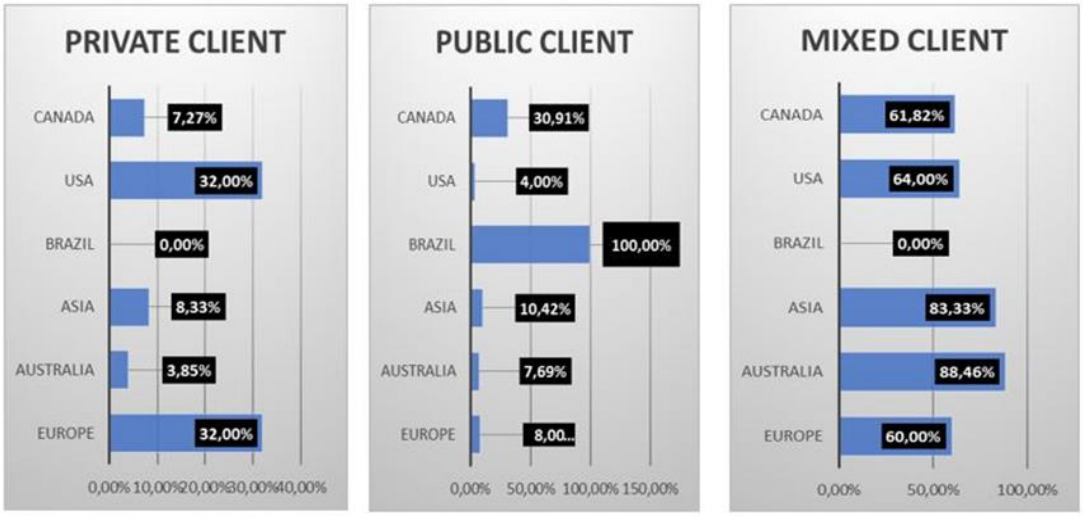


Figure 83: Distribution of "clients" among regions

- **Product**

Figure 84 proves that most of the time, SCPs develop and implement a clear specific product. Europe identified the characteristics of the products in all projects, while Asia has the highest score in no-specific product axis with 37,50% score. The reason behind

this result is that Asia has lots of pilot smart city projects and in those projects, some technologies are still under testing phases or developing.

- **Geographic Target**

Figure 85 indicates some significant results such as Brazil has more projects on the national level than urban and international level, Europe develops almost all projects aim to benefit on the international level. For other countries, they usually implement SCPs for their specific cities.

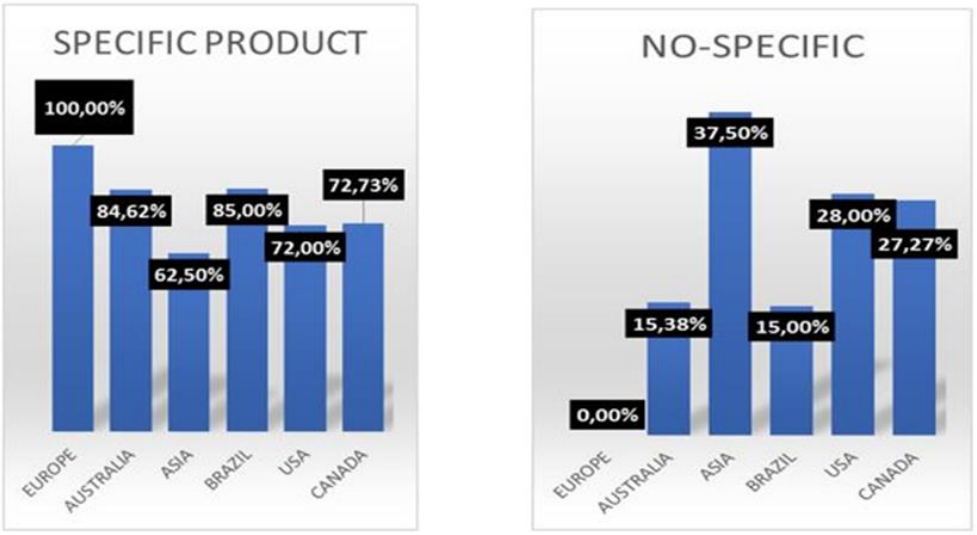


Figure 86: Distribution of "product" among regions

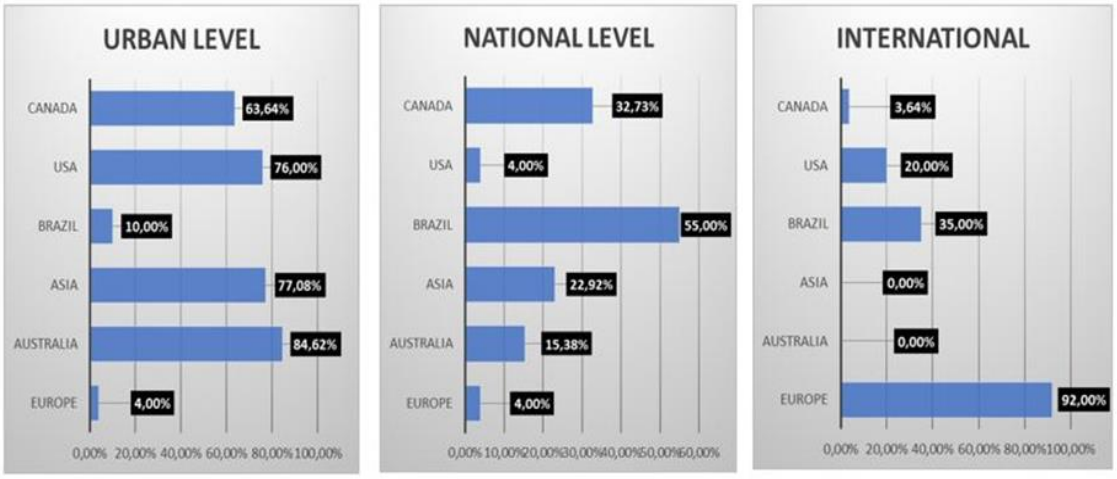


Figure 87: Distribution of "geographic target" among regions

3.8 Cluster Value Proposition

Cities are complex systems where the citizen, government and businesses interact between each other through some systems such as housing, transportation, utilities (energy, water, sewage, and so on), sanitation, communication, health, and education systems. Smart cities offer innovative solutions to these systems with the use of ICT. However, this complexity brings some critical problems for governments and private companies. The aim of this thesis is helping stakeholders of cities to identify a new business model for achieving successful SCPs. Therefore, we used the taxonomy introduced by Perboli et al. (2014) to compare different SCPs around the world. Other taxonomies also can be used for benchmarking but this taxonomy will help us to clarify the business models trend for SCPs. In the previous part of the thesis, each dimension of the taxonomy was analyzed and according to these results we merge all information and create a cluster value proposition. The detailed explanation about the methodology of this value proposition is explained in chapter 2. In this part of the thesis, firstly the macro categories of value proposition will be analyzed by each country and then introduce the global picture of the macro category which gives insights about the trends all around the world. Later, cluster analysis will present the most critical value propositions by each country and filtered by macro categories.

At the end of this chapter, the reader will have ideas about which smart city value propositions solve the critical problems of the cities around the world.

As we analyzed in Chapter 3, each continent has different focus areas to implement SCPs. Figure 88 illustrates the global analysis of behavioral, economic, environmental, operational&technological, and social macro category. Asia is boosting SCPs in almost every category from behavioral to social. However, Asia especially dominating the behavioral objectives with 48% score. For example projects like **iPUDONG New Area** or **Seoul** training its citizens about smart city services or giving free access to information. The unprecedented population growth led Asian countries to increase urban monitoring system sensibilization (40% of projects in Asia monitoring its urban areas). On the other hand, social objectives are also critical for Asia. (42%) Such as **the Thai Law Enforcement Agency Optimizer** aims to increase public safety, **Kanaiwa Hospital** project offers a better health system, **eGOVERNMENT-Nanjing** only focuses on e-government services. It is easy to note that, Canada focus on economic categories with 30%. For example, Canada improves investment and funding instruments with projects like **Capital Intelligent MTl, Smart Grid Fund,** and **Convergence**, or create potential economic

growth with projects **InnoParc, Waterfront Toronto, "O Net" gigabit fibre-optic network**. Definitely, Europe focuses on the environmental category where almost all of the project aims to improve buildings efficiency, clean environment, reduction of CO2 emissions and eco-friendly transportation alternatives such as electric bike (**ELE.C.TRA**) or car/bike sharing (**SmartenCity**) and EVs (80%of projects). On the other hand, Brazil faces critical energy problems as a country. The dependency of hydroelectric power and fossil fuel, push the Brazilian government to find solutions in operational technological and environmental categories such as smart grids, EVs, renewable energy sources like photovoltaic systems or wind farms. Surprisingly, the behavioral macro category has 1% and the social category has 3% from Brazil, and it means that compare with other countries Brazil has more serious problems about energy, economy, and politics. Both Brazil and Europe have the highest share in the environmental category with scores respectively 23% and 21%, but these two countries have different motivation to implement strategies related environment. Lastly, the USA, Canada, and Australia do not significantly focus on one objective. Especially, participatory democracy is one of the key actions undertaken by Canadian SCPs. **Alberta Smart city Alliance, Civic Innovation YYC,** and **Freeride for thoughts** are just some of the examples. Australia has the highest score (19%) on behavioral category. On the other hand, the USA has the lowest score in the behavioral category. (%6) To sum up, both countries are achieving more than one objectives at the same time with one projects. For example, **Smart Cities Plan in Australia, Melbourne Smart City, Hudson Yards NYC, Beyond Traffic in the USA** have strategies in these five categories.

In conclusion, the cluster value proposition analysis summed up in Figure 89. According to the pie chart, the social category has 31%, the operational&technological category has 21%, the environmental category has %19, the economic category has 16% and the behavioral category has 13%. The most critical problems are related to the social category and most of the projects are proposing a value through SCPs such as new infrastructures, diversity of housing type in the city, smart services for the citizen, efficient management of data, emergency warning system, and improvement of employment and job inclusion.

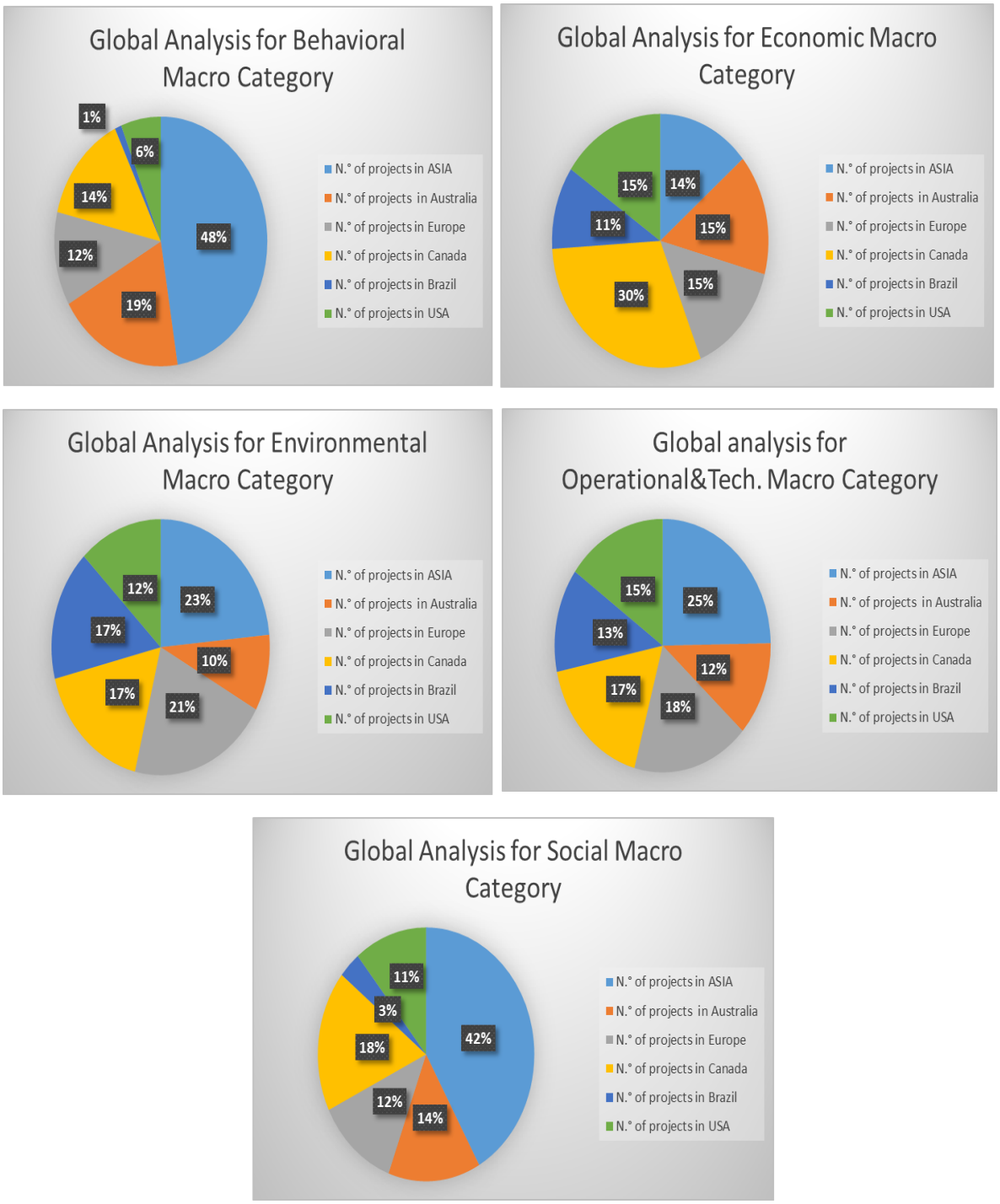


Figure 88: Macro category analysis at global scale

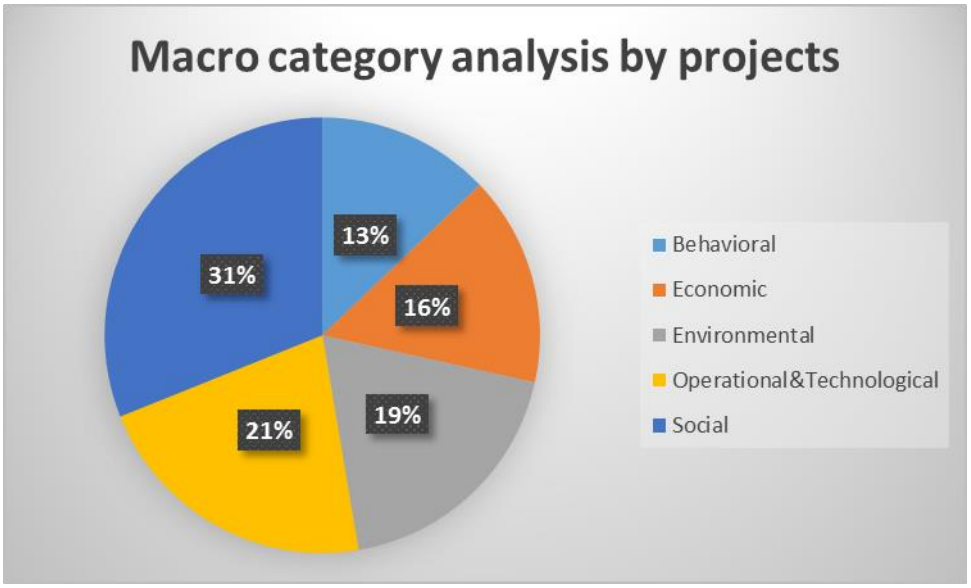


Figure 89: Macro category analysis by projects

Lastly, Figure 90 gives a picture of SCPs and their value propositions. At the global level, management of energy consumption, participatory democracy, reliable management of the grid system, renewable energy, and smart services for citizens are the key areas in which smart city development was focused in each situation.

Some of the best examples of SCPs in these areas:

Management of Energy Consumption: Gujarat Smart City in India, Sydney Decentralized Energy Master Plan in Australia, GRID4eu in Europe, Advanced Metering Infrastructure in Saskatoon, Canada, Cidades Do Futuro in Brazil, Bullitt Center Seattle in the USA.

Participatory Democracy: Ningbo in China, Digital Canberra in Australia, CROSS in Europe, Alberta Smart city Alliance in Canada, City 24/7 in the USA

Reliable Management of Smart Grid System: Jeju Island Smart Grid Test in South Korea, Intelligent storage for Australia's grid in Australia, City-ZEN in Europe, Schneider Electric Smart Grid Laboratory (SESG Lab) in Canada, Paraná Smart Grid in Brazil, Siemens Distribution Feeder Automation Orangeburg in the USA.

Renewable Energy: Low-Carbon Society System in Toyota City in Japan, Sydney Advanced Waste Management Treatment Master Plan in Australia, TRIANGULUM in Europe, Manitoba Hydroelectric power plant in Canada, Projects about clean energy – Furnas in Brazil, Greenovate Boston Climate Action Plan Update in the USA.

Smart Services for Citizens: New Songdo in South Korea, Smart Cities Plan in Australia, Replicate-Florence in Europe, Quebec web portal: SmartGuide software in Canada, ELETROPAULO Digital in Brazil, Array of Things in the USA.

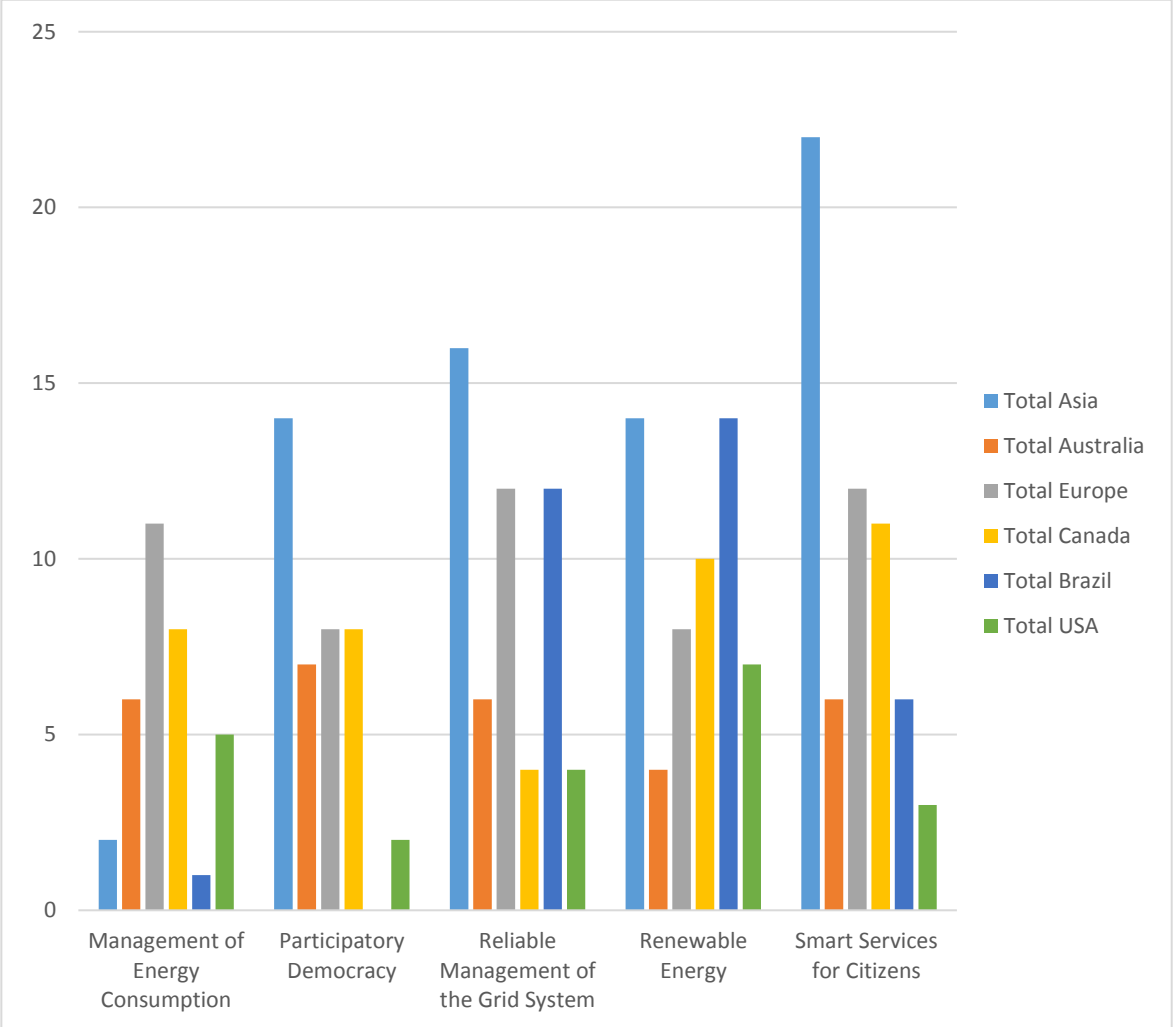


Figure 90: The most replicated value propositions by projects at global scale

As a conclusion, Asia has two counterparts of the population growth where China and India has an unprecedented growth, while Japan is facing an aging population. However, smart services for the citizen is the key value proposition cover for all Asian countries with the use of open data and innovative sensors and solid business models. Australia has one of the highest living standards, yet needs to implement big data and ICT to improve energy management, transportation systems, and buildings. Europe has a leadership position in smart cities. Thanks to European Commission initiatives like Horizon 2020, Europe is transforming its cities to become more sustainable and improve the quality of lives. In the case of Brazil, like other countries in Latin America, they need to do more progress in smart cities because they have major problems in traffic, energy, water, and government. For now, Brazil mostly focuses on energy-related strategies. Lastly, the USA and Canada already have advanced organization in most of their cities. However, both countries aim to transform their cities more innovative, more connected and more sustainable.

4 Overall Results and Discussion

The smart city is not a one-layer project, it is a multi-disciplinary project with different stakeholders. In addition, smart city concepts are evolving continuously because of the development of technologies. Thus, smart city projects present a wide variety of challenges to cities and city administration. Some of these challenges are recognizing the critical objectives of the city, identifying the right technology and finding a new business model to clarify the roles between public and private entities.

The aim of this thesis to collect data about different smart city projects at the global level, identify the trends in objectives and tools, promoting the successful business model, and give information about the outputs of the projects. The overall results will be explained in this chapter and it will enable the readers to address the global challenges and show what the applicable solutions from the case study results are. In this way, cities currently develop SCPs can benefit from each other's experiences.

- ***Objectives***

  Challenges such as the production of energy, transportation congestions, social innovation, and security of open data, crime rates of a city, industry growth, and service regulations are extremely specific to local contexts. In Asia, transportation and energy are the main objectives to governments and the private sector has to find long-term strategies. The significant population growth and scarcity of resources put pressure on energy and transportation systems in Asia. For example, China's population is growing at an unprecedented pace, especially in urban areas. This rapid urbanization stressing their infrastructure and creating significant congestion and air contamination challenges. Thus, national government supports the creation of dozens of new purpose-built smart cities. On the other hand, Fukushima nuclear plant accident in Japan forced the government to find new energy solutions. In Australia and the USA, we noticed an equal distribution between objectives. SCPs focus on developing multi-objectives projects, which covers more than one objectives. Both countries developing SCPs in order to make cities as comfortable, safe and modern as possible. Transportation, energy, and social innovation are the major objectives for Australia and the USA. Most of the SCPs aims to increase road infrastructure and safety, develop resilient and efficient energy production systems, and introduce services, which will increase the quality of lives. On the other hand, Brazil faces critical energy and water problem recently. Firstly,

in the northern part, people do not access clean water in several places. Secondly, climate change affects critical drought in the country and Brazil mainly produce its energy from hydroelectric power plants. Thirdly, recently Brazil faced with massive power outages. These reasons give an alarm to the Brazilian government to take serious steps in the energy area. Therefore, we noticed a new renewable energy systems projects, EVs projects, smart grid projects in almost all Brazilian projects. Even the reasons are different; energy is one of the key objectives in Europe. Energy is the main input of its strong industry and to protect its economy, Europe has to produce its own energy. Therefore, Europe develops projects to focus on renewable energy and reduce the dependency on finite sources. Building retrofitting, eco-friendly mobility and EVs are other projects to succeed in energy efficiency. Lastly, Canada focuses on social innovation and sustainable development. There are several projects to aim to create potential economic growth, to develop renewable energy systems, and to build a clean environment around the country.

- ***Tools***

Technology plays a crucial role in the realization of SCPs. ICT, IoT, big data and cloud computing are the main technologies of SCPs as it is explained in Chapter 2. Governments spend an enormous amount of money on these technologies but it is important to understand that technology has to be used properly to solve challenges. According to our analysis, each country develops innovative SCPs with the help of advanced technologies coherently with the objectives. Not surprisingly, ICT has been used as the key technology in every country. Database follows ICT as a second key technology at the global level. Big data enable local governments to transform their cities and answer the requirements of their citizens. Thus, data means everything for each country. Big data is generated through innovative sensors and portable devices. Thus, innovative sensors are definitely become another key technology for all SCPs in our analysis. In the case of energy-related projects, smart grids gain importance. For example in Brazil, smart grid technology is used more than other countries. Asia is the leader of ICT and sensors technologies. Thus, Asian Smart City Technology market is developing so quickly and they are exporting these technologies to other countries like the USA and Europe. On the other hand, countries like Canada, the USA, and Europe initiate research and developments projects with a great number of funds. Therefore, developed countries shape smart city markets. However, there some challenges to overcome at the global level. Firstly, the standardization of advanced technologies cause delays on SCPs.

Countries create organizations to develop standards and widely applied assessment frameworks. Secondly, governments should be partners of the private sector about security of data and develop policies about the partnership of the private and public sectors.

- ***Stakeholders***

Due to the nature of the city, the city consists of different actors; therefore, SCPs has to be co-creation of different stakeholders. Successfully all countries understand the importance of co-creation and we observed high participation of city, citizen, administration, and SMEs in almost every project. Especially engagement with citizen plays a role as important as technologies to create a smart city. Smart city solutions have to be useful for citizen otherwise citizen will not recognize the solution, will not appreciate and consequently, the SCPs will fail surely. Avoiding from the failure, the citizen should be involved in the design process and testing process. In most of the countries such as Asia, Australia, the USA, and Canada, university participation is very low. However, the universities role should not be underestimated. Because firstly, they give insights about the local environment and economy. Secondly, universities develop projects in low-cost compared with private sectors and give a chance to test technologies. Lastly, universities can give an opportunity to build a bridge between local governments and private companies through their research laboratories. To sum up stakeholders analysis, innovative SCPs are the co-creation of universities, citizens, city, administrations, SMEs, non-profit organizations and start-ups.

- ***Project Initiator***

According to analysis has done in chapter 3, public initiatives dominated the results. However, the formal leadership structures are the key to efficient and effective SCPs. According to political analysis of each country, local governments are responsible to deliver government services to its citizen and ensure that their citizen wants to live there. Therefore, local governments have to identify the problems of cities, then implement and manage the smart city solution. On the other hand, in the USA, private sectors are the dominant project initiators. This can be explained by the economic structure of the country and the aim of the projects. However, governments have to deliver better services to its citizen and they are the only entities can be impartial about the citizen needs. Therefore, public project initiators are the coordinator of the SCPs to bring

different interests and stakeholders together, and they are the regulator to ensure the standardization and regulations are in place.

- ***Business Model***

New technologies and innovative smart city solutions emerged the needs of the new business model. Because new technologies are changing the value of the systems, new innovative solutions need further funding supports to implement SCPs. Therefore, the roles between governments and the private sector have to be clearly defined. According to analysis, the Private-Public Partnership (PPP) is the most widely accepted partnership model. With this model, the public sector funds the project with funding programs or green bonds and on the other side, long-term risk is transferred to the private sector. Because most of the projects are about the development of infrastructure or advanced technology implementation, thus needs huge investments. Build and Operate or Build Transfer and Operate models are some of the examples of PPP structure. In this way, private companies take responsibility for implementation and operation of the project but during these phases, private companies collect revenues to cover its initial investment or even earn a profit. After the specified period, the facility will be returned to public entities. Another benefit of PPP is that the collaboration between public and private entities enable more integrated management structure and to foster fast decision-making. In some cases, private companies participate through human capital, software or infrastructure equipment. Consequently, the private sector plays a key role in the realization phase of the projects. Therefore, the public entities should attract the private entities to collaborate. Public entities should translate the benefits of the projects into the business language that private sector can understand. Because the main purpose of business is to maximize its profits. Therefore, public entities have to prove that private entities will generate a sufficient return on their investments.

In conclusion, PPP plays an important role where government investment participate as the guidance and implementation and private companies participate as the financial instruments and accelerator of the projects with advanced technologies. These two entities define a common language when creating value and translate the benefits of the projects into common languages. It is clear that business model innovation is needed for the sustainable growth and global recognition of SCPs.

5 Conclusion

In the last chapter of the thesis, the conclusion of the thesis and the future of the smart city will present.

Based on the literature review, smart city concept has continued evolution and there is no common definition of smart city. This study found some of the reasons behind it. Firstly, as it is widely-known technology changes constantly and rapidly. Even ICT and other technologies like IoT, cloud computing, big data, and broadband network are the essential part of the smart city development, the smart city definitions are changing accordingly the advancement of these technologies. Secondly, since there is no standardization of the concept of the smart city by any institution around the world, smart city projects do not have a common definition in terms of objectives, tools and business models. Lastly and the most important outcomes of the thesis is that smart city definition is affected by the needs, social, cultural and political background and geographic position of the countries.

Another argument supports that the different objectives, tools and business models of the smart city projects can be analyzed under the efficient and comprehensive taxonomy. The taxonomy introduced by ICT Center for City Logistics and Enterprises (ICE) from Politecnico di Torino is one that covers existing smart city concept with a managerial concept of the SCPs such as social inclusion, business and governance model and human and social relations. Taxonomy applied over two-hundred projects and reveals the similar characteristics of the projects, trends of tools and successful examples to be a guideline for further projects.

Different smart city definition by each region has been demonstrated in the first chapter. From that point, this study clearly shows that the economy, politics, and culture affect the management of the cities. Some of the findings from the analysis of SCPs at the global scale that Australia wants to focus on the well-being of its citizen and improve the transportation systems with the aim of protecting the environment. Asia, especially China, Japan, and India have unprecedented developments of smart city projects in recent years. All countries focus on improvements of their infrastructure systems, transform their cities into ecological cities and protect their environments and build new cities from the scratch with the advanced technologies to attract qualified people and business around the world. Brazil has some serious economic and energy problems. Compare with other countries around the world, Brazilian smart city projects are slow and needs a more comprehensive approach. In the case

of Europe, the EU allows cohesiveness, social inclusion, and powerful monetary governance among the members of the EU. However, local governments prioritize sustainable urban mobility, sustainably built environment, integrated infrastructures and processes in energy, ICT, and transport, open data governance, knowledge sharing, citizen focus, business model, funding and procurements. Lastly, the countries of North America are the wealthiest and has more technological advancements compare the rest of the world. This results in their smart city projects that big data and data sharing are the core technologies for most of the projects. They focus on sustainable development, protection of the environment and enhancing the high quality of lives for their citizen. Clearly, the findings of the analysis correspond with the smart city definitions of these countries which are discussed in chapter one.

The data obtained indicate that private-public partnership is critical for success. The participation of the private sector as important as public entities. Because the private sector has technical know-how which public entities still need to train their employees. Also, the private sector has innovative ideas, market knowledge, best practice researches and wider view about smart city concept. Among all countries, PPP was demonstrating the business model. Therefore, new business models for the smart cities will clarify the duties, value, and risk between public and private entities.

In the future research, the results of this thesis will ensure the foundation of the new business model for SCPs. Creation of centralized smart cities shared knowledge leads to capture valuable know-how, good practices, and success cases.

Lastly, further research on smart cities is explored. The new approach of a smart city is not just about connected and improved infrastructures, better services and smarter things, the smart cities of tomorrow increase the engagements between stakeholders of the cities in an intelligent, connected ecosystem. The goal of the new smart city approach is a higher quality of life and better stakeholder experiences. The advancement of the technologies will enhance the better city services and city decision making using the data, digital and design. Although the goal remains the same, the use of data will increase and consequently, end users such as citizens become more active users. Governments and private companies will use data and create a better solution and faster decision making. Therefore, in the future data will become a more important part of the smart city and enable city management to reimagine core city operations. Summing up to results, it can be concluded that businesses and citizens become more participative and co-creators and tomorrow’s smart cities will be more connected and collaborative.

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