Mapping Smart Cities Situation +CITIES: The Spanish Case

Neus Baucells[1(✉)], Concepción Moreno[2], and Rosa M. Arce[1]

[1] Researcher at TRANSyT, Universidad Politécnica de Madrid, Madrid, Spain
{neus.baucells,rosa.arce.ruiz}@upm.es
[2] Researcher at Universidad Politécnica de Madrid, Madrid, Spain
morenoconcep@gmail.com

Abstract. Cities are currently undergoing a transformation into the Smart concept. The Smart concept emerged in the same way as Smartphones or Smart TVs. A number of initiatives are being developed in the framework of the Smart Cities projects; however, there is a lack of consistent indicators and methodologies for assessing, financing and prioritising these kind of initiatives. The main aim of the research is to develop an evaluation model for Spanish cities and show dynamically in a map the degree of Smart development and their territorial characteristics. The study was carried out in 62 cities of the Spanish Network of Smart Cities (RECI) in 2015. The map is a tool to overcome the deficiency of information and methodologies, easy-to-use to evaluate smart cities projects. Moreover, it is a way of manage knowledge and information advances about Smart City initiatives. The map offers a database query and dynamic display characterizing Spanish cities.

Keywords: Map · Tool · Evaluation · Progress · Indicator · Monitoring Center · Visualization · GIS · Query · Citizens · Smart · Cities

1 Introduction

The concentration of people, companies and institutions in cities promotes creativity, innovation, diversity and economic growth [12]. Moreover, the synergy between different sectors increases the economies of scale thus becoming a key in a country's sustainable development [3]. Although over 80 % of global GDP is generated in cities, nonetheless, cities also have the highest pollution levels worldwide [7, 8].

Urban development has brought about several imbalances in cities. Cities must embark on a process of transformation by developing strategies to meet the challenges of creeping urbanization, demographic change and the new demands caused by climate change and the depletion of natural resources. Having these challenges in mind, it is crucial to manage and plan the expansion of a city by supporting economic growth and competitiveness, as long as maintaining social cohesion and environmental sustainability [3, 4, 10]. This involves multiple actors, high levels of interdependence, and different fields of action, in addition to conflicting goals and social and political complexity; consequently a holistic and multidisciplinary approach is necessary [1, 9, 11].

Urban planning today is regarded as the integration of a plurality of interests and active public participation. Urban planning now takes a more participatory approach,

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with new ways of representing data such as Geographic Information Systems (GIS) and new techniques for participation thanks to Information and Communications Technologies (ICT).

The concepts of Digital City or Connected City are closely linked to ICT in urban management and urban planning. A recently coined and related popular term is Smart City. The Smart City concept differs from the others by emphasizing environmental and social capital, and not only technology. It implies the use of ICT to provide sustainable economic development, tools for the judicious management of natural resources, and improvements to our quality of life, and offers an excellent opportunity to manage the urban future. ICT tools are essential for transforming traditional city into a Smart Cities [1, 13, 14, 16, 18].

Interest in Smart Cities has generated several theoretical discussions, but as yet insufficient progress has been made at implementing and evaluating related initiatives and projects. A Smart initiative must be evaluated through an integrated approach covering environmental, social and economic needs [2]. There are rankings of different city attributes such as quality of life and environment, and comparative studies between cities are emerging based on the Smart City concept [5, 11, 14, 15, 17, 19].

2 Objectives

There are numerous Smart City initiatives underway in the Spanish and European framework [6, 11, 14, 18]. However, indicators and standardized methodologies are required to evaluate, prioritize, implement and manage this type of projects. There is a lack of easy-to-use visual tools for interpreting vast amounts of information produced by these projects. The 2014 European report: "Mapping Smart Cities in the EU" clearly highlights the potential of mapping the situation of Smart Cities [14].

The +CITIES project is a research project coordinated by Rosa M. Arce from the *TRANSyT* (UPM) and funded by the Spanish Ministry of Economy and Competitiveness' State Plan for Scientific and Technical Research and Innovation *2013–2016*. This project goes one step further, by using maps as a dynamic tool to visualise the database and not only a way of representing data as static result. It solves the absence of visual tools and serves as a systematic evaluation method for assessing Smart City projects.

The +CITIES project is aimed at developing a comprehensive framework for assessing mobility and urban services projects to advance knowledge in this field and define methods for making informed decisions on smart investment strategies in a Smart Cities context. This system is of great interest to public and private bodies as a tool for prioritizing, developing and implementing strategies. Figure 1 shows the structure of the project development.

The project takes into account an expert opinion to complete the assignment. The vision of experts from a range of institutions and countries is essential to reinforce and validate the project. Consequently a survey was conducted involving experts in different fields related to cities.

The expected outcome of the +CITIES project is the improvement and development of more sustainable practices based on the application of ICT in transportation and urban services. This will lead to more effective management of energy consumption and

improve mobility. It will also establish conditions to help business and economic activity in a context of maximum respect for the environment and a more efficient use of resources.

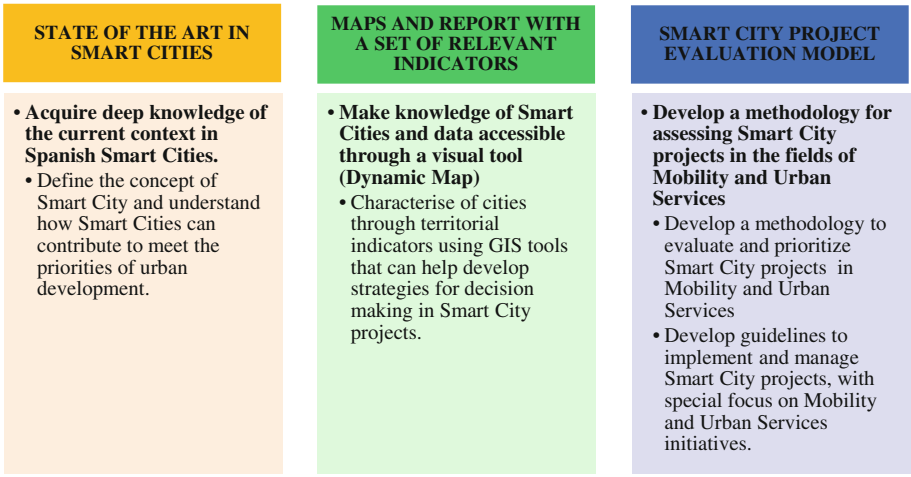

Fig. 1. +CITIES project structure

3 Methodology

A methodology for the evaluation of cities was developed according to the holistic concept of Smart Cities, and applied in 2015 to all cities in the Spanish Network of Intelligent Cities (RECI, www.reci.es). The aim was to contribute to the understanding of the processes of urban transformation designed to transform the conventional city into a Smart City (Fig. 2).

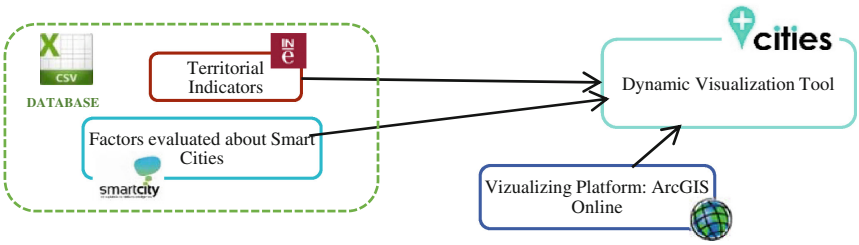

Fig. 2. General outline of the methodology

The purpose of this paper is to show the current information on Spanish Smart Cities on a dynamic platform. A query tool was developed by creating a dedicated database with a combined dataset, and merging it with a viewing platform. The data

used for the tool are classified into two clusters: an assessment model for Smart City initiatives from a city inhabitant point of view found in a previous work [15]; and some territorial indicators such as demographic or economic data for the 62 cities from the RECI study.

3.1 Smart City Evaluation Factors

+CITIES analyse the current situation of the Smart Cities in the RECI up to September 2015, when the present study concluded. This evaluation involved assessing the factors, taking into account "citizen's experience" The rating consists of a scale of 0 to 4, in which a factor of over 2 is defined as Smart (SC). A score of 2 or less refers to a conventional city (C).

The website of city councils and other services were visited to compile the relevant information and services needed to rate the below mentioned factors. The study adds value to statistical information, which is the usual source of information for similar comparative studies [5, 11]. In Fig. 3, it is shown the factors of each of the analysed axes.

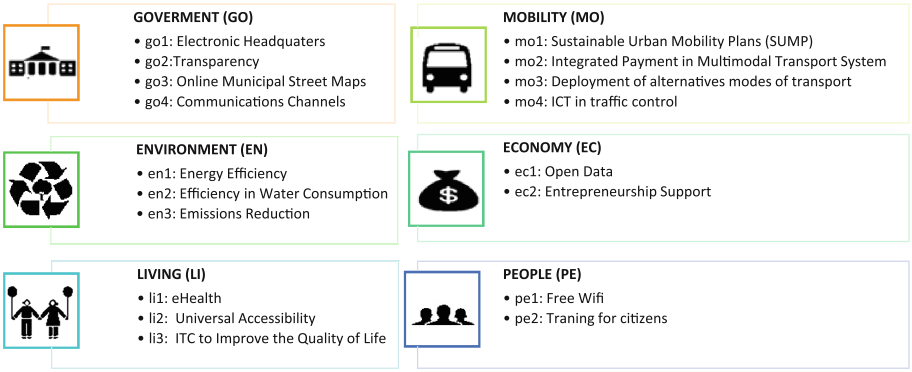

Fig. 3. Evaluated factors in the six Smart City axes

A Smart degree of deployment is assigned for Governance, Mobility, Environment, Economy, Living and People issues for each city, which is the average value of the factors in each city axis. Finally, a development level was assigned to each Smart axis and the average of the six scores was calculated for the degree of Smart City development. The aim was to obtain an overview of how far the 62 cities tested have advanced in the process of transformation toward a Smart City.

The analysis involved an evaluation of 18 factors related to the six axes of a smart city: Government (Go), Mobility (Mo), Environment (En), Economy (Ec), Living (Li) and People (Pe) [11]. In Table 1 are included the factors and assessment criteria in the six pillars of the Smart City.

Table 1. Factors assessed in the six Smart City axes

Axis	Factors Evaluated	Smart City (SC) or Conventional City (C)	
GOVERNANCE (GO)	(go1) Electronic Headquarters	SC: >2	With Electronic Headquarters
		C: =2	Electronic Headquarters in process and an easy-to-use source of information.
	(go2) Transparency	SC: >2	With a completed Transparency website
		C: =2	Transparency website in process or incomplete
	(go3) Online Municipal Street Maps	SC: >2	A Street map georeferenced with extra information for the citizen
		C: =2	Google maps or a basic map without extra information
	(go3) Communications Channels with the citizen	SC: >2	Municipal website, App with feedback
		C: =2	Traditional medias (email, telephone…)
MOBILITY (MO)	(mo1) Sustainable Mobility Urban Plans (SMUP)	SC: >2	With SMUP
		C: =2	Without SMUP
	(mo2) Payment Integrated in Multimodal transport system	SC: >2	Smart Card, Smartphone
		C: =2	Impersonal ticket
	(mo3) Deployment of alternative modes	SC: >2	Integrated payment with Public Transport
		C: =2	Bicycle registration
	(mo4) ICT in traffic control	SC: >2	ITC integrated
		C: =2	Just basic control
ENVIRONMENT (EN)	(en1) Energy efficiency	SC: >2	With two or more initiatives to reduce energy consumption
		C: =2	With at least one initiative to reduce energy consumption
	(en2) Efficiency in water consumption	SC: >2	With two or more initiatives to reduce water consumption
		C: =2	With at least one initiative to reduce water consumption
	(en3) Monitoring and reducing atmospheric emissions	SC: >2	With two or more ICT initiatives to monitor emissions
		C: =2	With at least one plan to monitor emissions
ECONOMY (EC)	(ec1) Open Data	SC: >2	Open Data information in the website
		C: =2	No accessible Open Data
	(ec2) Entrepreneurship Support	SC: >2	An Action Center with innovative initiatives
		C: =2	Traditional information in a physical center (events, basic information to create a company…)
LIVING (LI)	(li1) eHealth	SC: >2	Telecare or telehealth with follow-up
		C: =2	Conventional health assistance and health tips in the website
	(li2) Accessibility	SC: >2	Measures with ICT technology: Accessible touristic route...
		C: =2	Conventional measures: Tactile Pavement
	(li3) ITC to Improve the Quality of Life	SC: >2	At least a municipal project with an ICT infrastructure
		C: =2	ICT application in some punctual municipal events
PEOPLE (PE)	(pe1) Free WiFi	SC: >2	WiFi in public space (parks, streets or squares) with the accessibility information in the website
		C: =2	Some WiFi points around the city, without information
	(pe2) Training	SC: >2	With training courses or initiatives about accessibility to Smart services and participative approach of the city
		C: =2	Without a training program offered in Smart Services

3.2 Territorial Indicators

The Territorial database indicators was classified into four groups (see Fig. 4). The information was extracted from several sources such as INE (National Statistics Institute), IGN (National Geographic Institute), local city council website, the LaCaixa yearbook, and the Ministry of Finance and Public Administration among others. The completed database using an extensive set of territorial indicators for the visualization tool was created and exported to a viewing platform.

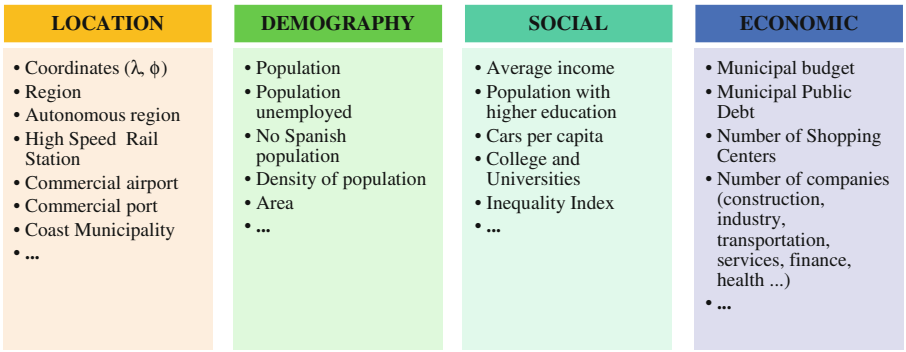

Fig. 4. Territorial indicators

3.3 Mapping Platform

A visualization tool was developed to represent and display the result, combining the RECI study database and the territorial indicators in a viewing platform. The platform used to visualize the results is ArcGIS Online by ESRI (*Environmental Systems Research Institute)*, and is a complete, cloud-based mapping platform that makes and shares maps.

4 Results

The outcomes are presented as a set of graphics and 3 maps, which are the result of the tool. A sample of 62 Spanish cities with a population of over 50,000 inhabitants was analyzed. The sample represents 35 % of the Spanish population and 43 % of Spanish population living in municipalities with more than 50,000 inhabitants; it also includes all Spanish cities with more than half a million inhabitants.

Figure 5 shows, for each of the six axes, the percentage of cities in the Spanish Smart Cities Network with a Smart Factor classification above 2. The labels on each column indicate the number of cities classified as Smart. The six dash lines indicate the average mark of cities classified as Smart in each axis. A solid grey continues line shows the number of cities classified as Smart out of the total, the average of the six axes, and the percentage it represents.

It is worth pointing out the low presence of Smart Cities in Environmental (14 cities) and Economic (16 cities) aspects. In contrast, the best results are for the Mobility (71 %) and Living (77 %) axis.

If the results are analyzed in more detail, those obtained for the factors in each of the axes have wide differences between the several factors that can be observed. The worse valued factor is Training (18 %) and the best results are in eHealth (100 %).

From the 62 cities, 61 have at least one axis valued as *Smart* and the majority of RECI cities have at least three Smart axes (Fig. 6). The top-scoring cities with six axes Smart are Barcelona and Madrid (Table 2). The Top Ten rated cities in Smart Cities has a minimum of four Smart axes.

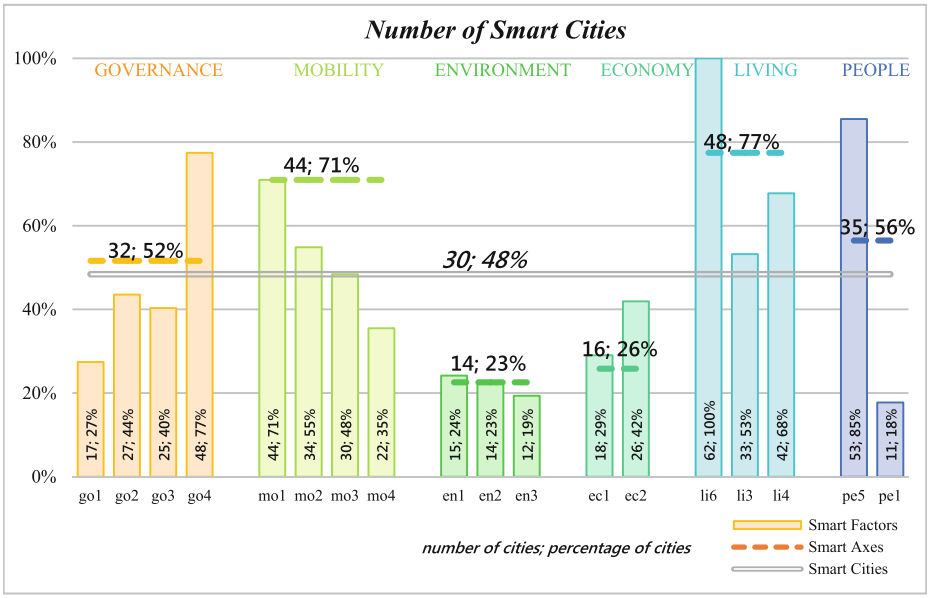

Fig. 5. Smart cities in each analysed factor

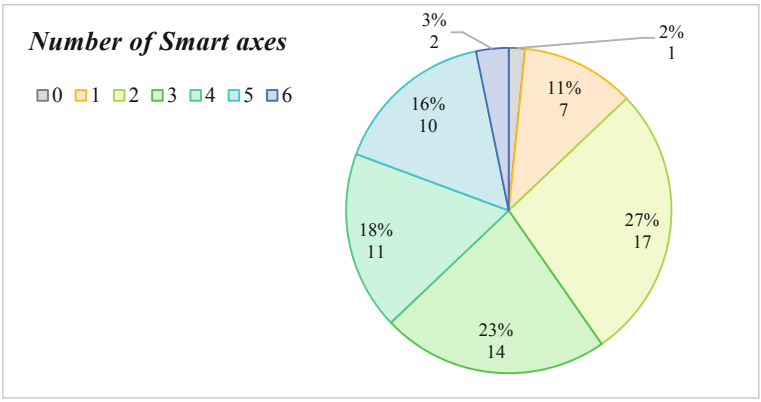

Fig. 6. Cities classification by the number of Smart axes

Figures 7, 8 and 9 are examples of the kind of data that can be represented on maps, such as the score for an evaluated factor–Transparency or Reduction of emissions in Fig. 7- or whether a city is classified as Smart in Mobility area (Fig. 8). In addition to the factors rated, the maps also show territorial factors such as the motorisation rate, population or the municipal budget per person in each city (Figs. 8 and 9).

Table 2. Top ten cities

Ranking Smart City	Municipality	Number of Smart axes	Population in 2014	Smart Score (0-4)
1	**Barcelona**	**6**	**1602386**	**3.29**
2	**Madrid**	**6**	**3165235**	**3.11**
3	Valencia	5	786424	2.68
4	Zaragoza	5	666058	2.67
5	A Coruña	5	244810	2.56
6	Sevilla	5	696676	2.55
7	Málaga	4	566913	2.54
8	Santander	5	175736	2.53
9	Gijón	4	275735	2.51
10	Pamplona	5	196166	2.47

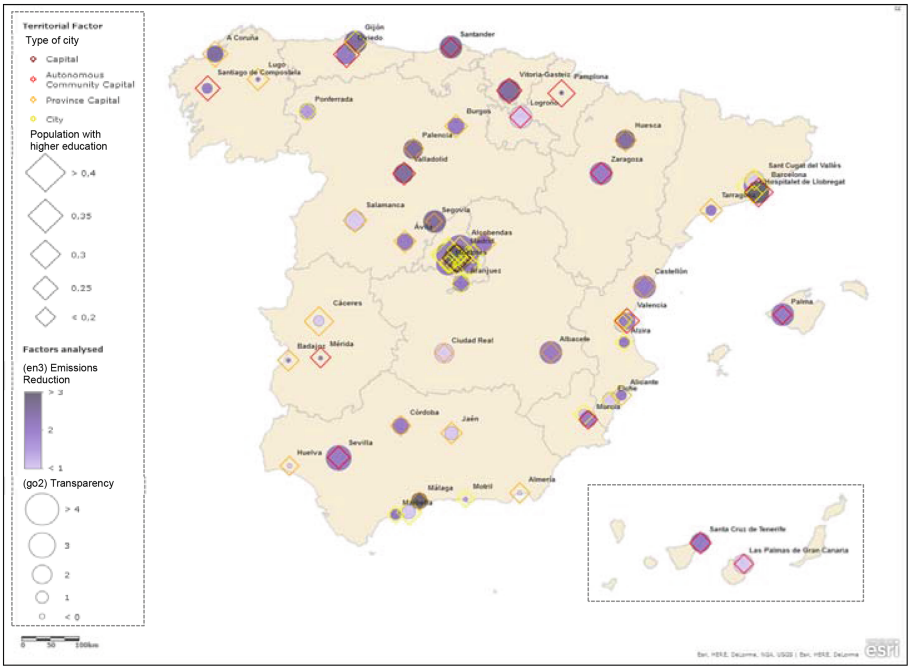

Fig. 7. Transparency, emissions reduction, population with higher education and type of city

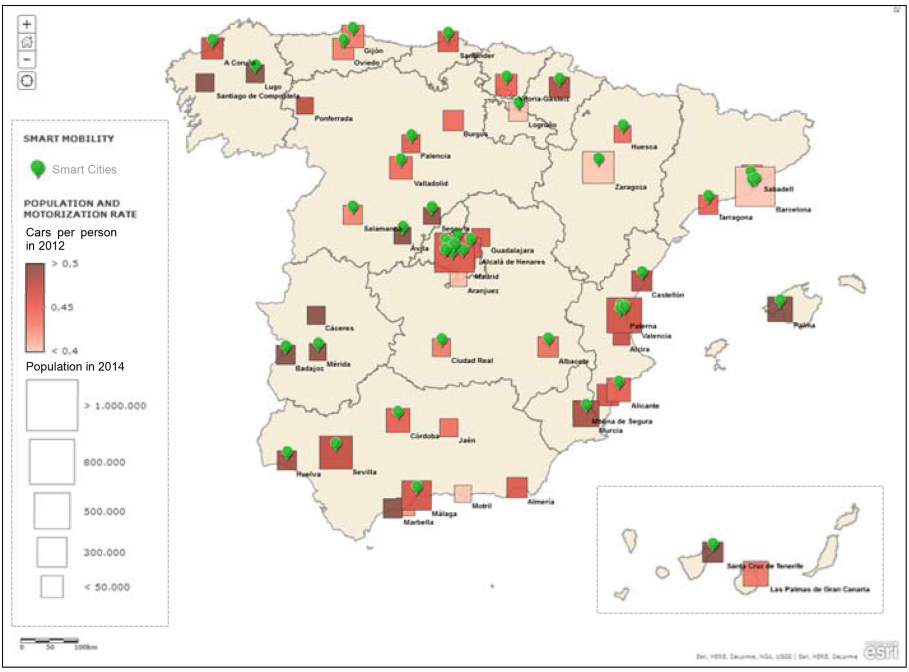

Fig. 8. Smart mobility cities, population and motorisation rate

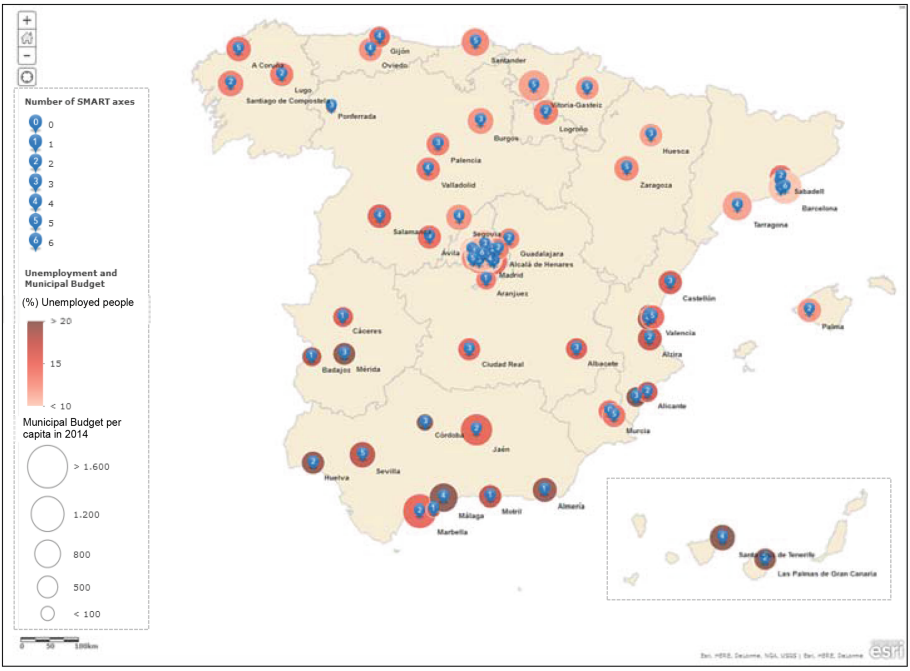

Fig. 9. Number of Smart axes, unemployed population and municipal budget

5 Discussion and Conclusions

The process towards what are known as Smart Cities is a reality, and, as can be seen, there is not a single model of Smart City [15]. There are many different kinds of smart cities: heterogeneous demographics, cities noted for their social or innovative commitment or cities with privileged contexts for certain businesses.

Cities evolve rapidly, the same as technology or society. The effect of cities on the lives of city dwellers requires good effective management of cities of each of the six axes described. Spanish smart cities have the good results for mobility and quality-of-life factors, which are key aspects in a city for inhabitants (Fig. 10).

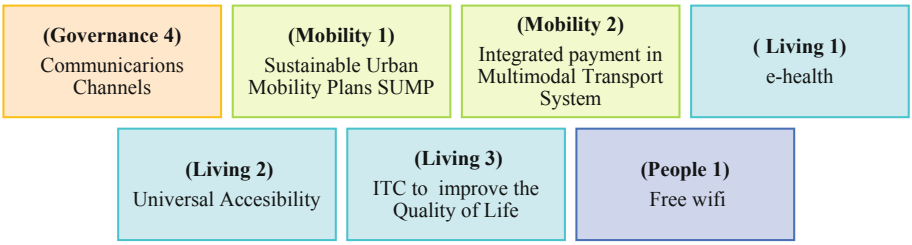

Fig. 10. Factors with a value higher than 2 in the 50 % of RECI cities

An example of Sustainable City due to the Smart City concept might be the Smart City Project in Málaga. This initiative was coordinated by Endesa "Smartcity Málaga" and has achieve an energy saving of more than 25 % in 5 years. This reduction means at the same time a decrease of 20 % of CO_2 emissions.

The map described in this study serves as a tool for the visualization and dynamic query of the status of Smart initiative and the features of the cities, and is intended to serve as the basis for a Spanish Smart Cities observatory. The purpose of this tool is to provide a graphic support to inform users about advances in the processes of urban transformation in the Smart City concept. In the future, this research should include more cities in the analysis and, more features that reveal their impact on the concept of Smart Cities. The culmination of this project is a National Monitoring Centre for Spanish Smart Cities to prioritize, develop and implement smart city strategies.

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