Convergence and Divergence Between Municipalities and Citizens about Smart City Actions' Priorities

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ABSTRACT

Most of smart city research focuses on the 'supply-side', and only limited research has been conducted about the 'demand-side' of smart cities: the smart city actions that are perceived by citizens as having higher usefulness, value and therefore priority; also limited research has been conducted for the comparison between the supply-side and the demand-side of smart cities. This paper contributes to filling these important research gaps. It investigates and compares smart city actions' priorities of the municipalities with the ones of the citizens, in order to identify points of convergence as well as of divergence. A novel methodology has been constructed for this purpose, which includes as a first step the development of a detailed taxonomy of possible smart city actions, based on previous relevant literature. This taxonomy is then used for collecting assessment data from municipalities as well as from citizens concerning these possible smart city actions. Furthermore, our methodology includes three layers of processing of the above assessment data, which identify: a) the priorities of these two important stakeholders concerning smart city actions; and b) points of convergence as well as points of divergence between them. This methodology has been applied in the context of the Greek local government. Assessment data concerning the importance of the smart city actions of the above taxonomy were collected from 144 Greek municipalities and 500 citizens; their processing has revealed an important divergence between these two important smart city stakeholders.

KEYWORDS

Smart cities, supply-side, demand-side, municipalities, stakeholder

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1 INTRODUCTION

Smart cities exploit the capabilities of ICT in order to support novel smart approaches and practices for addressing the inherent serious challenges and problems of modern cities ([Nam and Pardo, 2011a] and 2011b; [Chourabi et al., 2012]; European Parliament, 2014; [Dameri et al., 2016]; [Axelsson and Granath, 2018]). The high density of city populations increase strains on all city infrastructures and services, such as the ones for energy and water supply, transportation, health, education, government administration, etc.; so 'smart' solutions for addressing these pressing needs have to be found, which are highly efficient, effective and sustainable. At the same time it becomes imperative also to generate economic activity, employment and social well-being for these increasing populations. Information and Communication technologies (ICTs) can be of critical importance for developing such smart solutions to these inherent problems and needs of modern cities. The International Telecommunication Union (ITU) of the United Nations, based on an analysis of many existing definitions of smart cities, has developed the following synthetic definition: "A smart sustainable city is an innovative city that uses and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects" ([Kondepudi et al., 2014]).

Most of the research that has been conducted in the area of smart cities focuses on their 'supply-side', describing and analyzing smart city actions undertaken by government agencies, especially by municipalities, in various domains, and the benefits they provide as well as the challenges they face, and also developing novel smart city solutions and systems ([Giffinger et al., 2007]; [Chourabi et al., 2012]; [Cohen, 2014]; [Gil-Garcia et al., 2015]; [Sanchez-Corcuera et al., 2019]). However, limited research has been conducted about the 'demand-side' of smart cities, in order to understand the preferences and priorities of citizens concerning smart cities' development directions, and identify smart city actions that the citizens perceive as useful and valuable, addressing significant problems and needs of them. Also limited research has been conducted for the comparison between the supply-side and the demand-side of smart cities, in order to identify possible points of convergence as well as points of divergence between them. This would enable a better alignment of the former to the latter, and a better use of the scarce financial resources available for the development of the smart cities, focusing on the implementation of actions that are regarded by citizens as highly useful and valuable, which are addressing their real problems and needs; on the contrary a lack of knowledge concerning the citizen 'demand side' of smart cities will pose high risks of wasting huge amounts of taxpayers money for smart city actions that are minimally beneficial for the citizens, being based mainly on the perceptions, mental models, and probably the interests, of ICT vendors, technocrats and bureaucrats. Previous literature has concluded that the development of smart cities is a highly difficult and high risk undertaking, which requires participation and cooperation of many stakeholders, and especially the citizens, both in its planning, due to the multiplicity of possible smart city actions available as options and the need for priorities definition, and also in its implementation, due to its high complexity ([Leydesdorff and Deakin, 2011]; [Dameri et al., 2016]; Dameri et al., 2017; [Axelsson and Granath, 2018]; [Silva et al., 2018]; European Commission, 2019; [Allen et al., 2020]). A recent report of the European Commission on the development of smart digital cities in Europe highlighted the importance of taking seriously into account the 'demand-side' of it by placing 'citizens at the centre' of this effort (European Commission, 2019).

This paper contributes to filling the above important research gaps, making the following contributions:

I) It investigates and compares smart city actions' priorities of the municipalities with the ones of the citizens, in order to identify points of convergence and divergence, in the context of the Greek local government.

II) It develops a novel methodology for this purpose, which is based on the collection and processing of data from municipalities and citizens on the perceived importance of a wide range of possible smart city actions.

III) For the collection of these data a detailed taxonomy of possible smart city actions is developed, based on previous relevant literature, which includes 59 such actions, structured in 10 categories.

Our paper is structured in six sections. The following section 2 presents the background of our study, while the methodology and data collection are described in section 3. The detailed taxonomy of smart city actions we have developed is presented in section 4, followed by the results in section 5. The final section 6 summarizes the conclusions and proposes further research directions.

2 BACKGROUND

Considerable research has been conducted for the identification of the major elements of a smart city, meant as thematic areas of ICT-based smart interventions; we reviewed this research, in order to construct a detailed taxonomy of smart city actions (presented in section 4), to be used for collecting data from municipalities and citizens about the perceived importance of them. In this section we outline the findings of the most representative of these studies. A study conducted by the Centre of Regional Science of the Vienna University of Technology ([Giffinger et al., 2007]) identified six basic thematic areas of a smart city: smart economy (aiming at improving the competitiveness of local firms), smart people (aiming at improving social and human capital), smart governance (facilitating and promoting citizens' participation in public life), smart mobility (aiming at sustainable, innovative and safe city transport systems), smart environment (for protection environment and natural resources management) and smart living (for improving citizens' quality of life in several areas, such as housing, health, education, culture and safety). A study of the IBM Institute for Business Value titled 'A vision for smarter cities' ([Dirks and Keeling, 2009]) suggests that the main elements of smart cities correspond to the six main core sub-systems of modern cities, aiming to improve their efficiency and effectiveness: people (human and social networks, public safety (police, fire and disaster recovery), health, education and quality of life); business (improvement of competitiveness of city's business ecosystem, as well as its openness to foreign trade and investment, and balance of complex regulatory requirements with the need to minimize firms' unnecessary administrative burdens); transport (all aspects of road network, public transport network and sea/air ports, from provision to pricing); communication (telecommunications infrastructure, including telephony, broadband and wireless); water (the entire water cycle, water supply and sanitation, with emphasis on addressing problems with water efficiency, leakage, quality and the threat of flooding, which pose a significant threat to cities' sustainability); and energy (power generation and transmission infrastructure, as well as its waste disposal).

[Chourabi et al., 2012] adopt a synthetic approach, and based on a review of previous relevant literature develop an integrative framework for the characterization and the development of smart cities initiatives, which includes eight main elements of them: policy, organization, technology (regarded as 'inner-cycle' elements), and also people communities, economy, governance, natural environment and infrastructure (regarded as 'outer-cycle' elements). [Hancke et al., 2013] focus on the main elements of an advanced smart city that can be developed using sensors located in various points of the city and its infrastructures, in order to collect various kinds of 'real-life' data; they conclude that the most important of these elements are: smart infrastructure, smart surveillance, smart electricity and water distribution, smart buildings, smart healthcare, smart services and smart transportation.

The International Telecommunication Union (ITU) of the United Nations ([Kondepudi et al., 2014]) conclude that it is necessary "…to make sure that there is an overall development of energy, health care, buildings, transport, and water management in a city: (a) environmental care, with right technologies, cities will become more environmentally friendly; (b) competitiveness, with the right technologies, cities will help their local authorities and businesses to cut costs; and (c) quality of life, with the right technologies, cities will increase the quality of life for their residents". Also, they identified eight elements/components of a city, on which the development of smart cities should focus: (1) quality of life and lifestyle, (2) infrastructure and services, (3) ICT, communications, intelligence and information, (4) people, citizen and society, (5) environment and sustainability, (6) governance, management and administration, (7) economy and finance, and (8) mobility. [Yin et al., 2015], through a systematic review of smart cities' literature, defined in more detail the main elements of a smart city, identifying four main thematic domains of smart city applications, and for each of them several subdomains, which have been further elaborated by [Sanchez-Corcuera et al., 2019]:

i) Government (applications aiming at increasing its efficiency), including the following sub-domains: e-government, transparent government, public service, public safety, city monitoring, and emergency response.
ii) Citizen (applications aiming at making citizens happier): public transport, smart traffic, tourism, entertainment, healthcare, education, consumption, and social cohesion.
iii) Business (applications aiming at making businesses more competitive and prosperous): logistics, supply chain, transactions, advertisement, innovation, entrepreneurship, enterprise management, and agriculture.
iv) Environment (applications aiming at protecting and improving it): smart grid, renewable energy, water management, waste management, pollution control, buildings, housing, communities, and public space

In general, from the reviewed literature it can be concluded that the smart city concept is a highly multi-dimensional one: multiple elements of a smart city have been identified, which concern the use of ICT for enhancing and transforming different functions, resources or services of a city. However, their identification has been based on the analysis of smart cities 'supply-side' (i.e. on smart city actions implemented or planned by municipalities - mainly of large cities), and not on the analysis on their 'demand-side' (i.e. smart city actions that citizens perceive as useful and important). This literature has revealed that there is a very big number of possible smart city actions that can be implemented by municipalities; however, given the limited financial resources available, it is important to conduct a selective planning, focusing and placing priority on the most beneficial ones for the citizens, so the smart city 'demand-side' (i.e. the relevant needs, perceptions and priotities of the citizens) has to be seriously taken into account. In this direction the 'Unified Smart City Model' developed by [Anthopoulos et al., 2016] includes as main dimensions of a smart city not only its thematic areas of intervention (i.e. city facilities and services enhanced and transformed through the use of appropriate ICT) but also smart city planning and management as well. It is highly important to conduct a participative smart city actions' planning (i.e. selection and prioritization of the specific smart city actions to be implemented), which reflects not only ambitions of some politicians (who usually focus on impressive actions, supporting their 'political marketing'), and the marketing strategies of ICT vendors, but also citizens' relevant preferences and needs: to place priorities on smart city actions that are perceived by citizens as useful and valuable, addressing their 'real-life' needs and problems ([Castelnovo et al., 2016]; [Dameri, 2017]; [Webster and Leleux, 2018]; Allen et al., 2019). This is in line with the more general trend of citizens' participation in government planning, policy making and even budgeting, as well as their implementation, in order to make them more socially rooted and responsive to citizens' problems, needs and values ([Ferro et al., 2013]; Brun-Martos and Lapsley; [Noveck, 2015]; [Webster and Leleux, 2018]; Allen et al., 2019). Our research makes a contribution in this direction, as it investigates the priorities for smart city actions on one hand of the municipalities, and on the other hand of the citizens, and performs a comparison between the priorities of these two important smart city stakeholders, in order to identify points of convergence and divergence.

3 METHODOLOGY AND DATA

We have developed a methodology for assessing and then comparing smart city actions' priorities of the municipalities and the citizens, and finally identification of points of convergence and divergence; it consists of the following four steps:

I. Development of a detailed taxonomy of specific smart city actions that can be undertaken by a municipality (see following section 4).

II. Collection of assessment data on one hand from municipalities and on the other hand from citizens concerning the perceived importance of the smart city actions of the above taxonomy (see section 3.1).

III. Processing of the collected data in order to assess the priorities of each of these two important smart city stakeholders concerning the smart city actions that have to be undertaken (see section 3.2 and 3.3).

IV. Comparison of smart city actions' priorities of the municipalities with the ones of the citizens, and identification of points of convergence as well as points of divergence between them (see section 3.4).

3.1 Data Collection

For the above data collection a survey has to be conducted, based on two questionnaires that have been developed, one for municipalities (M_Questionnaire) and another one for citizens (C_Questionnaire). The municipalities' questionnaire initially includes some questions concerning the population of the city, the characteristics of the area (whether it is urban, rural, island, highland, lowland, touristic), and also demographics of the respondent (age, ICT familiarity, educational level, work experience); then it asks for each of the smart city actions of the taxonomy whether (Yes/No) it has been implemented in the particular municipality, and also whether (Yes/No) it will be implemented in the future. The citizens' questionnaire initially includes some demographic questions (age, gender, educational level, profession); then for each of the smart city actions of the taxonomy the citizen is asked to fill in the degree of his/her agreement about the importance of the action for making the city smart in a 5-points Likert scale (1=Strongly Disagree, 2= Disagree, 3=Neutral, 4=Agree, 5=Strongly Agree).

The municipalities' questionnaire was sent to all the 325 Greek municipalities, and 144 of them returned to us valid questionnaires

Table 1: Characteristics of respondent municipalities

less than 10.000 residents: 9.72%	Urban: 51.39%
between 10.000 and 20.000 residents: 22.92%	Rural: 48.61%
between 20.000 and 50.000 residents: 35.42%	Highland: 48.15%
between 50.000 and 100.000 residents: 24.31%	Lowland: 51.85%
more than 100.000 residents: 7.63%	Island: 18.75%
	Mainland: 81.25%

Table 2: Characteristics of respondent citizens

	18-25 years: 32%	Students: 32%	
Men: 53%	26-35 years: 22%	Public servants: 29%	Tertiary education:48%
Women: 47%	36-45 years: 22%	Free lancers: 18%	MSc: 31%
	46-55 years: 19%	Private sector employees:12%	PhD: 12%
	56-65 years: 4%	Unemployed: 6%	Elementary/Secondary educ.:9%
	above 65 years: 1%	Retired: 3%	

(response rate 44.3%); the main characteristics of them are shown in Table 1. We can see that our municipalities' sample includes mainly medium and large size municipalities, and less smaller ones (as for them most of the smart city actions of our taxonomy (see section 4) are less meaningful); also, there is a balanced representation of both urban and rural municipalities, and also lowland and highland ones, while most of them are in the mainland of Greece. The citizens' questionnaire was disseminated initially through the list of graduates of our University, who come from all areas of Greece, who were asked to disseminate it also to their friends and colleagues. Finally, we received 500 valid questionnaires; the demographic characteristics of the respondent citizens are shown in Table 2. We can see that our citizens' sample is balanced with respect to gender, and also employment sector (with similar shares of public sector and private sector employment), however more representative of the younger and middle aged and also the highly educated part of the population (who have more awareness and interest in smart cities).

3.2 Municipalities Data Processing

The first layer of processing will concern the data collected from the municipalities using the M_Questionnaire, and will include the following four processing steps:

M1. For each municipality we calculate for each of the N smart city actions of our taxonomy the assessment of its importance M_ACT_IMPi (i=1..N): it will take value 1 if the action has already been implemented, and 0.5 if the action has not been implemented, but will be implemented in the future.

M2. For each of these N smart city actions its average importance over all the respondent municipalities is calculated: MAV_ACT_IMPi (i=1..N).

M3. These N smart city actions are sorted according to their average importance for the municipalities MAV_ACT_IMPi, and in this way the priority order of each action for the municipalities MPRO_ACTi is determined.

M4. The top 20 smart city actions with respect to the priority assigned to them by the municipalities are determined and discussed; this enables drawing interesting conclusions concerning the perceptions and priorities of the municipalities concerning smart city actions.

3.3 Citizens' Data Processing

The second layer of processing will concern the data collected from citizens using the C_Questionnaire, and will include the following three processing steps:

C1. For each of these N smart city actions its average importance over all the respondent citizens is calculated: CAV_ACT_IMPi (i=1..N).

C2. These N smart city actions are sorted according to their average importance for the citizens CAV_ACT_IMPi, and in this way the priority order of each action for the citizens CPRO_ACTi is determined.

C3. The top 20 smart city actions with respect to the priority assigned to them by the citizens are determined and discussed; this enables drawing interesting conclusions concerning the perceptions and priorities of the citizens concerning smart city actions.

3.4 Municipalities – Citizens Comparison

The third layer of processing performs a comparison of the priorities assigned to these N smart city actions of our taxonomy by the municipalities with the priorities assigned to them by the citizens, aiming to identify points of convergence and divergence between them. For this purpose, for each of the N smart city actions of our taxonomy the difference between the priority order assigned to it by the municipalities and the priority order assigned to it by the citizens MC_PRODIF_ACTi (i=1..N) is calculated:

MC_PRODIF_ACTi = MPRO_ACTi - CPRO_ACTi

This enables us to identify:

- a group of smart city actions with low difference in their priority between municipalities and citizens, which represent points of convergence between these two smart city stakeholders;

- and also a group of smart city actions with high difference in priority between municipalities and citizens, which represent points of divergence between these two stakeholders: on one hand actions to which municipalities give higher priority than the citizens, and on the other hand actions to which citizens give higher priority than the municipalities.

Therefore, we can include in our smart city development plans initially the actions for which there is a convergence between municipalities and citizens concerning their high priority (i.e. a subset of the actions of the above group a, for which the average of the priorities assigned by the municipalities and the citizens is high); also, we can eliminate the actions for which there is a convergence between municipalities and citizens concerning their low priority (i.e. a subset of the actions of the above group a, for which the average of the priorities assigned by the municipalities and the citizens is low). At the same time consultation is required between municipalities and citizens concerning smart city actions for which we have divergence about their priority level (i.e. the actions of the above group b).

4 A DETAILED SMART CITY ACTIONS TAXONOMY

A taxonomy of smart city actions has been developed based on the findings of the previous research that has been conducted for the identification of the main elements of a smart city ([Giffinger et al., 2007]; [Dirks and Keeling, 2009]; [Nam and Pardo, 2011a]; [Chourabi et al., 2012]; [Hancke et al., 2013]; [Cohen, 2014]; [Kondepudi et al., 2014]; [Yin et al., 2015]; [Silva et al., 2018]; [Sanchez-Corcuera et al., 2019]). It includes 10 thematic categories of actions, which concern: ICT infrastructure, environment, transportation-mobility, health, waste management and water resources, energy – sustainable development, tourism and culture, economy – development, security and e-government; each of them includes a number of specific actions, so the taxonomy includes 59 actions in total. They are shown in Table 3.

5 RESULTS

5.1 Municipalities

In Fig. 1 we can see for each of the ten smart city action categories of our taxonomy its average importance over all the respondent municipalities. Also, in Table 4 are shown the top 20 highest priority actions for the municipalities. We remark that for the municipalities the smart city actions' category with the highest importance is the 'ICT infrastructure'. Three out of the top 5 actions belong to this category (1.1:Implementation of free wi-fi in municipal buildings and public areas; 1.4: Hardware and software upgrade in the municipal offices for a highly efficient back-office; 1.5: Electronic document flow management system for municipal offices). The second most important smart city actions' category for the municipalities is the 'e-Government'. In the top 5 actions we can see one action from this category (10.5: Development of applications enabling citizens to submit requests-problems through electronic channels), and another one in the 7th position (10.2: Electronic consultation on important municipal decisions and plans); in the top 20 actions there are three more actions from this category (10.8: Geographic Information Systems (GIS) applications for urban planning purposes (such as land use information, objective property values); 10.4: Electronic (online) provision of the municipal services through the municipal website; 10.6: Online monitoring system for collective bodies (e.g. city council) meetings). Similar importance is assigned by the municipalities to the 'Energy – Sustainable Development' smart city actions' category, with one action from this category appearing in the top 5 actions (6.4: Energy saving in the lighting of municipal streets and public spaces (by replacing existent lamps with led type ones, or by using a remote-control system) - smart lighting), and also another three actions in the top 20 actions (6.3: Energy savings in municipal buildings by upgrading exterior wall with insulation claddings and integrated interventions in cooling and heating systems - energy consumption monitoring and management system; 6.1: Installation of photovoltaics in municipal buildings; 6.6: Optimal routing and fuel consumption monitoring of municipal transportation vehicles, and fleet management systems, for reducing fuel consumption). Slightly lower is the importance assigned to the 'Tourism – Culture' smart city actions' category, with three actions from this category appearing in the top 20 actions (7.2: Development of electronic local tourist guide; 7.1: Development of a system for advertising and promoting local cultural ICT infrastructure and events through the municipal website; 7.3: Development of touristic content applications for mobiles). However, we remark that much lower is the interest of municipalities in the 'Economy – Development' and 'Waste Management & Water Resources' action categories, and even lower in the 'Security', 'Environment', 'Health' and 'Transportation-Mobility' ones.

Therefore, it can be concluded that the priorities of the municipalities concerning the development of a smart city are ICT infrastructure actions, mainly for providing electronic support of their own internal functions, and also electronic information and Internet access to citizens, as well as e-government actions, enabling mainly electronic provision of municipal services, electronic consultation between municipality and citizens, and electronic submission of citizens' requests. On the contrary, much less importance and priority is assigned to more ambitious and complex smart city actions that extend beyond the municipality, aiming to support and improve important functions of the city, such as the transportation, the waste management and the water resources, the monitoring and protection of the environment, the health and security services. A possible explanation for this might be that the latter actions are more complex, difficult and costly, as they necessitate the installation of various types of sensors in various infrastructures and points of the city, and also their interconnection through appropriate networks with central systems for collecting data from them, and then performing advanced processing of these data. These probably require the use of novel and therefore higher risk technologies of lower maturity, and also relevant knowledge, skills and experience that municipalities currently do not possess. On the contrary, the municipalities possess sufficient knowledge, skills and experience for the more traditional and mature technologies required for the above ICT infrastructure and e-government actions, as they are to some extent similar to relevant actions they have successfully implemented in the past; these more traditional technologies are regarded by them as more familiar and less risky. These findings indicate that municipalities seem to have a rather narrow vision of

Table 3: Smart city actions' taxonomy

Category	No	Actions
1. ICT Infrastructure	1.1	Implementation of free wi-fi in municipal buildings and public areas
	1.2	Implementation of optical fiber network (MAN)
	1.3	Data center infrastructure for collecting and storing data from Internet of Things (IoT) sensors
	1.4	Hardware and software upgrade in the municipal offices for a highly efficient back-office
	1.5	Electronic document flow management system for municipal offices
	1.6	Info-kiosks installation for providing information to citizens and visitors
	1.7	Installation of electronic boards providing information in real time (such as weather, local news, events and duty pharmacies)
2. Environment	2.1	Installation of electromagnetic radiation measurement sensors
	2.2	Installation of noise measurement sensors
	2.3	Installation of air pollution measurement sensors
	2.4	Installation of rain level measurement sensors
	2.5	Installation of atmospheric microparticles measurement sensors
	2.6	Installation of light level measurement sensors
3. Transportation - Mobility	3.1	Actions for monitoring and improvement of traffic management in real time
	3.2	Use of intelligent systems at pedestrian crossings for safe movement
	3.3	Smart bus stops (e.g. with online bus arrival information) for better public transportation
	3.4	Installation of sensors on transportation vehicles or roads for traffic flow monitoring
	3.5	Smart traffic information signs for traffic management
	3.6	Car parking spaces' sensors providing information to drivers for parking availability
4. Health	4.1	Implementation of health care tele-monitoring system to support vulnerable groups of people (such as disabled, suffering from Alzheimer's disease)
	4.2	Implementation of telemedicine system for measurements of key health indicators (such as pressure, blood sugar) of citizens, and medical records archive
	4.3	Implementation of applications for remote monitoring of patient progress in remote - isolated areas
5. Waste Management & Water Resources	5.1	Online quality measurement system of drinking water
	5.2	Online monitoring system with appropriate sensors for detecting possible water leaks in the water network
	5.3	Online monitoring system for immediate detection of possible water leaks in closed irrigation channels or irrigation tanks
	5.4	Actions encouraging - informing citizens about recycling through tele-education
	5.5	Online monitoring and management system of pumping and boring stations
	5.6	End to end irrigation management system with dam operation control, pumping stations control, and water flow control in piping
	5.7	Online waste containers' management system (with occupancy sensors) and waste collection fleet management (using GPS)
6. Energy – Sustainable development	6.1	Installation of photovoltaics in municipal buildings
	6.2	Construction of wind farms
	6.3	Energy savings in municipal buildings by upgrading exterior wall with insulation claddings and integrated interventions in cooling and heating systems - energy consumption monitoring and management system
	6.4	Energy saving in the lighting of municipal streets and public spaces (e.g. by replacing existent lamps with led type ones, or by using a remote-control system) - smart lighting
	6.5	Actions for citizen information and awareness about energy saving through tele-education
	6.6	Optimal routing and fuel consumption monitoring of municipal transportation vehicles, and fleet management systems, for reducing fuel consumption
7. Tourism - Culture	7.1	Development of a system for advertising and promoting local cultural ICT infrastructure and events through the municipal website
	7.2	Development of electronic local tourist guide
	7.3	Development of touristic content applications for mobiles
	7.4	Protection, promotion and enhancement of museums, galleries, monuments, caves, archaeological and historical sites through virtual tours
	7.5	Digitization of museum content for creating digital cultural footprint

8. Economy – Sustainable Development	8.1	Actions for promoting entrepreneurship in municipal websites
	8.2	Actions for the promotion and sale of local products via municipal websites
	8.3	Employment actions via municipal websites
	8.4	Innovative actions for support high technology farming (e.g. precision farming)
	8.5	Promotion of innovative technological activities via municipal websites
	8.6	Interactive consulting services for young entrepreneurs in municipal web platforms
9. Security	9.1	Fires early warning and response system
	9.2	Systems for citizens' protection in emergencies (such as earthquakes and floods)
	9.3	Using ICT for security and surveillance of public buildings and facilities
	9.4	Weather conditions monitoring and forecast systems for agricultural production
10. E-Government	10.1	Electronic voting application (e-voting) for municipal issues
	10.2	Electronic consultation on important municipal decisions and plans
	10.3	Collection of electronic signatures on important municipal issues (e-petitions)
	10.4	Electronic (online) provision of the municipal services through the municipal website
	10.5	Development of applications enabling citizens to submit requests-problems through electronic channels
	10.6	Online monitoring system for collective bodies (e.g. city council) meetings
	10.7	Free access to open data for use by individuals or other public agencies
	10.8	Geographic Information Systems (GIS) applications for urban planning purposes (such as land use information and objective property values)
	10.9	Implementation of e-Government Services provision framework

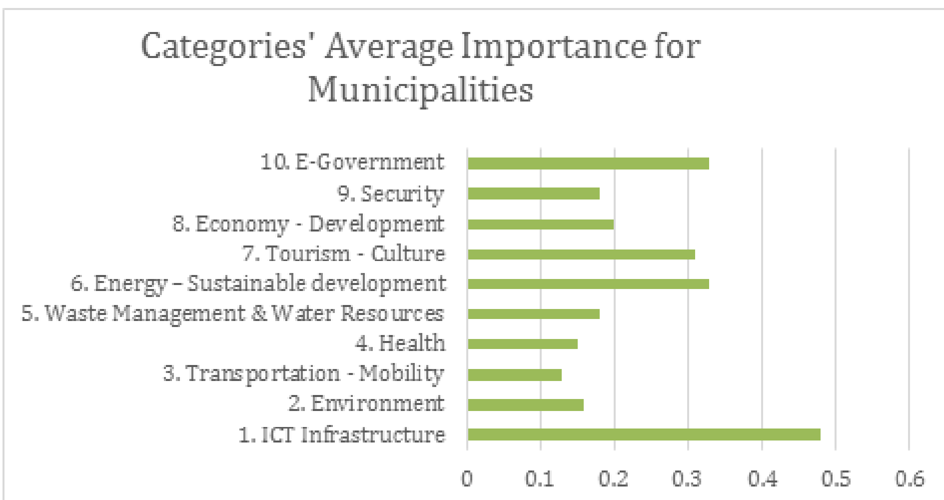

Figure 1: Average importance of smart city actions' categories for municipalities

smart city development, driven mainly by their existing knowledge, skills and experience base, and much less by the needs of their cities, oriented towards less ambitious and risky actions, which concern mainly activities of the municipality itself, and much less the important functions of the city.

5.2 Citizens

In Fig. 2 we can see the average importance for each of the 10 smart city action categories of our taxonomy over all the respondent citizens. Also, in Table 5 are shown the top 20 highest priority actions for the citizens.

We remark that for the citizens the smart city actions' category with the highest importance is the 'Health'. One out of the top 5 actions belong to this category (4.3: Implementation of applications for remote monitoring of patient progress in remote - isolated areas), while the remaining two actions of this category are among the top 20 actions (4.1: Implementation of health care tele-monitoring system to support vulnerable groups of people (such as disabled, suffering from Alzheimer's disease); 4.2: Implementation of telemedicine system for measurements of some key health indicators (such as pressure, blood sugar) of citizens, and medical records archive). The second most important smart city actions' category for the municipalities is the 'Security', with the highest importance action belonging to this category (9.1: Fires early warning and response system), and also another action of this category appearing in the top 20 actions (9.2: Systems for citizens'

Table 4: Top 20 smart cities actions for municipalities

No	Action	MAV_ ACT_IMP
1.1	Implementation of free wi-fi in municipal buildings and public areas	0.86
1.4	Hardware and software upgrade in the municipal offices for a highly efficient back-office	0.77
6.4	Energy saving in the lighting of municipal streets and public spaces (by replacing existent lamps with led type ones, or by using a remote-control system) - smart lighting	0.65
10.5	Development of applications enabling citizens to submit requests-problems through electronic channels	0.61
1.5	Electronic document flow management system for municipal offices	0.50
7.2	Development of electronic local tourist guide	0.47
10.2	Electronic consultation on important municipal decisions and plans	0.45
6.3	Energy savings in municipal buildings by upgrading exterior wall with insulation claddings and integrated interventions in cooling and heating systems - energy consumption monitoring and management system	0.44
10.8	Geographic Information Systems (GIS) applications for urban planning purposes (such as land use information, objective property values)	0.44
10.4	Electronic (online) provision of the municipal services through the municipal website	0.42
1.2	Implementation of optical fiber network (MAN)	0.41
2.1	Installation of electromagnetic radiation measurement sensors	0.40
6.1	Installation of photovoltaics in municipal buildings	0.36
8.1	Actions for promoting entrepreneurship in municipal websites	0.36
7.1	Development of a system for advertising and promoting local cultural ICT infrastructure and events through the municipal website	0.35
10.6	Online monitoring system for collective bodies (e.g. city council) meetings	0.34
1.7	Installation of electronic boards providing information in real time (such as weather, local news, events, on duty pharmacies)	0.33
6.6	Optimal routing and fuel consumption monitoring of municipal transportation vehicles, and fleet management systems, for reducing fuel consumption	0.33
1.6	Info-kiosks installation for providing information to citizens and visitors	0.32
7.3	Development of touristic content applications for mobiles	0.32

protection in emergencies (such as earthquakes, floods)). Similar importance has been assigned by the citizens to the 'Energy – Sustainable Development' smart city actions' category; three actions of this category are among the top 5 actions (6.4: Energy saving in the lighting of municipal streets and public spaces (by replacing existent lamps with led type ones, or by using a remote-control system) - smart lighting; 6.1: Installation of photovoltaics in municipal buildings; 6.3: Energy savings in municipal buildings by upgrading exterior wall with insulation claddings and integrated interventions in cooling and heating systems - energy consumption monitoring and management system). Lower, however considerable, is the importance assigned by the citizens to the 'Economy – Development' and the 'Waste Management & Water Resources', followed closely by three smart city actions' categories that are among the top ones for the municipalities (as mentioned in the previous section 5.1): 'Tourism-Culture', 'e-Government' and 'ICT infrastructure'.

Therefore, it can be concluded that the priorities of the citizens with respect to smart cities development concern a wider range of city functions and services, such as health services provision, protection from fires, bad weather conditions and other emergencies, development of economic activity and employment, water provision (both for drinking and for irrigation) and waste management. These priorities correspond to big 'real-life' problems and challenges that Greek citizens face (especially recently due to the long and deep economic crisis that Greece has experienced during the last decade), such as poor health services, big disasters from fires, increasing consumption and cost of energy, economic crisis and recession leading to increased unemployment and poor government services (both at the levels of central government and municipalities). Summarizing, the citizens seem to have a broader vision of smart city development than the municipalities, which concerns a wider range of city functions, and is driven by important problems and needs that citizens face. The importance and priority that citizens assign to possible smart city actions is shaped by the perceived benefits and value they can provide to important city functions for addressing significant citizens' problems and needs.

5.3 Municipalities – Citizens Comparison

A comparison of the findings presented in the previous sections 5.1 concerning municipalities and 5.2 concerning citizens reveals on one hand some convergences between them, but on the other hand more divergences. A first-level basic comparison can be made by comparing the top 3 smart city action categories and the top 20 actions of the municipalities with the corresponding ones of the citizens. From the comparison of the top 3 smart city action categories for the municipalities (see Fig. 2) with the top 3 ones for the citizens (see Fig. 3) we can identify only one common category, for which

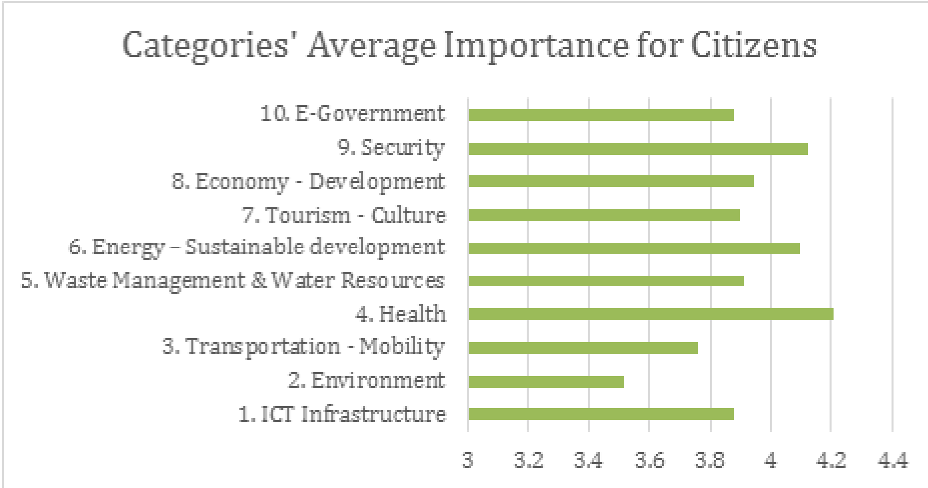

Figure 2: Average importance for citizens of main categories of smart city actions

Table 5: Top 20 smart cities actions for citizens

No	Action	CAV_ ACT_IMP
9.1	Fires early warning and response system	4.41
4.3	Implementation of applications for remote monitoring of patient progress in remote - isolated areas	4.36
6.4	Energy saving in the lighting of municipal streets and public spaces (by replacing existent lamps with led type ones, or by using a remote-control system) - smart lighting	4.34
6.1	Installation of photovoltaics in municipal buildings	4.28
6.3	Energy savings in municipal buildings by upgrading exterior wall with insulation claddings and integrated interventions in cooling and heating systems - energy consumption monitoring and management system	4.26
9.2	Systems for citizens' protection in emergencies (such as earthquakes, floods)	4.25
1.5	Electronic document flow management system for municipal offices	4.24
8.3	Employment actions via municipal websites	4.23
4.1	Implementation of health care tele-monitoring system to support vulnerable groups of people (such as disabled, suffering from Alzheimer's disease)	4.20
10.4	Electronic (online) provision of the municipal services through the municipal website	4.20
5.1	Online quality measurement system of drinking water	4.20
5.2	Online monitoring system with appropriate sensors for detecting possible water leaks in the water network	4.10
4.2	Implementation of telemedicine system for measurements of some key indicators (such as pressure, blood sugar) of citizens, and medical records archive	4.06
1.4	Hardware and software upgrade in the municipal offices for a highly efficient back-office	4.04
1.2	Implementation of optical fiber network (MAN)	4.02
10.5	Development of applications enabling citizens to submit requests-problems through electronic channels	4.02
1.1	Implementation of free wi-fi in municipal buildings and public areas	4.01
5.4	Actions encouraging - informing citizens about recycling through tele-education	3.99
5.7	Online waste containers' management system (with occupancy sensors) and waste collection fleet management (using GPS)	3.98
10.1	Electronic voting application (e-voting) for municipal issues	3.98

there is convergence between municipalities and citizens: the 'Energy – Sustainable Development' smart city actions; the other two top categories differ (ICT infrastructure and e-government for the municipalities – health and security for the citizens). Also, from the comparison of the top 20 smart city actions for the municipalities (see Table 4) with the top 20 ones for the citizens (see Table 5) we can identify 9 common ones, while the remaining 11 ones differ. The 9 common smart city actions, for which there is convergence between municipalities and citizens about their importance (through they might have different positions in the two top 20 actions lists), are:

1.1: Implementation of free wi-fi in municipal buildings and public areas

1.2: Implementation of optical fiber network (MAN)

1.4: Hardware and software upgrade in the municipal offices for a highly efficient back-office

1.5: Electronic document flow management system for municipal offices

6.1: Installation of photovoltaics in municipal buildings

6.3: Energy savings in municipal buildings by upgrading exterior wall with insulation claddings and integrated interventions in cooling and heating systems - energy consumption monitoring and management system

6.4: Energy saving in the lighting of municipal streets and public spaces (by replacing existent lamps with led type ones, or by using a remote-control system) - smart lighting

10.4: Electronic (online) provision of the municipal services through the municipal website

10.5: Development of applications enabling citizens to submit requests-problems through electronic channels

A second-level more sophisticated comparison between municipalities' and citizens' priorities concerning smart city actions can be made, as mentioned in 3.4, by calculating for each of the 59 smart city actions of our taxonomy the difference between the priority order assigned to it by the municipalities and the priority order assigned to it by the citizens (MC_PRODIF_ACTi, i=1..59). The average value of the absolute value of this priority order difference over all 59 actions is 17.28: this means that the priority orders assigned to these actions by the municipalities and the citizens differ on average by 17.28 positions, which indicates in general the existence of divergence between these two important stakeholders. From these calculations we can identify 11 actions for which there is very high divergence, with this difference exceeding 30 positions. For three of them the difference is positive (i.e. the priority assigned by the citizens is higher than the priority assigned by the municipalities):

4.3: Implementation of applications for remote monitoring of patient progress in remote - isolated areas

9.1: Fires early warning and response system

9.4: Weather conditions monitoring and forecast systems for agricultural production.

For the remaining 8 the difference is negative (i.e. the priority assigned by the municipalities is higher than the priority assigned by the citizens):

1.6: Info-kiosks installation for providing information to citizens and visitors

1.7: Installation of electronic boards providing information in real time (such as weather, local news, events)

2.1: Installation of electromagnetic radiation measurement sensors

5.5: Online monitoring and management system of pumping and boring stations

8.1: Actions for promoting entrepreneurship in municipal websites

10.2: Electronic consultation on important municipal decisions and plans

10.6: Online monitoring system for collective bodies (e.g. city council) meetings

10.8: Geographic Information Systems (GIS) applications for urban planning purposes (such as land use information, objective property values).

Also, we can identify 17 actions for which there is a good level of convergence, with this priority difference between municipalities and citizens being lower than 10 positions; for some of them there is convergence about their high priority, while for some others there is convergence about their low priority. So, a rational smart city participatory planning approach might be based on the former actions. In, particular, among the above 17 high convergence smart city actions there are 6 high priority ones, with the average of the priority orders assigned by the municipalities and the citizens being lower than 15:

1.2: Implementation of optical fiber network (MAN)

1.5: Electronic document flow management system for municipal offices

6.1: Installation of photovoltaics in municipal buildings

6.3: Energy savings in municipal buildings by upgrading exterior wall with insulation claddings and integrated interventions in cooling and heating systems - energy consumption monitoring and management.

6.4: Energy saving in the lighting of municipal streets and public spaces (by replacing existent lamps with led type ones, or by using a remote-control system) - smart lighting

10.4: Electronic (online) provision of the municipal services through the municipal website

6 CONCLUSIONS

Most of smart cities research has focused on its 'supply-side' (smart city actions undertaken by municipalities), but only limited research has been conducted about its 'demand-side' (the smart city actions that the citizens find useful, valuable and important), as well for the comparison between them, and the assessment of the degree of alignment of the former with the latter. This paper contributes to filling these important research gaps, by investigating and comparing smart city actions' priorities of the municipalities and the citizens, and based on them identifying points of convergence as well as of divergence, in the context of the Greek local government. For this purpose, a methodology, including a detailed taxonomy of smart city actions, has been developed, which can be quite useful for future relevant research. Our study has been based on the collection of assessment data concerning the above a wide smart city actions of the abovementioned taxonomy from 144 Greek municipalities and 500 citizens.

Our findings provide interesting and practically useful insights concerning the perceptions, priorities and general orientations of these two important stakeholders concerning smart city priority actions. On one hand, the municipalities regard as their main priorities in the area of smart city development actions concerning mainly the development of ICT infrastructures and e-government services, assigning much less importance and priority to more ambitious and complex smart city actions that extend beyond the municipality, aiming to support and improve important functions of the city, such as transportation, waste management and water

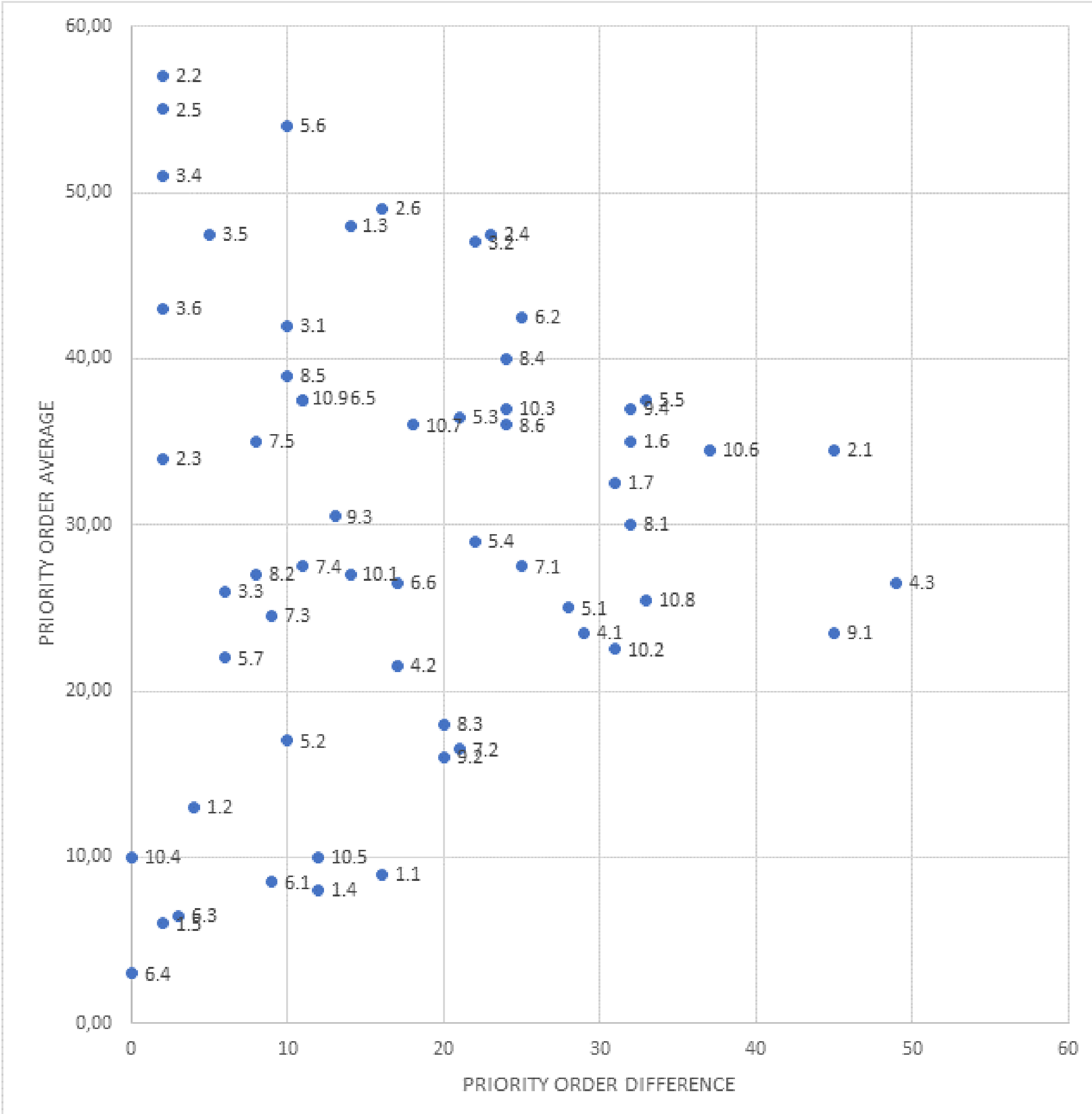

Figure 3: Priority order average versus priority order difference for the 59 smart city actions

resources, monitoring and protection of the environment, health and security services. On the other hand, the citizens seem to have a broader vision of smart city development. Their priorities cover a wider range of city functions and services, such as health services provision, protection from fires, bad weather conditions and other emergencies, energy saving, development of economic activity and employment, water provision (both for drinking and for irrigation) and waste management. So, the comparison between municipalities' and citizens' priorities, perceptions and orientations revealed on one hand some convergences between them, but on the other hand more divergences. The identified convergences can be used for the rational participative planning of specific smart city interventions, while for the divergences is required consultation between municipalities and citizens, so that better mutual understanding and convergence can be achieved. In particular, for the smart city actions for which the priority assigned by the municipalities is much higher than the priority assigned by the citizens it is necessary to conduct consultations with representative citizens (e.g. though urban/living labs, or focus groups – citizen panels) that aim to provide an understanding of the reasons for this divergence: does it exist because citizens do not know or cannot understand all the capabilities and the value that these specific smart city actions provide, or because they have some weaknesses that reduce their usefulness and value for the citizens? Furthermore, for the smart city actions for which the priority assigned by the citizens is higher than the priority assigned by the municipalities it is necessary to conduct similar consultations aiming to understand better the high value and usefulness of these actions that citizens perceive: do the citizens overestimate the value and usefulness of them (possible due to extensive 'marketing' of them by the press or ICT vendors), or the 'value for money' they provide (possibly because they cannot understand the extent of financial resources and in general the effort required for their implementation), or the municipality cannot understand some aspects of the value and usefulness perceived by the citizens?

The main limitation of our study is that it has been based on data from a single national context, so findings might have been influenced at least to some extent by its particular characteristics, such as the limited exploitation of ICT in government, and therefore the limited technological knowledge, skills and in general capacities of the Greek government agencies, and especially the municipalities; this might result in a narrow vision of smart cities development among Greek municipalities, which diverges from the broader vision of citizens. Therefore, further similar research is required in other national contexts, in order to examine to what extent the findings of the present study are generalizable. Also, further research is require for the extension of our taxonomy with additional smart city actions, and for the extension of our methodology in order to include not only quantitative data collection techniques, but also qualitative ones (such as focus groups - citizen panels, urban/living labs, consultation spaces and social media); special emphasis should be placed on the exploitation of existing relevant textual data (e.g. postings concerning existing or planned smart city interventions in various social media, such as Facebook, Twitter, blogs, fora, etc.).

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