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Smart and Sustainable Planning for Cities and Regions

Results of SSPCR 2017

Springer

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Foreword

This book presents a selection of the best papers delivered at the Second international conference on *Smart and Sustainable Planning for Cities and Regions 2017*, hosted by EURAC Research in Bolzano, Italy, and held on 22–24 March 2017. Comprising forty-six papers from policymakers, academics and consultant researchers, it sets out the state of the art on smart and sustainable planning, the findings of the groundbreaking research already conducted into the subject and progress made by cities and regions in meeting the challenges they face in championing future actions directed at climate change adaptation and the mitigation of global warming.

The groundbreaking research, challenges, adaptations and mitigations the book compiles include:

– Smart planning for adaptation and mitigation;
– Information and communication technologies (ICTs), space and society;
– The "next economy" for the city;
– Strategies and actions for good governance;
– Urban-rural innovation; and
– Rethinking mobility.

In addressing these themes, this book serves to show how climate change adaptation is only a headline in the smart and sustainable planning of cities and regions. It does this by getting beneath the headline and uncovering the lesser known, but no less significant contribution ICTs make to the smart and sustainable planning of cities and regions. In uncovering this contribution, the book reveals how the smart and sustainable planning of cities and regions assembles a platform for the design and construction of those spaces which society cultivates as the built environments of a "next economy". That "next economy" which is seen by cities and regions alike to be equally significant for the reason the governance of the urban and rural innovation this gives rise to is also able to rethink mobility.

Collectively, the papers force those policymakers, academics and consultant researchers championing the climate change adaptation measures of smart and sustainable planning, to not only rethink mobility, or call for the good governance of urban and rural innovation across cities and within regions, but also reflect on what the “next economy” contributes to the design and construction of those spaces which society considers key to the cultivation of built environments that are capable of mitigating global warming.

Edinburgh, UK

Prof. Mark Deakin
Edinburgh Napier University

Preface

Since 2015, the Urban and Regional Energy System research group at EURAC Research has organized the international conference on *Smart and Sustainable Planning for Cities and Regions* (SSPCR—http://www.sspcr.eurac.edu/).

This biannual event is gaining even more attention on the international level, thanks to its holistic and multidimensional approach. Indeed, the SSPCR conference focuses on innovative planning methodologies, tools and experiences aimed at supporting the transition of our cities and regions towards a smarter and more sustainable dimension, approaching various investigation scales, branches of science and intervention perspectives. Contributions from fields of research covering the scientific and professional communities of urban and regional planning are presented at SSPCR by international keynote speakers and complemented by selected participants. At SSPCR, research findings emerging from demonstration projects are also represented, so as to disseminate innovative approaches to smart and sustainable planning.

The keynote speakers at SSPCR 2017, hosted by EURAC and held in Bolzano, Italy, on 22–24 March 2017, are:

- **Mark Deakin**, Professor of Built Environment and Head of the Centre for Smart Cities, Institute for Sustainable Construction, at Edinburgh Napier University. He offers a critical synthesis of the smart-city literature. This is based on an interdisciplinary reading of smart cities and the insights a Triple Helix-inspired account of future Internet-based developments offers into the digital infrastructures, data management systems and renewable energies of cloud computing.
- **Hans Dubois**, Research Manager of the Living Conditions and Quality of Life unit at the European Foundation for the Improvement of Living and Working Conditions (EUROFOUND). Hans' talk is about the costs and consequences of inadequate housing in Europe and the quality of life in urban and rural Europe. He also outlines a new project on neighbourhood quality and the role of local-level measures in building up the quality of life.

- **Lia Ghilardi**, Founder and Director of NOEMA, a UK-based organization working internationally to deliver place mapping and strategic cultural-planning projects. Lia kicks-off and moderates the international debate on how cultural resources and culture-led regeneration strategies are playing a crucial role in the transformation of many European post-industrial cities. Such approaches to local development have been closely linked to economic competitiveness, attraction of investment and cultural tourism flows. International case studies are presented on Matera and Taranto (Italy), Amsterdam (the Netherlands) and Prague (Czech Republic).
- **Tamara Krawchenko**, Policy Analyst in the Regional Development Policy Division of the Organization for Economic Co-operation and Development (OECD). Tamara presents the findings of the OECD's report on The Governance of Land-Use in OECD Countries, offering analysis and recommendations on land-use policies and practices, with particular attention paid to the interactions between planning tools, fiscal frameworks and incentives.
- **Pierre Laconte**, President of the Foundation for the Urban Environment (FFUE). He is a past President of the International Society of City and Regional Planners (ISOCARP) and the former Secretary General of the International Association of Public Transport. He was also evaluator for the European Green Capital Award in 2012 and 2013 and a member of the Lee Kuan Yew World City Award Council. Pierre's presentation offers insights into how to answer the following questions about smart and sustainable cities: what is smart? What is sustainable?
- **Manel Sanmartí**, Head of the Electrical Engineering Research Area (EERA) at the Catalonia Energy Research Institute (IREC). Manel's talk is about the GrowSmarter project, a smart-city project funded by the European Commission under its SCC1-2015 call, which had the objective of transforming cities for a smart, sustainable Europe by deploying 12 smart energies, mobility and ICT solution in three main European cities: Stockholm, Cologne and Barcelona.
- **Sabine Sulzer**, Head of the Lucerne Competence Center for Energy Research (LUCCERNE) and Professor of Sustainable Energy Systems at the Lucerne University of Applied Sciences and Arts (HSLSU). Sabine offers a presentation on the coordinated research project in Switzerland concerning energy efficiency in buildings and districts. The goal of the project is to reduce the environmental footprint of Swiss building stock by a factor of three.

SSPCR 2017 keynote speakers and international guests have the paramount role of inspiring the discussion among delegates and introducing the thematic sessions. During the three conference days, about ninety oral and poster presentations are given over to attendees coming from 20 countries. The organizers believe this goes some way to confirm the status of SSPCR 2017 as a high-level international communication platform and event for members of the scientific and professional community to share their latest experiences of smart and sustainable planning.

This book comprises a selection of the best contributions presented at SSPCR 2017, facing the challenge of inspiring the transition of urban areas and rural regions towards smarter and more sustainable places to live. To this aim, planners and stakeholders are called to take over—in a multidimensional perspective—both the urgent issues related to climate change and energy efficiency and the new changes introduced by cities' digitalization and the integration of ICT into infrastructures, mobility and social interactions.

The second edition of the international conference on *Smart and Sustainable Planning for Cities and Regions*—SSPCR 2017—is supported by ISOCARP, OECD, Springer, EUROFOUND, FFUE, AISRe, Urbasofia, and in partnership with Klimamobility 2017 and New Metropolitan Perspectives 2018.

We wish to express our sincere gratitude to the reviewers, Scientific Committee members, keynote speakers, session chairpersons, Organizing Committee and members of staff at EURAC for making this conference successful. Finally, the editors would like to express special thanks to Mr. Pierpaolo Riva, Springer editor, for his professional assistance in publishing this volume in the book series Green Energy and Technology.

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Bolzano, Italy — Daniele Vettorato
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About the Editors

Adriano Bisello is an Urban and Environmental Planner, with more than ten years of working experience and a strong interest in the field of smart-city projects and low-carbon urban-regeneration strategies. He did his Ph.D. in Real Estate Economics, investigating the co-benefits of smart-energy projects at the urban level. From 2006 to 2012, he worked as a consultant and a freelancer for public administrations and engineering companies in northern Italy, contributing to strategic and operative planning document design and strategic development of environmental assessment processes. Since 2013, he has been a member of the Urban and Regional Energy Systems team at EURAC in Bolzano (Italy) as a senior researcher, working in a multidisciplinary and international team. His current activities range from local to European-funded projects in the field of smart cities, international energy planning and sustainable energy policies and plans. He is a passionate public speaker and co-author of research works published in international books and journals. Since 2015, Adriano has managed the international conferences on *Smart and Sustainable Planning for Cities and Regions* (SSPCR), where researchers and practitioners from all over the world meet to discuss how to address the main contemporary challenges of urban, regional and energy planning. Since 2015, he has been a member of SIEV (Italian Real Estate Appraisal and Investment Decision Society) and, since 2016, of ISOCARP (International Society of City and Regional Planners).

Daniele Vettorato is an Urban Planner, holding a Ph.D. in Environmental Engineering, and works on Smart and Sustainable Energy Systems for cities and regions. Since its foundation in 2012, he has been the coordinator of the Urban and Regional Energy Systems research group at the Institute for Renewable Energy—EURAC. He has been the Vice President of ISOCARP (International Society of City and Regional Planners) since 2017 and a board member since 2015. He is one of the promoters of the international conference on *Smart and Sustainable Planning for Cities and Regions—SSPCR*. Daniele has been a project and financial manager in many EU projects (FP7 smart-city project SINFONIA, H2020 smart-city project

STARDUST, Interreg Alpine Space RECHARGE.GREEN, Interreg South East Europe LOCSEE, Interreg Alpine Space GRETA).

Pierre Laconte is a Doctor of Laws and also of Economics (Catholic University of Louvain) and an honorary Ph.D. (Edinburgh Napier University). He is President of the Foundation for the Urban Environment, which seeks to link urban planning, transportation and the environment, and he is a past President of ISOCARP (International Society of City and Regional Planners) and former Secretary General of the International Association of Public Transport. Pierre was an evaluator for the European Green Capital Award in 2012 and 2013 and a member of the Lee Kuan Yew World City Award Council. He is one of the three planners responsible for the Louvain new university town in Belgium, which received the Abercrombie Award of the International Union of Architects. His publications include *Sustainable Cities—Assessing the Performance and Practice of Urban Environments* (co-ed., C. Gossop, 2016); *Brussels: Perspectives on a European Capital* (co-ed., C. Hein), which shared the Society for Human Ecology's 2008 award for best publication; *Water Resources and Land-Use Planning: A Systems Approach*" (co-ed., Y. Y. Haimes, 1982); and *Human and Energy Factors in Urban Planning: A Systems Approach* (co-eds., J. Gibson and A. Rapoport, 1982).

Simona Costa is a Senior European Policy Expert with long experience in Regional Policies, Energy, Sustainable Transport, Innovation and Financial Engineering for public authorities. She has gained more than 23 years' experience in the multilevel European lobbying context in Brussels, working for EU institutions (European Parliament and European Commission) and in industrial lobbying (Leonardo Group). From 2000 to 2015, she was head of the office of the representative of the Regione Liguria (Italy) in Brussels. At present, she represents the city of Genoa in Brussels. She plays a facilitator's role in involving local and regional stakeholders in the low-carbon-economy process uptake and in the EU's project management. She is actively involved in the implementation of complex projects in the energy and transport fields (i.e. TEN T programme, H2020 programme and COSME). In the European Innovation Partnership for Smart Cities and Communities, she is the chairman of the Integrated Planning Policy and Regulation Action Cluster.

A Goal-Oriented Framework for Analyzing and Modeling City Dashboards in Smart Cities

Katiuscia Mannaro, Gavina Baralla and Chiara Garau

Abstract For several years, many cities around the world are moving through a number of initiatives to implement the so-called "city dashboards", as an opportunity for a new quality of urban life in terms of knowing and governing cities. The main contribution of this paper is to examine how city dashboards are performing on various metrics and comparing them in order to understand what they do. Starting from this perspective, to the best of our knowledge and by examining dashboard examples, there are many differences in the products that go by the name "city dashboards". Moreover there are several methodological and technical issues that are not dealt with and yet solved in terms of data, indicators and benchmarking. The design of a city dashboard needs a clear vision of the direction that public administrations intend to undertake, alongside an ability to build scenarios and analyze the results of experiments in the context of the changing urban variables. Given the gap in academic literature concerning this subject, we developed a goal-oriented framework for examining the characteristics of various city dashboards and developing a taxonomy. Our framework enables a more systematic process for developing an effective city dashboard and provides useful insights to decision makers. The results suggest that some features emerge and our findings highlight specific clusters.

Keywords City dashboard · Urban governance · Taxonomy · Smart cities, goal/question/metric

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1 Introduction

For several years, many cities around the world are moving through a number of initiatives to implement so-called "city dashboards", as an opportunity for a new quality of urban life in terms of knowing and governing cities. As the term "city dashboard" gains wider and wider adoption, there is still confusion about what a city dashboard is.

Basically, the city dashboards' implementation has faced both the innovative technological processes and societal perspectives, it has to be used in response to users' needs, residents' well-being and city sustainability. Therefore, the same concept of city dashboard has assumed different definitions, not only on the basis of the displayed and offered services, but also in response to social challenges that the cities of the future will be required to confront. Generally speaking, a city dashboard is a big data platform designed, on the one hand, to allow city's users to get up-to-date information about a city and, on the other hand, to give access to a wide range of datasets about the city to help decision makers. This tool consists of several modules, each of which contains a number of applications that display various data about the city (e.g., real-time data, such as temperature, humidity, air quality, number of car-rental locations, traffic cameras, static data, indicators etc.) (Kitchin et al. 2015).

The proliferation in recent years of various styles of dashboards has led us to attempt to clarify understanding about this tool. Even if city dashboards are defined and shaped in relation to the needs of the urban context and of the local public administrator's goals, the design of a city dashboard requires a clear vision of the direction that public administrations intend to undertake, as well as an ability to build scenarios and analyze the results of experiments in the context of changing urban variables.

This paper aims to clarify the features of the city dashboards in the context of the smart-cities paradigm, due to the gap in the academic literature concerning this subject. We developed a taxonomy for analyzing the characteristics of various different city dashboards by using an approach based on a goal-oriented framework.

Starting from these statements, the paper is organized as follows. Section 1 provides an introduction and the motivations for the paper. Section 2 discusses the relevant literature on city dashboards and presents some types of city dashboards and their roles. Section 3 analyzes their salient features and describes the framework in order to support the elicitation of dashboard requirements. Section 4 presents the research results. Finally, Sect. 5 states conclusions and suggest future research.

2 State of the Art

Many governments are considering to implement city dashboards for their cities and to use this technology to improve the performances of urban services and, consequently, of smart-city governance. According to Meijer and Bolívar

(2016: 392), we accept the following definition of smart-city governance: "smart city governance is about crafting new forms of human collaboration through the use of ICTs to obtain better outcomes and more open governance processes". Recently, smart-city governance has been related to the city-dashboard tool. This emerging topic has been attracting increasing attention from scholars, public administrators and politicians (Kitchin et al. 2015, 2017; Osella et al. 2016). In this context, city-dashboard implementation has become very popular as a means to present big data in effective way and to communicate important information in a clearly and efficiently way. Suakanto et al. (2013: 1) assume that a smart-city dashboard can help to predict and accommodate the daily citizens' needs thanks to data monitoring. Dameri (2016: 71–72) defines a smart-city dashboard as a big data platform enabled to "measure the smartness of a city, both to evaluate the reached goals and support further decisions, investments and initiatives". Kitchin and McArdle (2016: 2) state that "city dashboards use visual analytics—dynamic and/or interactive graphics (e.g., gauges, traffic lights, meters, arrows, bar charts, graphs), maps, 3D models and augmented landscapes—to display information about the performance, structure, pattern and trends of cities". Usurelu and Pop (2017: 94) consider the city dashboard as a tool "primarily concerned with processing large amounts of heterogeneous data from sensors, cameras, social streams, user generated content and data produced by city authorities, and displaying it in an easy to consume form". According to Fegraus et al. (2012), a city dashboard, a web-based decision support tool, is a key cyber infrastructure component designed to satisfy the smart-city objectives and urban ecosystem services. However, government logic is moving from using city dashboards for monitoring and disciplining city users to controlling and influencing their actions, behaviors, effects and opinions (Kitchin et al. 2017).

In particular, browsing online, we found many examples of city dashboards, such as screen-based displays that show the most important performance indicators, city users' behavioral analysis, multi-charts used for data analysis with a series of interactive tools that graph historical data, real-time traffic information, real-time public transportation schedules, and so on. Tables 2 and 3 in Sect. 3 summarize a bird's-eye view of the twenty-five most representative online city dashboards that we selected.

The aforementioned smart city-dashboards offer various user friendly interfaces and data. We noted that there are many different ideas of what a dashboard is, and, because they are not based on an international standard, they lack diverse viewpoints (temporal, spatial, and so on) for various types of users (Zdraveski et al. 2017: 36) and depend on policies, indicators and benchmark selections, their communication and visualization, their deployment and their intended use (Kitchin et al. 2015).

This amplifies the key characteristics of an ideal city dashboard. In addition, today's cities are extremely complex systems in which the materiality of the places interacts with the immateriality of the information in accordance with the smart-city paradigm (Caragliu et al. 2011; Angelidou 2015; Ahvenniemi et al. 2017; Carta 2017).

For this reason, we feel the need to understand how cities are being analyzed and monitored through city dashboards in order to frame them within a more all-encompassing vision.

3 Method

In order to structure our analysis, we followed the well-known paradigm called Goal Question Metric (GQM) Approach, proposed by Basili (1993) for defining the software measurements. The GQM approach identifies three steps. As suggested by its name, the GQM Approach provides a method for defining Goals, refining them into Questions and then defining the Metrics to collect data. This approach has been applied with good success by researchers in several contexts (Akbar et al. 2014; Basili et al. 2014; Behkamal et al. 2014; Mannaro et al. 2004; Southekal 2017; Yeh and Huang 2014). For this reason, we state that its application is suitable also in this context. GQM defines a top-down approach based on three levels: (i) a conceptual level (Goal); (ii) an Operational level (Question); and (iii) a quantitative level (Metric). The goal can be set through specific methodological steps: to define the object that is the primary target of the study (i.e., it that will be analyzed), the purpose that expresses how the goal will be reached, the issue (with respect to) and the viewpoint (from the viewpoint of). A set of questions is used to reach the specific goal. Finally, a set of metrics is associated with every question in order to answer it in a measurable way: the same metric can be used to answer different questions (Fig. 1).

For the sake of brevity, we present in Table 1 some questions and metrics related to the following goal: analyze and classify the thematic areas represented in the city dashboards from the viewpoint of policy makers in order to understand the city trend in terms of smartness strategy.

The metrics plan describes exactly how the data will be researched.

In order to answer the first question (Q1) of the reported example, we searched online city dashboards, and the searches were made in the following databases: Scopus, ScienceDirect, Web of Science, Google Scholar and Google Search. The search was conducted during the period October 2016 to early 2017. The first

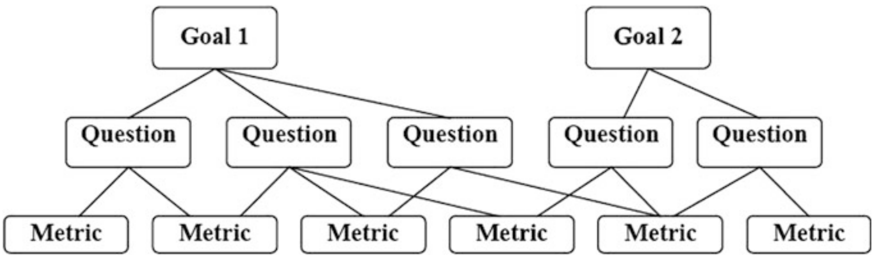

Fig. 1 GQM approach Caldiera and Rombach (1994)

Table 1 GQM approach

Goal	Purpose	Analyze and classify
	Issue	the thematic areas represented in the
	Object	city dashboards
	Viewpoint	from the viewpoint of policy makers in order to understand the city trend in terms of smartness strategy
Question	Q1	Have cities invested in dashboard technology?
Metrics	M1.1 M1.2	n° city dashboards found by search engine: Google, Google images n° city dashboards found in the literature: Scopus, ScienceDirect, Web of Science, Google Scholar and Google Search
Question	Q2	What types of information are shown in city dashboards?
Metrics	M2.1 M2.2	n° information extracted by web scraping n° information manually extracted
Question	Q3	Are the information types gathered under a specific thematic area?
Metrics	M3.1 M3.2 M3.3	n° thematic areas n° information in thematic areas n° information not classifiable
Question	Q4	Can the various types of information collected from the city dashboards be classified in a general taxonomy?
Metrics	M4.1 M4.2 M4.3	n° indicators defined in ISO 37120 n° indicators defined on Global City Indicators Facility—GCIF to use a semantic definition

challenge was to identify an initial set of papers about cities that invested in dashboard technology.

Moreover, our focus in these database searches was to identify keywords and formulate search strings using Boolean operators. We used the following search terms in combination: "city dashboard" OR "urban dashboard", "civic" AND "dashboard", "dashboard" AND "smart city" AND "dashboard" by selecting together the fields article title, abstract and keywords.

The main finding in these articles was that city dashboards and multi-chart displays are quite different. Briefly, Mendonça et al. (2016) describes a smart city-platform, available for police officers, aiming at contributing to improved public safety that employs a web dashboard to support data analysis and statistics. Bui (2015) describes the architecture of some platforms to monitor data related to air pollution, then only in prototype, at a research level. The system proposed by Cagliero et al. (2015) is validated by real non-emergency data acquired in the Turin Smart City environment, and it analyzed an open dataset of non-emergency calls, available only for the government. Nesi et al. (2016) report on research performed in the context of a national smart-city project on mobility and transport integrated with services. The project is grounded on an ontology and tools for smart-city data aggregation and service production. Finally, a large part of the relevant papers found in the literature describes dashboards' prototypes and their architecture; such as IT platforms to handle and manipulate data in order to extract useful information.

Our research aims to analyze the type of data displayed and made accessible by city administrators in the city dashboards, so as to better understand the thematic areas selected for improving urban governance. We identified Google Search as main search engine for accessing online city dashboards worldwide. We selected a representative sample of dashboards: the most-used search criterion was that every dashboard had at least five thematic areas to analyze.

Totally, we identified 25 online city dashboards. In Table 2, we report the list of 20 city dashboards specific for each single city or region with some additional elements (country, area and inhabitants). In contrast, in Table 3 reports on the remaining five dashboards, each of which aggregates a set of dashboards related to various cities.

In order to answer to the question Q2 of our GQM—"What information are shown in city dashboards?"—we studied the selected online city dashboards, one by one, and we collected information to understand the knowledge gathered for each given city.

In relation to Table 3, we decided to consider these dashboards as a single entity, and we report below some remarks.

CityDashboard (reference [21] in Table 2) aggregates simple spatial data for cities around the UK and displays the data on a single dashboard. It links eight different dashboards related to each specific city (London, Brighton, Birmingham, Cardiff, Edinburgh, Glasgow, Leeds and Manchester). In this case, given the small number of dashboards, we analyzed them one by one, and we found that these city dashboards show the same types of information. Moreover, some cities listed in [21], such as London (reference [6] in Table 2) and Birmingham (reference [7] in Table 2), have also additional dashboards with additional types of information, or in the case of Glasgow (reference [8] in Table 2) with similar data but with an interface totally customizable by citizens.

OECDBetterLifeIndex[1] (reference [23] in Table 2) is a dashboard that compares 38 countries around the world—members of the Organisation for Economic Cooperation and Development, or OECD.[2] The main goal is to promote policies that will improve the economic and social well-being of people around the world (OECD 2017). This interactive tool gives eleven topics reflecting what the OECD has identified as essential to well-being in terms of material living conditions (e.g., housing, income, jobs) and quality of life (e.g., community, education, environment, governance, health, life satisfaction, safety and work-life balance).

FabCityDashboard (reference [22] in Table 2) is a platform to monitor city resilience and aggregates 16 cities. It is based on well-being indexes developed by OECD (2017) at country and regional levels. It has been developed under the Fab City project which proposes a new model for locally productive and globally connected self-sufficient cities.[3]

[1]https://www.oecdregionalwellbeing.org/assets/downloads/Regional-Well-Being-User-Guide.pdf.

[2]http://www.oecd.org/.

[3]http://fab.city/.

Table 2 City dashboards' list from [1–20]

City/region	Country	Area (km^2)[a]	Inhabitants	Link	Ref.
New Castle	UK	113.44	279,100	http://uoweb1.ncl.ac.uk/raw_downloader/	[1]
Newark	USA	61.60	502,029	http://data.ci.newark.nj.us/group	[2]
Jersey	USA	54.7	262,146	http://data.jerseycitynj.gov/group	[3]
Western Pennsylvania	USA	data not found	around 4,000,000	http://www.wprdc.org/ https://dat14a.wprdc.org/group	[4]
New York	USA	1,214	8,550, 405	http://data.beta.nyc/group	[5]
London	UK	1,572.15	8,787,892	https://data.london.gov.uk/	[6]
Birmingham	UK	267.77	1,111,300	https://www.birmingham.gov.uk/	[7]
Glasgow	UK	175.5	595,080	http://dashboard.glasgow.gov.uk/	[8]
Gold Coast	Australia	1,402	527,660	http://dashboard.cityofgoldcoast.com.au/	[9]
Bellevue	USA	87.8	121,347	https://data.bellevuewa.gov/	[10]
Surrey	UK	1,662.50	1,132,390	http://dashboard.surrey.ca/	[11]
Venice	Italy	415.9	261,728	http://dashboard.cityknowledge.net/#/venice	[12]
Firenze	Italy	102.32	382,346	http://dashboard.km4city.org/view/?iddasboard=MzA=&nome_dashboard=Firenze2	[13]
Dublin	Ireland	114.99	527,612	http://www.dublindashboard.ie	[14]
Portland	USA	376	583,776	https://www.portlandoregon.gov/cbo/article/523301	[15]
Edmonton	Canada	684.37	877,926	https://data.edmonton.ca/	[16]
Madrid	Spain	604.3	3,141,991	http://ceiboard.dit.upm.es/dashboard/	[17]
Lerwick	UK	12.78	6,830	http://www.lerwick-harbour.co.uk/dashboard	[18]
Sydney	Australia	12,368.7	4,921,000	http://citydashboard.be.unsw.edu.au/	[19]
Salt Lake City	USA	285.9	192,672	https://dotnet.slcgov.com/PublicServices/Sustainability/	[20]

[a]All data come from Wikipedia

Table 3 City dashboards' list from [21] to [25]

Region/project	Link	Reference
UK	http://citydashboard.org/choose.php	[21]
FABCityProject	http://dashboard.fab.city/	[22]
OECDProject	http://www.oecdbetterlifeindex.org/	[23]
USA	https://www.civicdashboards.com/	[24]
America Latina	http://www.urbandashboard.org	[25]

CivicDashboard (reference [24] in Table 2) is a platform which includes information for 3143 counties and more than 30,000 municipalities in the USA. Such information is contained in a specific dashboard for each city, and they are based on ISO 37120 indicators. Using the platform, a user can easily compare information regarding different cities included in the project from a smart-city point of view. We analyzed this collection of dashboards as a single city dashboard because of their similar contents and structure. Moreover, given the high number of involved cities we decided to analyze, only 30 cases were randomly selected to ensure that all cities had the same data structure.

UrbanDashboard (reference [25] in Table 2) contains information about 37 cities from Latin America and Caribbean, and it proposes a single dashboard for each of them. It uses more than 150 quantitative indicators to follow economic and population growth and to compare the involved cities.

On the basis of our GQM, we measured the question Q2 using the metric M2.1 and M2.2. We extracted data from online city dashboards by using both a web-scraper tool called Import.io and methods of manual extraction in all cases in which the automatic data extraction (e.g., inside images) was impossible.

Import.io is a web-based platform for extracting data from websites. By entering a URL as input, Import.io tries to extract data from the online resource in an automatic way. It also allows user to train the tool in order to catch the right field to download the collected data in various formats. In our case, we used CSV format.

To answer to the third question Q3—"Are the information gathered under a specific thematic area?"—we gathered the raw data and built a table for each of the 25 dashboards, following the same structure. For the sake of brevity, we report in Table 4 only one representative example. We chose the case of Dublin city (reference [14] in Table 2). Table 4 contains the following fields: Thematic Areas,

Table 4 Structure of the table for the city dashboard of Dublin

Thematic areas	Datasets	Comments	Type of data
Health and crime	Number of people waiting on trolleys in Dublin hospital, number of theft and related offenses, number of public order and social code offenses	Can be split into two different areas?	Real time data + Indicators
Transport	Current drive time M50 north 24 min, current parking spaces in Dublin 2782, etc.		
Environmental indicators	Sound level at Irishtown Stadium is 55.85 db, weather, current air quality, etc.		
Industry, employment and labour market	Unemployed, employed, etc.		
Housing indicators	Average cost newly-built house, average cost of pre-owned house, average monthly residential rent, etc.		

Dataset related to each thematic area, potential Comments (for example, not all datasets are linked to a specific theme, so we used this field to put some considerations useful for our analysis), Type of data displayed (e.g., real time, static data, indicators, data analysis, other).

In this phase, we faced some issues. Firstly, in some dashboards we found datasets without descriptions or details, and sometimes they had not been inserted into a specific thematic area. Or, we did not find any dataset within the declared thematic area. In other cases, a thematic area was too generic to be classified, or the datasets were inconsistent with the thematic area under which they had been published (i.e., in the Newark dashboard, reference [2] in Table 2, the dataset "Certificate of Occupancies" was under "Public Safety" area). In all these cases, we considered the data only if the correlated thematic area was present or we assigned a new thematic area in a subjective way when it was possible, otherwise we rejected the information. For the mentioned reasons, we did intensive work in order to fill the table.

Secondly, we found different types of dashboards, not only on the basis of the choice of the thematic areas, but also in terms of data representation. For example, we found that some city dashboards have a list of open datasets linked only to a specific theme, or sometimes the same dataset is duplicated in different thematic areas. Moreover, some of these datasets are linked to a specific monothematic dashboard showing the time trends: this type of dashboard resembles a balanced scorecard used in business activities. This latter tool evaluates not only current scenarios but also the future targets of the companies.

Step by step, following our GQM, we identified the main question of our research in Q4—"Can the various types of information collected from the city dashboards be classified in a general taxonomy?".

Taxonomy refers to the study of classification and allows better understanding of the domain of interest. In our case, the domain refers to the city dashboards in a smart-city context.

After having collected the data from dashboards, the next step was to answer to Q4.

We summarized in a single table the information found in terms of thematic areas and their datasets. Unfortunately, each city uses subjective words to identify a thematic area, and sometimes there are not consistent with the thematic areas and their datasets and vice versa. For this reason, we classified and aligned the different terminology. Similarly to Pani et al. (2015), we defined a general dashboards' taxonomy using an iterative method combining two approaches: bottom-up (BU) and top-down (TD). Namely, following the BU approach, we collected data from the online city dashboards; then using the TD approach, it was possible to classify this information in accordance with a national or international standard.

By using the TD approach, we defined a reference taxonomy, and we mapped the rules. In accordance with the smart-city indicators such as ISO 37120 (2014) and Global City Indicators Facility (GCIF) (2013), we set the themes defined in the mentioned standards as a reference for the thematic areas and the indicators as a reference for dataset or information.

Simultaneously, we followed the BU approach to detect data from online dashboards and to classify them by using the previous reference taxonomy.

For each thematic area identified in our taxonomy, we verified for all 25 tables of the selected dashboards whether there was the same knowledge in terms of datasets or information. We considered not only the indicators but also the semantic concept in order to give a semantic definition to the thematic areas. We used Tipalo—a tool implemented by Nuzzolese et al. (2013)—which identifies the most appropriate types for an entity in DBpedia. Tipalo—a free online available tool—enables one to type a label of a Wikipedia entity and returns a RDF graph containing the semantic definition. Briefly, this tool uses a minimal graphical interface with a single input. In Fig. 2 we show how Tipalo works: if we type the label "Economy", Tipalo returns its semantic definition: "An economy is an area of the production, distribution, or trade, and consumption of goods and services by different agents in a given geographical location". We used this tool to inspect the definitions for each thematic area. However, a single label may not represent completely a specific thematic area. For this reason, we searched more than one definition for some thematic areas by typing relevant labels. A typical example is shown in Table 6 in which the "Safety and Emergency response" thematic area is associated with four different semantic definitions by using four different labels.

The themes identified by ISO 37120 are seventeen in number; then we added three themes coming from GCIF in order to cover some information found in the selected dashboards.

We listed the selected themes in Table 5, and we used them as a reference to define the categories of the taxonomy.

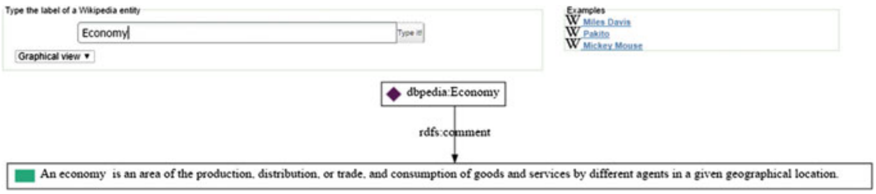

Fig. 2 A screenshot of Tipalo

Table 5 List of themes proposed in ISO 37120 and GCIF

ISO 37120		GCIF
Economy	Health	Housing
Education	Recreation	People
Energy	Safety	Civic engagement
Environment	Solid Waste	
Finance	Telecommunication and innovation	
Fire and emergency response	Transportation	
Governance	Urban planning	
	Wastewater	
	Water and sanitation	

We matched the themes identified in Table 5 with the theme gathered for each selected city dashboard by analyzing the data extracted from each city dashboard. The most frequently found thematic areas found in the selected dashboards were: Environment, Transportation, Finance, and Safety. Instead, Shelter, Telecommunication and innovation, Governance are the thematic areas less frequently found. Moreover, we did not find any matching for some thematic areas (listed in Table 5) in the analyzed city dashboards.

In this phase, we decided to keep pending the unclassified information.

Finally, we conducted a test phase before refining the classification in order to cover all thematic areas. We used *UrbanDashboard* (Reference [25] in Table 2) as our dashboard test object due to the large number of represented data and the proposed topic.

We matched the majority of themes identified in the previous step and listed them in Table 5. We found that the following topics were not present:

1. Citizen engagement and social-media participation;
2. Transparency;
3. Tourism;
4. Weather;
5. News;
6. Social services;
7. Cultural diversity.

Among these seven topics, some of these were the previously pending unclassified topics. In order to cover this gap and incorporate the new topics, we refined the first classification.

We describe below how we added the new thematic areas and how we redefined the previous ones (shown in Table 5).

1. *Citizen Engagement and social media participation.*
2. *Transparency.*
   According to ISO 37101 (2016), we referred to "*Governance, empowerment and engagement,*" and we added in the thematic area Governance of Table 5 the following themes: (i) *Citizen engagement and social participation* and (ii) *Transparency*. We redefined the new thematic area in our taxonomy as "Governance and engagement", and finally we inserted Civic Engagement (listed in Table 5) within this.
3. *Tourism.*
   We found data related to Tourism only in three dashboards, and we inserted this topic into Recreation thematic area of Table 5.
4. *Weather.*
5. *News.*
   These data are typical of real-time dashboards; we inserted these data in a new area that we named "Other".

6. *e services.*
   We incorporated this topic in Shelter of Table 5.
7. *Cultural diversity.*
   We added this topic to People of Table 5 and renamed the thematic area as "People and cultural diversity".
   In order to simplify the taxonomy and due to the low occurrence of some themes, we combined "*Housing*" and "*Shelter*" of Table 5 into a single field "Housing and social services", at the same way "*Water and sanitation*" and "*Wastewater*" *in* "*Water*", "*Fire and emergency response*" and "*Safety*" in "*Safety and emergency response*", "*Environment*" and "*Solid waste*" in "*Environment*", finally "*Transportation*" and "*Telecommunication and innovation (TI)*" *in* "*Mobility, TI*".
   The newly identified thematic areas have been added to our taxonomy derived from ISO 37101, ISO 37120 and GCIF. In the next section, we show an extract of the taxonomy.

4 Results

The built taxonomy proposes a dashboard's classification of thematic areas into which we suggested the datasets to incorporate. In total, we obtained 15 different categories that represent the classified thematic areas.

In Fig. 3, we show on the abscissa the new thematic areas obtained in our taxonomy and on the ordinate the number of analyzed city dashboards and related to the new classification.

For the sake of brevity, we show without details an extract of our taxonomy (see Table 6). Table 6 presents only two of the 15 thematic areas classified as "*Mobility,*

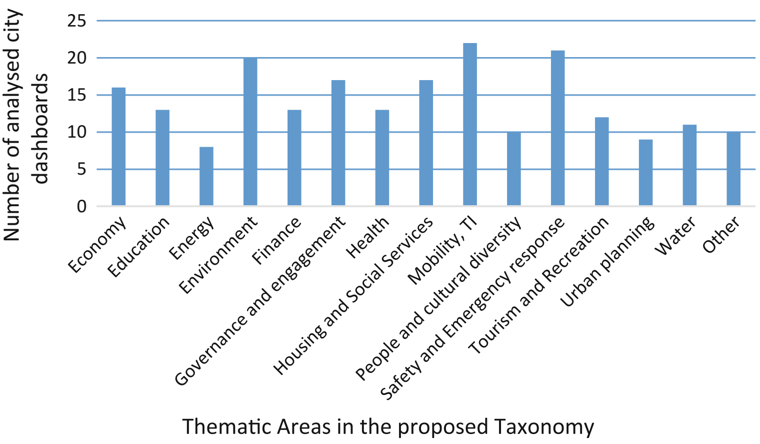

Fig. 3 Number of occurrences of the thematic areas in analyzed online city dashboards

Table 6 An extract of the taxonomy showing "Safety and emergency response" and "Mobility, TI" categories

Final tag	Dashboard theme	Semantic definition	Data
Safety and Emergency response	<Public Safety> <Safety> <Municipal services> <Justice> <Traffic Cameras> <Webcam> <Crime> <Police Bureau> <Livability> <Security> <Community Safety> <Municipal Services—Safety> <Fire & Rescue> <Emergency communication> <Livability> <Vulnerability to natural disasters in the context of climate change> <……..>	http://dbpedia.org/page/Safety http://dbpedia.org/page/Emergency http://dbpedia.org/page/Fire_department http://dbpedia.org/resource/Natural_disaster	Crime prevention overview Police arrest data, Annual crime rate, property crimes per 100,000, Violent crimes per 100,000, Number of new public alerts registrations, Victimization rate, Level of domestic violence, Citizens' perception of police's honesty, Hurricane evacuation zones, Percentage of time unit from closest station is available for response, 311 Call response time, Existence of risk maps, Existence of adequate contingency plans for natural disasters <……..>
Mobility, TI	<Traffic> <Transportation> <Tube Line Status> <Cycle Hire> <In services Rail> <Cruise Ship> <Airplane> <Trains> <real time bus position> <Transport> <Bureau of Transportation> <Mobility> <Infrastructure> <Wi-Fi> <Connectivity> <………>	http://dbpedia.org/page/Transport http://dbpedia.org/page/Wi-Fi http://dbpedia.org/page/Telecommunication https://en.wikipedia.org/wiki/Internet_access	Congestion, Parking spaces, Traffic flow, Average speed, Light rail train, Signalized intersections, Subway station entrances, Number of buses, Train network—ferry network, Bike share, Car share, Electric vehicles, Pedestrian safety, Public transportation (including taxi), Internet connectivity, Wi-Fi, Active devices, Wi-Fi heatmap, Percentage of households with a computer, Number of home computers per 100 inhabitants, Mobile broadband internet subscriptions, Mobile cellular phone subscriptions <…….>

IT" *and* "*Safety and emergency response*" which have the most significant and predominant presence in the analyzed dashboards (Fig. 3).

In our taxonomy for each thematic area, we identified a *Final Tag* (see Table 5). For each category, there are three dimensions: *Dashboard Themes* (some of the corresponding themes come from analyzed dashboards); *Semantic Definition* (it contains the DBpedia semantic definitions obtained by using *Tipalo* tool); and *Data* (data related to the category in terms of dataset, indicators or information coming from analyzed dashboards).

During the classification, we identified the four emerging clusters reported below.

Cluster 1. This cluster contains dashboards with data regarding the city administration and typically shared by government with their community. This kind of dashboard is based on data analysis over time or the use of indicators.
Cluster 2. This cluster contains dashboards that present information of public interest, such as transportation, weather, hospital, parking, warnings, etc. These dashboard show real-time data and interactive maps.
Cluster 3. Dashboards in this cluster are described in the literature in terms of technical architecture. These may process a lot of different information coming from the city and implement data integration, analysis and decision making.
Cluster 4. This cluster contains platforms that make comparisons between different cities; this is possible because data and information are expressed in the same format, and they contain the same indicators.

Furthermore, all the above clusters use maps as graphical tools to present the information. The usage of maps has been becoming increasingly widespread by administrations to show the selected information—in fact it is certainly more intuitive and more impactful.

5 Discussions and Conclusions

City dashboards are defined and shaped in relation to the needs of the urban context and of the local public administrator's goals. However, the design of a city dashboard needs a clear vision of the direction that public administrations intend to undertake, as well as an ability to build scenarios and analyze the results of experiments in the context of changing urban variables. This paper clarified the features of the city dashboards in the context of a smart city through an approach based on a goal-oriented framework.

In particular, we structured our analysis by using a GQM approach. Our aim was to analyze and classify online city dashboards in order to understand the city trends and identify the direction that public administrations intend to undertake. To better grasp the city dashboards' domain, we developed a city-dashboard taxonomy that classifies online semi-structured data by using an iterative method combining the bottom-up (BU) and top-down (TD) approaches. We analyzed 25 city dashboards in order to classify them or determine some classification criteria.

Our proposed taxonomy classifies 15 different categories identifying specific thematic areas. It may be useful in designing a new smart-city dashboard because it provides a specific number of typical elements with their semantic definition and gives suggestions about related datasets to insert.

Moreover the results of our analysis identified four different clusters on the basis of the purpose of a dashboard. *Cluster* 1 contains city dashboards useful for public administrators. By using these type of dashboards, they can communicate a specific government policy to the community with a clear political choice (e.g., showing safety data such as number of law enforcement, crime rate, traffic accidents etc., pays particular attention to security policies for the citizens and the city). *Cluster* 2 includes city dashboards useful for city users in which the information is oriented to citizens' services. Generally, these dashboards do not show a political view, but they pay attention to real-time information. *Cluster* 3 contains city dashboards useful as public administration tools with potential and benefits for governance. The analysis of data may help the government to make decisions by improving existing policies or introducing new ones. *Cluster* 4 presents city dashboards useful to assess the smartness of a city. Making comparisons with similar cities may be useful not only to improve but also to inspire other virtuous cities.

In our opinion, our framework is a useful tool to develop an effective smart-city dashboard and may provide insights for the decision makers. Every city can benefit from having a dashboard if it knows what the purpose of a dashboard is. A well-implemented dashboard may help enhance the process for becoming a smart city. At the same time, a city should take into account the above emerging clusters before implementing a dashboard in accordance with its governance policies. The constant change in today's cities and their dynamic development lead to the conclusion that the dashboard's taxonomy and the identified clusters should not be considered as definitive but a starting point to understand the same trends in the cities. We are working to better define the best way to monitor cities in order to optimize urban governance in relation to the local and specific context.

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