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URBAN INDICATORS AND THE SMART CITY AGENDA

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TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

LIST OF ABBREVIATIONS

ICT	Information and communication technologies
KPI	Key performance indicator
WCCD	World Council on City Data

SUMMARY

The use of urban indicators and benchmarking exercises by local governments has proliferated in the last few years, mainly owing to the sustainability agenda. These kinds of indicators aim at measuring, tracking, assessing and comparing cities' performance, with a view to guiding policy formulation and implementation. Diverse frameworks for sustainable development indicators have emerged, mostly produced by European and international organisations. Recently, initiatives involving key performance indicators (KPIs) have been influenced by the smart city agenda and the digital revolution, in terms of content, data collection, analysis and dissemination processes. ICT, big data, open data, real-time information, data analytics, dashboards and operation centres are some of the main components of this movement. Taking into account the different KPI initiatives and their evolution, the POCACITO project defined a set of urban indicators oriented to assessing cities' performance and to analysing their transition towards a post-carbon future, comprising economic, environmental and social dimensions. However, several methodological and policy limitations can be observed when urban indicators are used, notably in the development of benchmarking exercises among cities of different countries. Finally, this Policy Brief looks at ways to support trends towards standardisation, openness, interoperability, innovation and collaboration, which can inform data-driven policy-making at local/regional, national and European levels.

1 INTRODUCTION

Within the framework of the POCACITO project, key performance indicators (KPIs) were defined to assess and compare cities' performance along economic, social and environmental dimensions, and to analyse their transition process towards a post-carbon future.

The aim of this Policy Brief is to assess KPI initiatives, comprising urban indicators and benchmarking exercises, in the context of the smart city approach. The objectives are to understand the evolution of these initiatives in an era of digital revolution, and to identify their limitations and fragilities with a view to informing local, national and European policies.

2 IMPORTANCE OF URBAN INDICATORS

According to Godin (2003), "indicators are recurrent quantified measures that can be tracked over time to provide information about stasis and change with respect to a particular phenomenon".

KPIs seek to measure, track and assess performance, so as to inform and guide policy formulation and implementation. This is usually called evidence-based or knowledge-based policy-making. Moreover, indicators intend to explain present patterns and to predict and simulate future situations. They steer operational practices with respect to specified targets, providing evidence of the success or failure of measures and policies (Kitchin et al., 2015).

Indicators are also used to compare and rank cities' performance, through benchmarking exercises. According to Kitchin et al. (2015), "city benchmarking consists of comparing urban indicators within and across cities to establish how well an area/city is performing vis-à-vis other locales or best practices".

3 SUSTAINABLE DEVELOPMENT INDICATORS

Over the past decades, the use of urban indicators and benchmarking exercises by local governments has proliferated. The main reason behind this trend has been the sustainability agenda, which has led to the expansion of sustainable development indicators. In this context, "sustainability depends on social, economic, environmental and governance factors" (European Commission, 2015). Different frameworks of indicators are being used by public authorities, with varied objectives, scales, conceptual models and methodologies (Table 1).

The selection of indicators is always a key issue, mainly driven by the criteria of relevance, clear messages, data availability and data quality (Silva et al., 2014). Sometimes this process takes place with the support of stakeholders. In addition, the use of composite indicators and indexes, combining several measures and systems of weights, is common in urban benchmarking exercises.

Table 1. Examples of sustainable development indicators

Indicator framework; study/report	Organisation	Year
China Urban Sustainability Index	Urban China Initiative	2014
European Green Capital Award	European Commission	2010
European Green City Index	Economist Intelligence Unit; Siemens	2009
Global City Indicators Program	Global City Indicators Facility	2007
Indicators for Sustainability	Sustainable Cities International	2012
Reference Framework for Sustainable Cities (RFSC)	RFSC	2012
Cities Statistics - Urban Audit	Eurostat	2004
Urban Sustainability Indicators	European Foundation for the Improvement of Living and Working Conditions	1998
STAR Community Rating System	Sustainability Tools for Accessing and Rating Communities (STAR)	2011
Urban Ecosystem Europe	International Council for Local Environmental Initiatives (ICLEI); Ambiente Italia	2007
Urban Metabolism Framework	European Environmental Agency	2010
AT Kearney Global Cities Index	AT Kearney	2008

The traditional data underpinning indicators are mainly official statistics or data provided by public or private entities. These analyses are often complemented with "small data studies" (Kitchin, 2014), such as case studies, questionnaires, audits and focus groups.

These data "often rely on samples, are generated on a non-continuous basis, the number of variables are quite small, are aggregated to a relatively coarse spatial scale, and are often of limited access" (Kitchin et al., 2015).

The trend towards standardisation of city data has emerged recently. The first international standard was published in May 2014 (ISO 37120 – Sustainable Development of Communities: Indicators for City Services and Quality of Life), which includes 100 indicators that measure a city's social, economic and environmental performance. It was developed using the framework of the Global City Indicators Facility, which has been tested by more than 250 cities worldwide. The World Council on City Data (WCCD) provides a certification to cities based on the number of indicators reported and verified according to ISO 37120.

According to the WCCD, cities need standardised indicators to manage and make informed decisions through data analysis, benchmark and target, leverage funding with senior levels of government, plan and establish new frameworks for sustainable urban development, and evaluate the impact of infrastructure projects on the overall performance of a city.

4 SMART CITY INDEXES AND INDICATORS

Given the growing economic importance of cities, the process of urbanisation and the challenges imposed by climate change, the smart city concept has arisen as a new urban-development paradigm, which in turn has led to the emergence of smart city indicators and indexes (Table 2). The objective is to evaluate urban intelligence and to compare the performance of cities, demonstrating how cities best use ICT to improve quality of life, foster sustainability, and boost competitiveness and innovation.

Table 2. Examples of smart city indexes and indicators

Indicator framework; study/report	Organisation/author	Year
Smart Cities: Ranking of European Medium-sized Cities	Vienna University of Technology et al.	2007
The Top Smartest Cities in North America	Fast Company, Boyd Cohen	2012
The Top Smartest European Cities	Fast Company, Boyd Cohen	2012
The Top Smartest Cities in Asia/Pacific	Fast Company, Boyd Cohen	2013
Smart City Ranking in Chile	Boyd Cohen, Universidad del Desarrollo	2014
UK Smart Cities Index	Eric Woods et al., Navigant Research	2016
Smart City Ranking Brazil	Urban Systems	2015
Smart City Index Portugal	INTELI	2012
Icity Rate – Classification of Italian Smart Cities	Forum PA	2012
Italia Smart – Smart City Index 2016	Digital Agency - Italy	2016
White Paper "Smart Cities Analysis in Spain"	IDC	2011
Toward a framework for Smart Cities: A Comparison of Seoul, San Francisco & Amsterdam	Jung-Hoon Lee, Yonsei University, Seoul, Korea	2012

One of the first approaches was outlined in the study on *Smart Cities: Ranking of European Medium-sized Cities* (Vienna University of Technology et al., 2007), in which six characteristics of smart cities were presented: smart economy, smart people, smart governance, smart mobility, smart environment and smart living. The smart economy comprises factors associated with economic competitiveness, such as innovation, entrepreneurship and internationalisation. In sequence, smart people includes the level of

qualifications of the residents, the quality of social interactions and openness. Political participation, the functioning of the administration and public services make up the smart governance dimension. Smart mobility refers to local and international accessibility, the availability of ICT and transport systems. Smart environment includes such aspects as natural conditions, pollution, resource management and environmental protection. Finally, smart living includes quality of life (culture, safety, housing, tourism, etc.). The study integrates 74 indicators and 70 cities.

According to the "Strategic Implementation Plan" (European Commission, 2013) of the European Innovation Partnership on Smart Cities and Communities, smart city performance indicators and metrics are very important to measure and compare cities' progress. Yet, there is still no integrated indicator system that supports reliable progress monitoring in all fields relevant to smart cities, both within a city over time and among cities. Furthermore, the "Operational Implementation Plan" (European Commission, 2014) explicitly refers to the need "to develop and pilot an EU wide smart city indicator framework as a collaborative exercise; adapting [*sic*] existing measurement assets; and establish a means to achieve wide adoption".

With this objective, a project called "CITYkeys" was approved in 2015 under Horizon 2020.[1] Being coordinated by the research institute VTT (Finland), the aim is to develop and validate, with the aid of cities, key performance indicators and data collection procedures for common and transparent monitoring as well as the comparability of smart city solutions across European cities.

5 EVOLUTION OF KPI INITIATIVES

In line with the smart city agenda, KPI initiatives are being influenced by the possibilities offered by the digital revolution (Table 3). Fixed and mobile internet, ubiquitous computing, social media and Web 2.0 applications, database design and systems of information management, distributed storage of data and new forms of data analytics are key elements of this digital revolution (Kitchin, 2014).

At present, more data are being produced every two days than in all history prior to 2003. According to Rial (2013), 1.7 million bytes of data per minute are being generated globally. This is the so-called 'big data' phenomenon, which consists of "massive, dynamic, varied, detailed, interrelated, low cost datasets that can be connected and utilized in diverse ways, thus offering the possibly of studies shifting from: data-scarce to data rich; static snapshots to dynamic unfoldings; coarse aggregation to high resolution; relatively simple hypothesis and models to more complex, sophisticated simulations and theories" (Kitchin, 2014). In the same vein, Kleinman (2016) defines big datasets as "those available at massive scale; accessible in real time or close to it; have high dimensionality; and are much less structured than conventional datasets".

The possibility of accessing real-time data, which is being captured through sensors, cameras, social media and other devices, is a characteristic of the smart city vision. Kitchin (2014) describes this phenomenon as the "real-time city".

Table 3. Traditional and recent KPI initiatives

Variable	Traditional urban indicators	Innovative urban indicators
Focus	Focus on sustainable development and on environmental, economic and social dimensions	Focus on smart development and on the contribution of ICT to economic development, environmental protection, and social cohesion
Data collection	Official statistics or data provided by public or private entities, censuses Generated on a non-continuous basis Data are scarce Isolated and simple data Centred on samples Small number of variables High-cost datasets	Real-time data and information, collected through sensors, cameras, smartphones, etc. Generated on a continuous basis Data rich (big data) Interrelated and varied data Tend to be centred on the entire populations or systems High number of variables Low-cost datasets
Data analysis	Traditional statistics Simple hypothesis and models Coarse aggregation	Urban science Complex, sophisticated simulations and theories High resolution High-powered computation Data analytics centres
Data dissemination	Mainly closed data Static data; reports	Open data Dynamic data and online dashboards (visualisation)
Policy-making processes	Limited evidence-based decision- and policy-making processes	More accurate evidence-based decision- and policy-making processes
Main actors	Institutionally supported measurement (cities, international organisations)	Corporate-supported measurements (cities, consultants, multinationals)

[1] See http://citykeys-project.eu/.

In this respect, "governments are often overwhelmed by data, and express considerable interest in better, faster, and cheaper ways of extracting value from data" (Kleinman, 2016). Traditionally, this has been the domain of statistical analysis, but conventional statistics are now being complemented or even challenged by the new paradigm of data science. "By combining elements of statistics, computer science, and artificial intelligence, data science may offer better techniques and methods for how to learn from data" (Kleinman, 2016).

This new urban science is replacing traditional urban studies. Urban science is defined by Townsend (2015) "as an emerging domain of research at the intersection of science and design, drawing on new disciplines in the natural and informational sciences, that seeks to exploit the growing abundance of computation and data".

In this context, cities are opening up data, sharing them with residents, businesses and universities. Larger cities, such as London, Amsterdam, Barcelona, Berlin, Copenhagen, Paris, Stockholm and Vienna, are launching open data initiatives (European Commission, 2016). The release of data on transport, mobility, the environment and so forth enables the development of applications by companies and developers, enhancing innovation. Public and private entities can support this process through the organisation of app contests and hackathons.

London was one of the first European cities that started an open data initiative in 2010. In March 2016, the "Data for London: City Data Strategy" was published with the following ambition: "we want London to have the most dynamic and productive City Data Market in the world". Lisbon, one of POCACITO's case study cities, has recently launched its open data portal within the "Lisboa Aberta" (Smart Open Lisbon) programme. It intends to facilitate Lisbon's city life by challenging start-ups to solve urban problems with open data.

In some cities, real-time data are being communicated to residents through 'city dashboards', which display a number of indicators and provide visualisations (maps, graphics, etc.) that help interpretation and analysis. The London City Dashboard [2] and Dublin Dashboard – City Intelligence[3] are some well-known examples.

Furthermore, dynamic dashboards are often on display on computer monitors in modern control rooms (single data analytics centres) (Kitchin, 2014; Kitchin et al., 2015). One recognised case study looks at Rio de Janeiro's Operations Centre, supported by IBM. It integrates 30 city operators in the same room and collects real-time data and information with a view to supporting decision-making processes mainly related to natural disasters and accidents.

6 THE POCACITO APPROACH

Taking into account the different KPI initiatives and their evolution, the POCACITO project defined a set of urban indicators oriented to assessing and comparing cities' performance, and to analysing their transition process towards a post-carbon future. It is still a traditional approach, due to the current data limitations, but it integrates some of the insights of the new data collection and analysis trends.

The POCACITO team categorised the KPIs under social, environmental and economic dimensions. All the relationships, interconnections, feedback loops and redundancies from one dimension to another, including their sub-dimensions and indicators, were analysed to gain an overview of the transition process without compromising the evaluation mechanism.

The social dimension is concerned with equity, both within the current generation and between the generations during the transition process to post-carbon cities, which is expected to be smooth for all residents. The benefits for inhabitants that come out of living in a reduced-carbon city are highlighted, showing that these cities are places where it is pleasant to live and the values of equity and social inclusion are present. Special attention has been given to standards of living related to such essential aspects as education and health (for example, life expectancy and well-being). Unemployment rates and poverty are also issues

[2] See http://citydashboard.org/london/=.

[3] See http://www.dublindashboard.ie/pages/index.

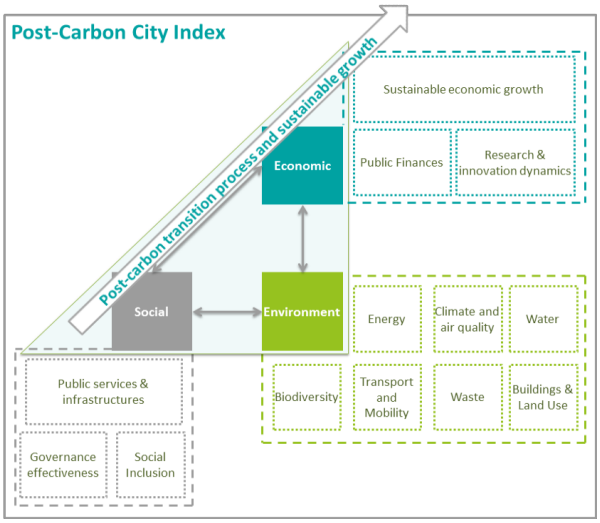
considered in the context of post-carbon cities. The public services and infrastructure that are available for residents are analysed, as well as aspects of governance and civic society promoting the positive sense of culture and community.

The environmental dimension investigates the sustainable profile of the cities and assesses not only the current impacts on the environment, but also those during the transition process, evaluating the environmental resilience of the cities. It is important to continually adapt the strategies in order to mitigate the negative impacts on the environment during the transition process. The environmental dimension covers the energy sector in general, taking into account final energy efficiency as well as the resource depletion associated with energy consumption. Post-carbon cities pay special attention to greenhouse gas emissions and their contribution to climate change. Some energy-intensive sectors are emphasised, such as transportation/mobility and the building stock. Biodiversity and air quality are critical themes that also belong to this dimension. Concerns regarding waste and water are also evaluated.

The economic dimension covers sustainable economic growth based on the wealth of the cities and their inhabitants. It recognises that investment is crucial to promoting post-carbon cities, in particular investment related to sustainable facilities. The labour market and the business cycle are considered to demonstrate the dynamics of a post-carbon economy in a green economy paradigm. Public finances are also analysed, because those cities with a lower level of indebtedness are more prepared to face the challenges during the transition process towards a post-carbon city. This dimension also includes expenditure on research and development, as no city can become a post-carbon one without innovation.

Indicators were selected taking into account i) the definition of a 'post-carbon city', ii) a set of existing frameworks of indicators and iii) a set of criteria defined by POCACITO partners, namely relevance, clear messages, data availability and data quality. Partners participated in the indicator selection process by discussing indicators and developing mind maps. Three mind maps were produced to identify indicators that are highly correlated, i.e. the indicators that 'incorporate' more information – the most 'substantial' indicators. At the end, a final list was produced, which was used in the case study analysis.

Figure 1. Dimensions and sub-dimensions of the POCACITO approach



7 LIMITATIONS OF KPI INITIATIVES

Despite the benefits, several limitations of KPI initiatives have been identified. Some of these difficulties were faced by the partners during POCACITO development.

The first group of limitations is related to technical and methodological issues. During the POCACITO project, questions of data availability, veracity and quality emerged. The definition of the geographical limits of a city brings additional problems, namely when we want to compare cities located in different countries. The majority of data and information are only available at Eurostat NUTS I, II or III levels, as data and information at the municipality or city levels is almost inexistent. Moreover, it is difficult to collect the data of different countries for the same years, which can prejudice the analysis. These limits are particularly risky as decision- and policy-making processes are based on this kind of information and knowledge.

The second group of limitations is linked to policy issues. In fact, KPI initiatives are never neutral; they are contingent, relational and contextual. Data do not exist independently of the ideas, practices, contexts and systems used to generate, process and analyse them (Kitchin et al., 2015). The

selection of indicators, parameters and weighting is also a non-objective process. Additionally, KPI analyses can be reductionist, since they simplify the complexity and multidimensional picture of the city. Such analysis "decontextualizes a city from history, its political economy, the wider set of social, economic and environmental relations that frame its development, and its hinterland and wider interconnections and interdependencies that stretches out over space and time" (Kitchin et al., 2015). It assumes that it is possible to compare the cities using same type of information in a standardised way, despite the variety of contexts and environments.

It is considered possible to objectively measure urban life in an 'instrumented city', a perspective influenced by a technocratic governance approach defended by some advocates of the 'technology-driven smart city' conception. Indeed, according to Hollands (2008), an "element characterizing self-designated smart cities is their underlying emphasis on business-led urban development (…) there is a general world-wide recognition (…) of the domination of neo-liberal urban spaces, a subtle shift in urban governance in most western cities from managerial to entrepreneurial forms, and cities being shaped increasingly by big business and/or corporations".

Thus, "how cities view indicators, benchmarking and dashboards, the kinds of indicators and systems they deploy, and how they employ them falls into two broad camps, both of which reveal the inherent tension in such initiatives between facilitating empowerment, democracy, accountability and transparency, and enacting regulation, control, efficiency and effectiveness" (Kitchin et al., 2015).

8 POLICY RECOMMENDATIONS

The above analysis suggests the following trends and recommendations for European, national and local governments:

Standardisation. Use agreed common standards (definitions and metrics) to contribute to improved collaboration within and between local governments.

Interoperability. Use agreed protocols and common data formats that facilitate interoperability across systems (European Commission, 2014).

Openness. Make data accessible to third parties (companies, entrepreneurs, residents, universities, etc.) in order to promote transparency, democracy and the development of innovative applications (open data).

Innovation. Use innovative indicators reflecting the technological, social and economic changes (the sharing economy, do-it-yourself, etc.), such as indicators related to electric mobility, bike-sharing and car-sharing systems.

Dissemination. Promote the dissemination of data and information through new visualisation techniques, such as maps and graphics (online dashboards), and make data available in public spaces.

Collaboration. Enhance collaboration among cities, universities and industry in data collection, analysis and dissemination processes, through urban science methodologies.

Civic participation. Promote the participation of residents and communities in data collection and analysis processes, through do-it-yourself sensors or smartphones.

Awards. Launch a 'European Capital of Smart Growth' initiative (similar to the European Capital of Innovation), with the evaluation based on a common set of dimensions and indicators.

Rescaling. Produce and use data at lower geographical levels, such as municipality and city levels, privileging functional territories over administrative territories.

Funding. Fund research and innovation activities in the field of open data and big data, enhancing the development of information products and services.

Legislation. Produce data-friendly legal frameworks and policies, namely in the area of public procurement to bring the results of data technology to the market.

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PROJECT

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