Evaluation of cities' smartness by means of indicators for small and medium cities and communities: A methodology for Northern Italy

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The need to develop policies that improve energy and environmental sustainability as well as technological innovation is the basis for the increase of the smartness of cities around the world. In the European Union, protocols were developed to measure the smartness of cities through indicators. These indicators however are tailored for large cities and do not fit the case of small cities in a satisfactory way. The paper develops a methodology for assessing smartness through indicators that is applicable to small and medium-size cities. The choice of the indicators is consistent with the ISO 37120 standard and it is inspired by the environmental indicators used in the Sustainable Energy Action Plan of the EU. The proposed methodology could be seen as an expansion of Governance strategies already partially adopted by many cities. The methodology is applied to 3 municipalities of northern Italy and the results obtained are discussed in the paper.

Keywords:
Smart City
Assessment tools
Rating systems for sustainability
Indicators of smartness
Smartness audit
Information communication technologies

1. Introduction

This paper focuses on the topic of "urban smartness", namely the set of features and processes that make a city a "Smart City". Due to the complexity of this topic, it is necessary to analyze definitions and concepts before going in depth into the issue of what makes a city a Smart City. Many definitions of Smart City were developed in literature. Most of them are characterized by common elements, such as the idea that a Smart City is a city built around the human being. The smartness of a city refers to its ability to promote a lifestyle in which the needs of the individual citizen match those of the community. This idea encompasses a view of the citizen who do not play only a passive role (i.e. citizens are passive users of the services that are offered them), but also an active one. In such view, citizens are players in the planning process that improves the smartness of the city. Shared definitions of the factors that influence the evolution of cities into Smart Cities and of the process that leads to the increase of their smartness were not developed yet. This is partially due to continuous upgrading of the concept of quality of life as well as of technologies and related needs and opportunities (see for example the Internet revolution). In this context, the creation of Smart Cities should not be looked at like a goal in itself but rather as a process that must be analyzed as such.

In the Italian context, two protocols (ICity Rate and Smart City Index) provide a methodology for evaluating urban smartness, but these are applicable only to metropolitan contexts and therefore exclude the possibility to use them for most of the Italian territory. This is because this territory is rather characterized by small and medium-sized cities.

This article seeks to show how the scientific definitions of Smart City has been transposed into practical concepts in the Italian arena and how these concepts were translated into protocols and good practices. Moreover, it aims at proposing a methodology for analyzing and grading the smartness of small and medium-size cities.

When dealing with the topic of Smart Cities it is relevant to consider also the evolution of cities towards models that value the sustainable development by promoting sustainable governance. The Covenant of Mayors project (http://www.covenantofmayors.eu/about/covenant-of-mayors_en.html) which started in 2008 under the support of the European Union is an interesting initiative in this sense. As of April 2017, 2956 Italian municipalities under 50,000 inhabitants had joined the initiative on a voluntary basis. The project represents a first step towards the implementation of planning measures to cut climatic emissions through the monitoring of their energetic consumption and the drafting of energy budgets. In this way, the project paves the road for a debate on citizens' quality of life. While environmental sustain-ability as conceived in the Covenant of Mayors project is an important matter to consider when talking of Smart Cities, other aspects are relevant too and the Smart City approach offers a comprehensive view on the factors that are pertinent to citizens' quality of life. That is where our interest in promoting a Smart City protocol for small and medium-size municipalities comes from. Here follows a list of the reasons that

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persuaded us to develop a methodology for the Italian situation, most of which are relevant also for other national contexts in the European Union:

- most projects regarding Smart Cities concern large cities (e.g. Milan, Turin, Rome, Venice, Naples, etc.) however most of the Italian population is concentrated in small and medium-sized cities: 23% of the Italian population lives in cities with more than 100,000 inhabitants, 47.5% lives in cities with less than 20,000 inhabitants while 31.3% lives in cities with less than 10,000 inhabitants.
- it is not possible to apply the same smartness indicators used for evaluating big cities to small and medium-size towns. The assessment of smartness in these cases must be adapted and/or modified in order to meet actual needs;
- Small and medium-size cities have the opportunity to support the development of groups of citizens moved by critical thinking whose role is necessary to promote environmentally friendly projects like strategies for sustainable mobility (i.e. routes equipped for electric cars, cycle paths, bike sharing, car sharing, etc.);
- Information and Communication Technologies (ICT) has a significant contribution in virtually connecting companies, citizens and other actors, as well as providing services that enable them to limit travels to large urban centers;
- Several small and medium-size cities have long been committed to promoting the SEAP (Sustainable Energy Action Plan) within the framework of the Covenant of Mayors. The implementation of Smart City models can constitute a strategy for expanding the governance strategies already adopted.

Our proposal of a methodology is as a way to expand the role of environmental and critical thinking in governance strategies already adopted by small and medium-size cities around Europe. The proposed methodology is applied to 3 municipalities of northern Italy in order to provide an example of how the methodology can be used. We then discuss the results obtained by analyzing the various steps of the study.

2. Background

2.1. Literature review

The technical and scientific literature on the Smart Cities topic is consistent. Some of the available literature deals with the definitions of Smart Cities while some studies assess sectorial aspects such as energy, environment, or ICT – Information Communication Technologies – in relation to Smart Cities. Finally, other pieces of literature address the use of indicators that evaluate urban smartness by examining case studies developed in specific cities or neighborhoods that invested in processes to increase their smartness. Some of the studies mentioned above engage in a comparison between the concepts of smart and sustainable city. Many authors believe that these two concepts should be seen in an integrated way and that smart cities are necessarily sus-tainable cities.

Albino, Berardi, and Dangelico (2015) identified different academic definitions of Smart Cities and underlined that the assessment of urban smartness must take into account that cities have different priorities for achieving their objectives and that they must promote an integrated development of different aspects.

Other definitions of Smart Cities are centered on single features of smartness. For example, Hall (2000) focuses on the smartness of infrastructures. He discusses the application of new technologies to current urban centers and he develops a future 20-years scenario by conceptualizing a city framework that may exist. The author states that a city can optimize its resources, plan its preventive maintenance activities and monitor security aspects that maximize services to its citizens only if the conditions of all of its infrastructures (including roads, bridges, tunnels, rails, subways, airports, seaports, communications, water, power and major buildings) are monitored and integrated.

All definitions of Smart Cities converge on recurring concepts like sustainability, interaction with the IOT − Internet Of Things − and the quality of life. By analyzing the literature on Smart Cities it becomes evident that Smart City is a complex and dynamic concept. Javidroozi, Shah, Cole, and Amini (2015) defined a city as a complex enterprise and stated that integrating cities' systems is essential for smart cities that need to provide inter-communication and inter-operation between sectors. In this view, cities have become smart not only in terms of automation of services, buildings and traffic systems, but also in ways that enable us to monitor, understand, analyze and consequently plan the city to improve efficiency, equity and quality of life for its citizens (Carli, Dotoli, Pellegrino, & Ranieri, 2013). In fact Carli et al. (2013) propose a two-dimensional framework (the degree of objectivity of observed variables and the level of technological advancement for data collection) for classifying performance indicators for smart cities. The aim of such framework is supporting policy makers in identifying the technologies that can be adopted, in order to measure and monitor a Smart City in clever ways and in order to adopt suitable actions for the city management and planning.

Angelidou (2015) identifies the four forces that shape the Smart City concepi: urban features, knowledge and innovative economy, technology push and demand pull. Angelidou (2015) provides also interesting conclusions about strategic planning for the development of smart cities and continues the discussion about how smart cities can be planned in a cohesive way.

Several studies examine Smart Cities in terms of technology. These works underline the centrality of ICT in Smart City system. In modern societies, the quick development of information technology and its applications (i.e IOT, cloud computing big data, next generation mobile broadband networks, etc.) is an emerging trend. Yuan and Liu (2014) propose an evaluation model for Smart Cities information applications and services made of four levels of indicators: necessary data and services integration capabilities, intelligent application services capabilities, user experience and support capabilities.

In this light, a city becomes a Smart City when a specific approach is applied to achieve sustainability based on ICT, namely when opportunities are available to create networks and pick up a large amount of data that are constantly updated (the so called "big-data") and are aimed at improving urban planning (Mosannenzadeh & Vettorato, 2014). Mosannenzadeh and Vettorato (2014) state that the application of ICTs in urban services and infrastructures and the integration of different systems in planning as well as in the implementation and investment in innovation are essential features of a Smart City.

Smart Cities should not be just a concentration of innovative technologies, as other issues are equally important and deserve attention. In this respect, Thite (2011) developed a study around a city where supporting creative economy through investment in quality of life is an important goal and they underline the importance of social aspects in this context. The goal of supporting creative economies is an element that attracts knowledge workers to live and work in Smart Cities. Thite (2011) explore also the implications of urban planning on the theory and practice of human resource development.

Moreover, Komninos (2011) focus on the variable geometries of spatial intelligence in Smart Cities, defined as territories with a high capacity for learning and innovation built upon the creativity of their population, their institutions of knowledge creation and their digital infrastructures for communication and knowledge management. Komninos (2011) contribute to increase the understanding of the different processes that make communities more intelligent. They also show that collective intelligence advance efficiency and cities' governance.

Carli et al. (2015) provide another economical perspective: the Smart City concept was recently introduced as a strategic means to encompass the growing importance of ICT, as well as social and environmental capital in defining cities' competitiveness and sustainability.

Databases on innovative tools are useful for the definition of indicators through which we measure the cities' performance. An important example is the RES NOVAE project (Laboratorio Smart City, 2017) that propose a dashboard and decision support tool for the energy governance of Smart Cities (Carli et al., 2015). From the analysis of traditional and innovative tools, the authors investigate solutions to support decision makers in determining the optimal action plan for implementing smart strategies in the city energy governance.

Yuan et al. (2014) observed that the concepts of Smart City is still under development and that the research on the indicator systems for evaluating Smart Cities is also at an early stage of development. Even though a number of organizations put forward a clear indicator system, there is still need of integrated and systematic definitions, as well as evaluation systems for the IoT applications and services of Smart City programs.

In smart cities, new technologies play an important role. The literature includes studies that analyze the relationship between ICT/IoT and Smart Cities or between ICT/IoT and sustainability improvement. Dameri (2016) contributes to this topic by analyzing the relationship between Smart City and ICT. The role of ICT in driving a sustainable future is the topic of a study edited by Global e-Sustainability Initiative (2012). This study highlights the potential of environmental improvements offered by ICT in various sectors (power sector, transportation, manufacturing, agriculture, building and service and consumer sectors) and includes some interesting case studies.

The relationship between sustainability and ICT is analyzed in the work of Hilty et al. (2011) who provide an overview of existing approaches to the use of ICT in the service of sustainability: Environmental Informatics, Green ICT and Sustainable Human-Computer Interactions. The authors argue that a combination of efficiency and sufficiency strategies is the most effective way to stimulate innovation. This is also supposed to boost ICT's potential to support sustainability.

Kramers, Höjer, Lövehagen, and Wangel (2014) reflect on whether ICT solutions can effectively reduce energy consumption in cities. The article explores the opportunities of using ICT as an enabling technology to reduce energy use in cities.

Finally, an overview of smart sustainable cities and the role of information and communication technologies are the topic of a report published by the International Telecommunications Union (2014).

With regard to smartness indicators, the literature shows a considerable interest in this topic. Marsal-Llacuna, Colomer-Llinàs, and Meléndez-Frigola (2015) argues that sustainability indicators used since 1995 under Local Agenda 21 are one of the causes of the Local Agenda 21's failure. In order to visualize the initiative's achievements in Smart Cities, the cited papers propose the use of synthetic indices rather than of static indicators. These indices could be updated based on real-time data. In this view, the use of new technologies (i.e. IoT devices supported by ICT) is essential in the management of large amounts of data. In the conclusions, the authors advise that official standardization bodies, i.e. ISO, CEN-CELENEC, take the lead in the elaboration of summarizing indices.

The literature analyzed gives rise to an interesting and constructive debate on sustainability, which is considered the true backbone of smart cities. Talking about smart cities, sustainable cities or smart sustainable cities is not just a matter of terminology but of substance. The most recent work that deepens this topic is that of Ahvenniemi, Huovila, Pinto-Seppä and Airaksinen (2017). The study analyze 16 sets of city assessment frameworks (eight smart city and eight urban sustainability assessment frameworks) comprising 958 indicators altogether, by dividing the indicators under three impact categories and 12 sectors. According to the authors, Smart Cities must be considered an evolution of the sustainable cities and they recommend the use of a more accurate term, namely "smart sustainable cities". Technological innovation is to be considered a positive addition and it must not remain the only goal of the evolution of cities. The goal should rather be sustainability in its environmental, social and economic components.

Bibri and Krogstie (2017a,b) provide a complete and updated reference framework. Their paper provides "a comprehensive overview of the field of smart and sustainable cities in terms of its underlying foundations and assumptions, state–of–the art research and development, research opportunities and horizons, emerging scientific and technological trends, and future planning practices" (Bibri & Krogstie, 2017a, 2017b, p. 183).

Other interesting works dealing with the relationship between the sustainability and urban smartness are those of Ibrahim, Adams, and El-Zaart (2015), Kobayashi, Kniess, Serra, Ferraz, and Ruiz (2017) and Höjer and Wangel (2015).

The enthusiasm of recent studies on the Smart City topic could be appeased by few critiques that may be raised towards the positive aspects of these cities. For example, many of the promises contained in the "Smart City revolution" are not perceived as such by users and ci-tizens. The suspicion is that the industries that propel innovation push the market with unethical goals, and sometimes stimulate needs that do not exist. The fear is that the technological component of the Smart City concept and the interests of private industries, however indispensable, prevail over the social component and the inclusiveness of Smart Cities. The ideas and reflections expressed by Glasmeier and Nebiolo's work (2016) are interesting in this regard. The authors argue that "Smart cities are the object of desire of technology corporations that seek new markets for existing products as well as simultaneously seeking, for themselves, the status of being "smart" with the hope of improving their chances of attracting economic development investment" (Glasmeier & Nebiolo, 2016 p. 1). The authors are not to blame when they state that in 2016 a shared definition of smart cities is not yet available in literature. The Smart City arena did not yet come to a common understanding of the topic and the complexity of the issue lends itself to criticism sometimes unjustified.

Neirotti, De Marco, Cagliano, Mangano, and Scorrano (2014) are optimistic and above all constructive: in their paper, they provide policy makers and city managers with useful guidelines to define and manage the application of Smart City strategies and to plan actions towards the most appropriate implementation goals.

2.2. Existing protocols for the evaluation of the smartness of cities in the EU and in Italy

The need to measure the smartness of cities gave rise to different projects aimed at outlining a procedure for evaluating cities by means of indicators that support the rating of such smartness. The objective of these projects is comparing different cities based on the evaluation of both a partial rating (i.e. with reference to various evaluation areas like smart economy, smart mobility, smart people, smart environment, etc.) and an overall rating of urban smartness.

For example, European Smart Cities (European Smart Cities, 2017) is a European project dating back to 2007 that aimed at assessing the smartness of European medium-size cities. It was financed by European Union funds and was conducted by the Polytechnic of Vienna in collaboration with the University of Ljubljana and the Technical University of Delft. For the first time in Europe, such project defined and applied a ranking tool that allowed comparing the potential "smart" features of 70 cities with a population of less than 500,000 inhabitants. An inter-active assessment tool, available on an Internet platform [www.smart-cities.eu], allows developing the overall ranking but also partial rankings that take into account the urban smartness related to specific evaluation areas (economy, mobility, environment, people, governance). Each evaluation area is composed of indicators, which together sum up to 74. Each indicator has a specific weight. The interactive interface allows assessing the smartness of each city by basing on the rating of each area as well as of each individual indicator. As all ranking modules, positive and negative aspects characterize the European Smart City Index. On the negative side, the project is affected by the

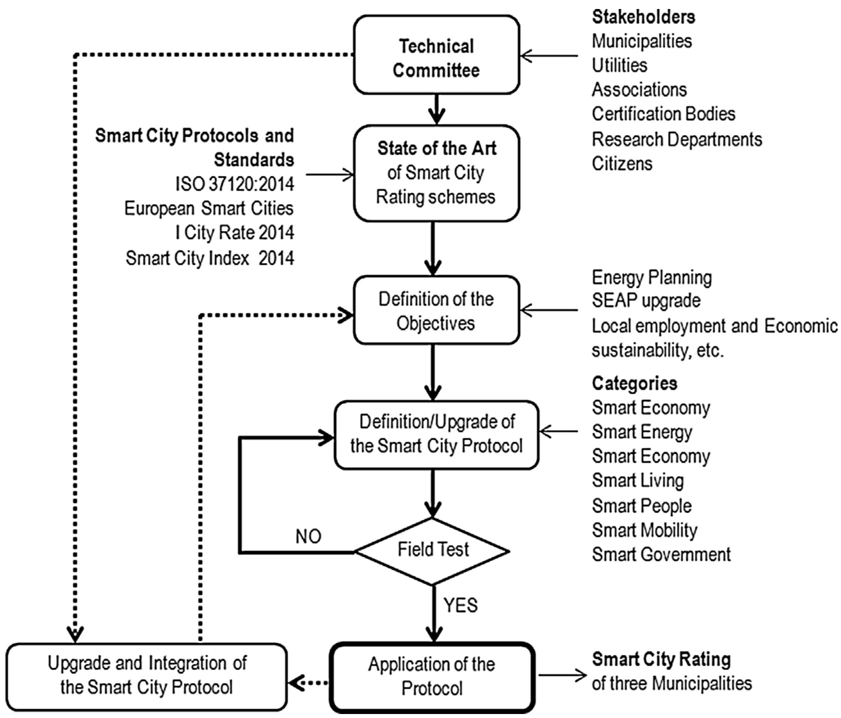

Fig. 1. Flowchart representing the methodology for the development of the Smart city protocol.

subjectivity of the criteria and rules' definition and by the lack of feedback by the assessed municipalities. The main positive element of this project is the comparison of medium-size cities with similar characteristics.

Two Smart city ranking projects were carried out in Italy. The first one is ICity Rate (2017), promoted by ICity Lab of Forum PA together with ANCI (National Association of Italian Municipalities). The second one is Smart City Index (Ernst & Young, 2016). ICity Rate ranks 103 cities and publishes an annual catalog with the complete description of the assessment carried out. Smart City Index compares all Italian municipalities that are provincial capitals. Smart City Index ranking procedure allows also monitoring changes in a dynamic way, by comparing the assessments related to different years. This project allows evaluating urban smartness by examining 9 subjects with a total of 153 indicators. The "broad band" subject area is assessed through 6 indicators, the "smart mobility" area through 35 indicators, the "smart health" area through 9, the "smart education" through 6, the "smart government" area through 54, the "smart mobility" area though 14, the "renewable energies" area through 7, the "energy efficiency" area through 14 and the "natural resources" area through 8.

2.3. The international standards ISO 37120

ISO 37120 (2014) provides a set of indicators to measure cities' services and quality of life. This standard satisfies the need of indicators to measure cities' performance in terms of sustainable development and resilience and it fills the gap generated by other existing sets of indicators that are not standardized or comparable over time or across cities. ISO 37120 (2014) provides a comprehensive methodology that enables cities of all sizes to be assessed in terms of their economic, environmental and social performance in relation to other cities. Its indicators are structured around several themes according to the different sectors and services provided by a city: Economy, Education, Energy, Environment, Finance, Fire and emergency response, Governance, Health, Recreation, Safety, Shelter, Solid waste, Telecommunication and innovation, Transportation, Urban planning, Wastewater, Water and sanitation, Reporting and Record maintenance.

The set of indicators is divided into 46 "core" and 54 "supporting" indicators. The use of core indicators is mandatory for assessing cities' performance while that of supporting indicators is only recommended. In addition to these indicators, "profile" indicators are defined that provide basic statistics and background knowledge. Such information is helpful to determine which cities are interesting for peer comparison.

The indicators can be used to measure performance of city services' management and quality of life over time, while monitoring the progresses and comparing the performance between cities that share best practices. Whereas cities may not have direct control over factors regulating some of these indicators, when interpreting the results of a particular service area, it is appropriate to consider the results of multiple types of indicators across themes.

The ISO/DIS 37120 standard is currently under revision by the Technical Committee ISO/TC 268 Sustainable Cities and Communities. The standard ISO/NP 37122 "Sustainable Development in Communities- Indicators for Smart Cities" is in the "proposal" phase, and was not yet published.

3. Description of the methodology

This paper describes a new method for evaluating urban smartness through a set of indicators that is applicable to small and medium-size cities.

Compared to existing protocols that use indicators based on national or regional databases, this methodology applies a specific type of analysis called "*smartness audit*", which assesses concrete results of policies promoted by municipalities in different evaluation areas. Most smartness indicators are built starting from information that is locally available and that are already held or can be easily retrieved by technical offices of the municipalities involved in the audit. The systematic collection of this urban, social, economic and environmental information makes the protocol an effective monitoring tool for government policies.

3.1. General overview of the methodological approach adopted to develop the Smart city protocol

According to what happens in the promotion and management of the SEAP, the methodological approach we adopted involved a large number of stakeholders. Sharing choices in governance policies and including different actors are key elements in the development of Smart city models.

Fig. 1 shows the steps adopted in the project. Initially, a Technical Committee was set up with the voluntary participation of different stakeholders among which Municipalities, Utilities, Associations, Certification Bodies, Research Departments, Universities and Citizens.

The Technical Committee had a strategic role in the development of the protocol: in addition to defining its technical directions in the initial steps, it was engaged in verifying the application of the protocol in the experimental stage and dealt with the periodic update of the protocol.

In the definition of the evaluations areas (or categories) and indicators contained in the protocol, the Technical Committee had the role of considering the needs expressed by stakeholders and the eco-nomic, societal and infrastructural features that characterize the small and medium-size municipalities (approximately less than 50,000 inhabitants).

An important step of the method used to develop the protocol is the field test. The application of the protocol's indicators, many of which are proposed by the political representatives of the Technical Committee, require the retrieval of basic information. The purpose of the field test is to check whether this information is available and sufficiently reliable, as well as whether it is necessary to employ human and instrumental resources to build up administrative procedures aimed at finding such information.

3.2. Definition of the indicators of the proposed protocol

In order to define the indicators we analyzed the following projects and protocols: ICity Rate, Smart City Index and ISO 37120. We also took into account the action plans for sustainable energy processed by the municipalities that joined the European Covenant of Mayors pro-ject. We chose these references as they focused on willingness to steer policies towards sustainability and reduce energy consumption at local level, which is a feature that matches the rationale behind the development of Smart Cities.

The mentioned projects and protocols were analyzed to identify the following elements:

- the main features;
- the scope of application;
- the thematic areas within which the indicators were developed;
- the strength points;
- the critical elements;
- the different types of indicators used across evaluation areas;
- the data source useful for the calculation of the indicators;
- the complexity involved in finding the information to calculate the indicators;
- the measure units of the indicators;
- the relative weight assigned to the indicators;
- the indicators' standardization process;
- the results of the analysis carried out;
- the degree of comparison of results over time or across cities.

As a consistent protocol suitable for the assessment of the smartness of small and medium-size cities was not available, a new set of indicators was developed with the support of the Technical Committee. Initially, the Technical Committee conducted a recurrence analysis of the indicators used by ISO 37120, I City-Rate and Smart City and evaluated them according to specific criteria. In order to meet the needs of the project, the newly defined indicators had to be:

- mirroring the features of Italian cities;
- consistent with the size of small and medium cities;
- normalized;
- characterized by easy calculation;
- accessible to validated source of data for the calculation;
- suitable and effective to represent specific features of small and medium cities;
- comparable over time or across cities.

The Technical Committee defined a set of indicators after discussing the indicators over time, modified and revised them the indicators during several meetings that led to a finalized version. A total of 70 indicators were identified, as shown in Appendix A.

In a first phase, the Technical Committee analyzed the indicators' recurrence within the protocols used as reference (I City-Rate and Smart City Index) and the ISO 37120 and started evaluating the selected indicators according to the abovementioned criteria. In a second phase, the Technical Committee selected indicators that were already present in one of the protocols analyzed or in the ISO 37120, that were relevant to evaluate the aspects characterizing the categories and that were consistent with the criteria outlined above.

In the last step, the list of indicators was enriched with newly introduced indicators that did not belong to those included in the reference projects and protocols. These indicators satisfied needs that were specific for the Smart City Protocol such as:

- indicators that responded to demands coming from territory (i.e. ECO_07);
- indicators that valorized new innovative solutions (i.e. ENV_04);
- indicators that valorized actions that are consolidated at local level (i.e. LIV_13, LIV_17);
- indicators and data already present in the SEAP (i.e. ENV_01, ENE_08);
- indicators that evaluate aspects related to the use of energy sources other than electrical sources (ENE_03);
- indicators that respond to the new integrated climate change approach of the SEAP (i.e. GOV_12);
- indicators that enhance electrical mobility also in relation to national legislations (D.L 22/06/2014) (MOB_08).

The indicators are structured around 7 evaluation areas (smart economy, smart energy, smart environment, smart governance, smart living, smart people and smart mobility) that allow analyzing results related to a city considering a specific theme. In this way, a city can become able to identify and address priorities for future actions in specific contexts.

The table included in Appendix A in Supplementary material 2 was developed to better explain how the indicators were defined. This table compares the indicators employed by the projects and protocols used as reference to develop the Smart City Protocol. It highlights whether the Smart City Protocol indicators are present in the other sets of indicators and vice versa. The "X" symbol indicates the presence of indicators in a specific set even if different measurement units are used to measure them. The "X *" symbol indicates the presence of an indicator in a specific set when the indicator evaluates the same feature but in different terms. For the ISO standard Table indicates also whether the indicator is a "core" or "support" indicator.

The "level" column of Appendix A in the Supplementary file 2 indicates whether the indicator falls under the category "International", "European" or "Regional". The "International" label refers to the fact that the indicator can be used without adjustments anywhere in the world. The "European" label refers to international indicators that undergo the effect of European Directives. "Regional" indicators are meant to be adapted locally by taking the socio-economic aspects of environmental issues into account.

A supplementary worksheet was then developed for each indicator with the following information:

- code (it consists of 3 letters which stand for the category and progressive numbers related to the same category);
- category of evaluation (evaluation areas);

Table 1
Comparison of the indicators' set of the Smart City Protocol with the indicators' set used in ISO 37120, I City-Rate and Smart City Index.

Categories	ISO 37120:2014	I City Rate 2014	Smart City Index Between 2014	Proposed Smart City Protocol
SMART ECONOMY	Economy (7) Finance (4)	Economy (25)	Culture and Travel (64)	Economy (7)
SMART ENVIRONMENT	Environment (8) Solid waste (10) Wastewater (5) Water and sanitation (7) Urban planning (4)	Environment (7)	Natural resources (15)	Environment (6)
SMART ENERGY	Energy (7)	–	Renewable energy (20) Energy efficiency (23)	Energy (12)
SMART GOVERNANCE	Governance (6)	Governance (17)	Governament (129) Justice (25)	Governance (12)
SMART LIVING	Fire and emergency response (6) Health (7) Recreation (2) Safety (5) Shelter (3) Telecommunication and innovation (3)	Living (20)	Broad Band (8) Health (19) Education (7) Security (33)	Living (17)
SMART MOBILITY	Transportation (9)	Mobility (8)	Sustainable mobility (22)	Mobility (8)
SMART PEOPLE	Education (7)	People (18)	–	People (8)

Note: the numbers in brackets indicate the number of indicators included in each category.

- description of the indicator;
- goal of the indicator;
- source of the data (database used to find the data);
- availability of the data in the Sustainable Energy Action Plans;
- overall data availability;
- measurement method (the indicators have two different measurement methods: "score" and "yes/no");
- measure units;
- procedures for data updating.

For the complete list of the indicators refer to Appendix A.

Table 1 provides a comparison among the reference projects and protocols and the Smart City Protocol, analyzed based on the seven categories defined by the Technical Committee for the Smart City Protocol.

3.3. Calculation of the smartness indicators

In this paper, a normalization value is proposed through the minimum-maximum method on a scale of values from 0 to 10, assigning 0 to the worst value and 10 the best value. From a sustainable point of view, some of the values have a positive impact if they are lower.

The value is obtained from the Eq. (1).

$$I_v = abs((-10 \times P) + ((x_v - x_{min})/(x_{max} - x_{min})) \times 10) \quad (1)$$

where

abs stands for absolute value

I_v is the indicator value

P indicates whether the final value is inversely proportional (Yes = 1/No = 0)

x_v is the value obtained for the case study

x_{min} is the minimum value

x_{max} is the maximum value

The minimum and maximum values were defined based on the analysis of the values obtained for each specific indicator and derived from the available databases. When possible, we used databases which included municipal level data. When this was not possible, we used values related to broader territorial areas like provincial or regional values. The code in the "range code" column indicates the method used to calculate the minimum and maximum values, as shown below (Table 2).

Table 2
The range calculation method.

Range Code	Range calculation method
A	Value calculated from existing databases
B	Spread method
C	Yes/no method

Method A: is the most comprehensive method and it is based on using the available databases to define the range of values. Most of the databases result from the work of national research institutes (ISTAT – Istituto nazionale di statistica, ARPA – Agenzia regionale per la prevenzione e protezione ambientale), energy operators (GSE – Gestore Servizi Energetici) and local providers of services (CAP Holding for the supply of water). The database prepared for SEAP projects through a bottom-up initiative joined by many municipalities in Lombardy Region represented an important source of data for the energy sector.

Method B: in the cases in which it is not possible to calculate ranges from the databases available at municipal scale, we refer to the spread method. The spread method involves the definition of the average indicator value for the reference Province (real data retrieved from sector studies) and the definition of a percentage of deviation in order to obtain the minimum and maximum values. This percentage was defined from a survey that involved the municipalities of the area through questionnaires distributed to representatives of departments and technical offices. The minimum and maximum values are defined through the application of the Formulas (2) and (3).

$$x_{min} = (x_a - x_a \frac{P_s}{100}) \quad (2)$$

x_{min} is the minimum value

x_a is the average value for the Province of Milan

P_s is the percentage of deviation (spread)

And

$$x_{max} = \left(x_a + x_a \frac{P_s}{100}\right) \quad (3)$$

where

x_{max} is the maximum value

x_a is the average value for the Province of Milan

P_s is the percentage of deviation (spread)

Method C: for these indicators the achievement of a specific goal is required. Therefore, if the goal is reached, the value is "yes" and the score is 10, while if the result is "no" 0 points are attributed to the indicator. The only exception is the indicator GOV_04 "Interactivity level of municipal activities" whose score ranges from 0 to 4. This score is discretized in 5 levels from 0 to 4. A high value is assigned if predefined requirements are satisfied (e.g. the digitization of civil registry documents). The final score is then normalized on a scale from 0 to 10, and proportionally defined based on the level of achievement. For example, the value 1 corresponds to 2.5 points, and 10 points are assigned to the value 4.

As for the indicators, supplementary worksheets were prepared to illustrate the range calculation method. For each indicator range, the supplementary worksheets included information related to:

- range definition for the indicator;
- calculation methodology;

– reference database for source data;
– indicator type;
– estimation method for minimum and maximum values;
– measure unit;
– year in which the data was collected;
– procedure of data update;
– notes.

3.4. Calculation of weights and final rating

The steps after the calculation of the indicators are the calculation of:

– the weight of each indicator within a specific evaluation area;
– the total weight of the entire evaluation area;
– the final score defining the overall city's smartness.

Through weights applied to individual indicators and to individual categories, it is possible to steer local governance by emphasizing those aspects that are considered more critical and therefore need greater attention. In our methodology, the weights chosen by the Technical Committee that considers the peculiarities of the territory in which the municipalities are located.

The definition of weights comes from a political choice shared within the Technical Committee that gives a local connotation to our approach and makes the methodology applicable in all socio-economic contexts. Flexibility is one of the main features of the proposed methodology and this is demonstrated by the fact that, in addition to being adaptable to the most varied territorial contexts, the protocol we present is suited to changing the weight assignment over time in relation to possible changes.

The maximum score for overall smartness is 70.
Table 3 shows the weighting subdivisions in relation to the seven *Evaluation* Areas.

3.5. Updating of the methodology for evaluating urban smartness

The methodology we propose needs to be regularly updated mainly because the average values of the indicators are progressively increasing and due to the evolution of technological development as well as of policy developments. That is why it is necessary to decide whether re-calculating reference values or eliminating some of the indicators.

The values of the indicators are collected from the database and the information is made available by the municipalities. Therefore, every descriptive card contains information on the data collection procedure, the frequency of definitions upgrading and the reference figure. A similar approach is adopted for the determination of the minimum and maximum range indicator, which is useful for determining the score.

The weight indicator will vary depending on the needs of the involved communities, technological developments and the changing policy context.

Table 3
Weights related to Evaluation Areas.

Evaluation area	Weight
SMART ECONOMY	0,08
SMART ENERGY	0,20
SMART ENVIRONMENT	0,10
SMART GOVERNANCE	0,20
SMART LIVING	0,20
SMART PEOPLE	0,10
SMART MOBILITY	0,12

Table 4
Characteristics of the municipalities under analysis.

Code	Number of inhabitants in 2016	Area [km^2]	Population density [n. inhab./km^2]	Approval date of the SEAP
Carugate	15,126	5.39	2,806.31	2011.03.02
Melzo	18,710	9.82	1,886.25	2011.11.28
Pioltello	36,897	13.09	2,818.72	2011.11.03

4. Application of the methodology

4.1. Description of the real context

To demonstrate the validity of the proposed methodology, the set of indicators were applied to three small and medium-size cities in Lombardy Region. Compared to other Italian regions, Lombardy region has encouraged energy efficiency policies in the building sector the most. Before starting the application, we analysed the evolution in terms of energy efficiency of the housing market in the Lombardy Region. In particular, we assessed the work of Belli, Brolis, Mozzi, and Fasano (2013), Dall'O', Norese, Galante, and Novello (2013), which deals with the energy performance of buildings.

The municipalities we worked with are located in the east of Milan Province, and are placed in a homogeneous geographical area. Table 4 shows features that characterize the three municipalities. The degree days of the municipalities involved are the same as those of Milan (the provincial capital of Lombardy region), namely 2,404 days. This is important because energy indicators are partly influenced by the climatic data of the site under study.

Important commercial activities take place in Carugate, where one of the biggest commercial centers of northern Italy is located. In Melzo the food sector industries play a major role. Pioltello is characterized by large residential areas with a high concentration of immigrants and therefore social aspects are among the most critical factors.

All three cities share local policies strongly tailored to the improvement of environmental sustainability. Moreover, all three municipalities joined the Covenant of Mayors project and approved as well as implemented a SEAP.

Carugate is well-known all over Italy as in 2004 it introduced a building code with mandatory rules aimed at the sustainable improvement of energy efficiency in the building sector. It was the first municipality in Italy to do so. On an experimental basis, Dall'O', Galante, and Torri (2011), applied a methodology for energy classification of buildings in 2010, implemented on a GIS (Geographic Information System) platform.

In 2012, an infrared audit campaign was conducted on 14 existing buildings located in Carugate. The buildings were constructed in different periods and therefore were characterized by a variety of building technologies.

With respect to Melzo, Dall'O', Norese et al. (2013) propose a multicriteria analysis to support the administration in programming SEAP with a sustainability focused approach. The scope of the work was to identify the best mix of technologies to increase the energy efficiency of existing buildings by reducing greenhouse gas emissions.

Dall'O', Galante, and Pasetti, 2012 analyzed the topic of evaluating potential energy savings through an energy retrofit of the existing building stock by including in the study the three Municipalities considered in this paper.

Pioltello represents a social reality that is articulated and difficult to manage and therefore is a very different case to study compared to Carugate. The higher number of inhabitants most probably cause the difficulty linked to its analysis. The problem of immigration and the consequent demand for housing is an issue that currently the town tries to solve through innovative strategies, such as the assignment of building permits to controlled prices of vacant properties.

To conclude, the involved municipalities were already implementing activities for improving sustainability and increasing their urban smartens appeared to be rather easy for these cities. Our methodology is characterized by the involvement of cities that already adopted environmental sustainability policies through their participation in the SEAP program. Consequently, it appears that the three Municipalities opted for the application of the smartness assessment methodology are an ideal breeding ground for a shift from a simple approach to a sustainability-oriented attitude to increase smartness.

4.2. Organizational and operational aspects of the smartness audit

In our methodology we define the “audit smartness” as the set of activities that involve the collection of data and information needed to develop the indicators. One of the features of our approach is to develop indicators based on real data derived from the local territorial context and provided by the municipalities involved, rather than statistical data.

We encouraged good cooperation with the technicians responsible for the various municipal departments (Territorial Department, Department of Urban Planning, Transportation Department, Department of Administration and Budget, Department of Culture, Department of Health, etc.) and we fostered the involvement and cooperation between different subjects (administrative staff and technical staff) which normally act independently.

Based on our experience we found that some information useful for calculating indicators is already available in organized databases, while others require a more complex analysis of documents (reports, drawings, etc.).

In this phase a note describing the indicator, the calculation range and essential aspects for future update of the database was also compiled.

The field study was followed by the calculation of the indicators’ value according to the methodology proposed: the yes/no score was discussed with the municipality offices, while for the range definition an additional processing work was necessary.

From a purely operational point of view, the first draft of the protocol was concluded with the verification of the consistency of the indicators’ data. The application of the protocol we developed was followed by the application of some adjustment to the reference intervals, which will be made more precise in the future through the involvement of a larger number of municipalities.

5. Results and discussion

5.1. Results

The indicators identified are aggregated in seven categories which are shown in Table 5. Table 5 reports also the rating attributed to the three case study municipalities through in smartness auditing. The same results are illustrated graphically in the radar diagram of Fig. 2. Table 5 allows comparing the promising and the problematic

Table 5
Smart rating (performance) for the 3 case studies.

Evaluation Area	Carugate	Melzo	Pioltello
Smart Economy	5.24	**5.98**	3.76
Smart Energy	**5.55**	3.68	5.33
Smart Environment	**6.64**	5.27	4.41
Smart Governance	**6.75**	5.54	6.50
Smart Living	**5.15**	4.03	4.71
Smart People	2.70	3.98	**4.57**
Smart Mobility	3.08	4.18	**4.86**
TOTAL Score	**35.12**	32.68	34.13

features of the three municipalities with respect to each one of the seven categories. The numbers in bold indicate the highest values.

The overall values attributed to the performance of the three municipalities are very close to each other. Albeit minimal, the differences between scores show interesting aspects related to the analysis of the three municipalities. The study of these aspects is deepened during the activities to support the planning and the monitoring of the SEAP.

Carugate is the municipality with the highest overall score (35.12), as well as the highest scores for 4 categories out of 7. Instead the municipality scored rather low with respect to two of the categories, Smart People and Smart Mobility. The presence of shopping centers that attract the population of neighboring municipalities generates traffic problems that need to be solved by the City Council.

Pioltello was attributed an overall score which is in between those of the other two municipalities. Interestingly, it scored rather high with respect to the categories in which Carugate was lagging behind. Instead, with respect to the Smart Economy category, the municipality needs to implement some improvements. This datum draws a difference between Piotello and Melzo, as the second municipality scored the highest in this category.

Melzo had an overall score of 32.68 which is the lowest of the three overall scores attributed to the municipalities. The city had an excellent performance in the category of Smart Economy, especially due to the industrial vocation of the Municipality. However, with respect to the other categories the municipality scored lower than Carugate and Pioltello. In particular, for the Smart Energy category it scored half than Carugate.

To summarize, the fact that Municipalities were attributed similar overall scores does not preclude the possibility of noticing important differences by looking at partial data. The reason why they scored mid values is probably that they are small municipalities which often have to make choices imposed by higher level governmental bodies parti-cularly in the transportation sector, or spread good practices such as SEAP. This brings up the need to analyze more in detail the differences that can be identified among the single categories, which provide a realistic image of the level of smartness of the municipalities.

5.2. Critical issues emerged

The data collection mad clear that the proposed methodology had some pitfalls. A first pitfall concerns the data sources that often were partially or completely inaccessible. This was mainly because some of the ranges were obtained with the spread method B, even though the use of this method will be gradually eliminated in favor method A. Another pitfall was the procedure of data update. We amended to the problem by including a specific field in the indicator and range fact sheets. For example, the ISTAT data refer to censuses that are carried out every ten years, while the same entity is concerned to carry out sectoral intermediate surveys.

The measure units must be calibrated to the context of small and medium towns. For example, bicycle paths are measured in km per 100,000 inhabitants for big cities while in km for 100 inhabitants for small towns.

Regarding the indicators that are attributed a yes/no label, it was necessary to define a detailed check-list that clarified the requirements that had to be fulfilled for obtaining a positive score. By applying the methodology we present is Section 3 and with the support of a spreadsheet, all the indicators were drawn for the three case studies and reported in Appendix A.

Once the procedure is defined, the cost of applying the methodology is determined by the time required to perform the various stages of the smartness audit. In order to make an assessment of the overall costs of the analysis up to the indicator definition, the duration of individual phases is monitored for each municipality and the results, measured in days/man, are shown in Table 6.

The time spent to make a complete analysis depends on several

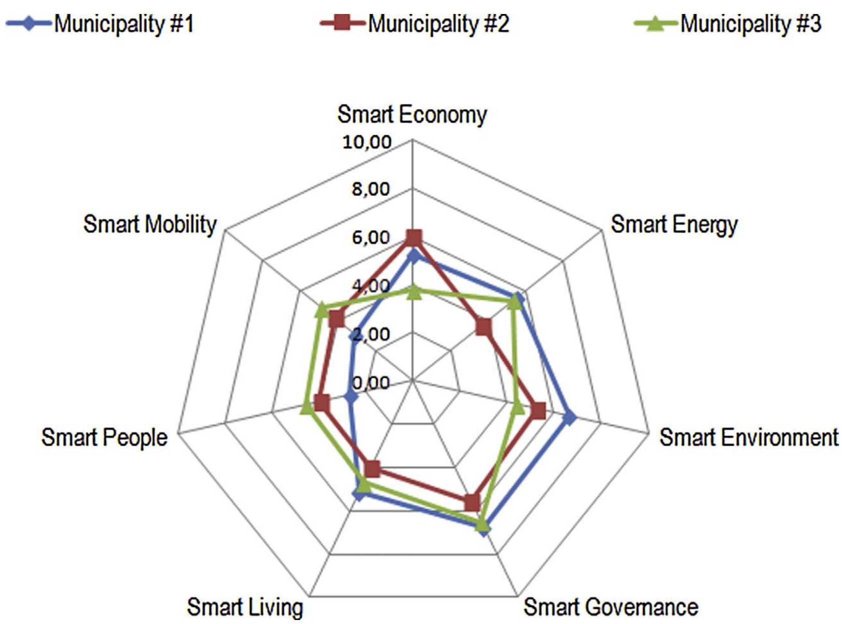

Fig. 2. Smart rating (performance) for the 3 case studies.

factors: the availability of organized data, the size of the municipality, as well as the willingness of the technical and administrative staff to cooperate.

Table 6 shows that there is no correlation between the cost measured in man/days and the number of inhabitants of the municipality. By examining the data of Table 6 it becomes clear that a limited amount of time is required for carrying out one smartness audit. This ensures the feasibility of the data collection and of the utilization of the in-dicators we propose. Therefore, the protocol we propose can be defined as an approach useful to promote, correct and verify the improvements of smartness policy.

The results of the analysis of the costs measured in relation to the time spent can reassure the municipalities about the economic feasibility of this protocol. It is important to note that the goal is not the one of making a general classification and compare best and worst cities, but rather that of highlighting critical issues and promising features of the municipalities through useful comparisons between different cities.

6. Conclusions

The term Smart City brings with it many elements of complexity, but it represents the backbone of a revolution involving modern cities that is changing our way of life. The analysis of technical literature highlighted several elements that confirm such complexity. Firstly, a terminology problem can be identified that raises the question of what a Smart City actually is. At the time this study was carried out, the scientific arena still did not hold a common definition for the term but dozens of definitions that are often very different. While analyzing literature we developed a concern, namely that the often used term "smart" conceals a will to promote new technologies at all costs and not for what they can actually offer.

Some authors affirm that sustainability should still be the main goal of city development towards Smart City models. They assert that it is more appropriate to talk about Smart Sustainable Cities rather than of Smart Cities.

We support this thesis by proposing a methodology for analyzing city smartness. The methodology we propose is an evolution of projects with important practical impacts such as the latest Convenant of Majors project promoted by the European Union.

This paper describes a method for assessing the smartness of a city through a set of indicators that are applicable to small and medium-size cities and communities. Our interest in small and medium-size cities is not casual but justified by the fact that most of the studies on Smart Cities available in literature are focused on large cities. We therefore aimed at filling the gap existing in literature.

The proposed methodology was applied on an experimental basis in three municipalities located in the Lombardy Region. A comparable number of inhabitants but different socio-economic features characterized the municipalities. As our methodology has been structured with the inclusion of "Regional" indicators, this methodology could be applied also in other contexts in the world.

The flexibility of the approach proposed, which focuses on the important role of the Technical Committee on the choice of indicators and the definition of weights to apply to the indicator and evaluation areas, is the most important feature of this methodology.

Existing rating systems for Smart Cities rely heavily on information from national or regional databases and therefore rarely suit small and medium-size municipalities. A methodology of smartness analysis defined based on information at national or continental scale can fit the assessment of large cities but it has limits if applied to small and medium-size cities, for which some indicators do not make sense. The experience of the European project Covenant of Majors, particularly appreciated by small and medium-size communities, showed the interest and the will to promote local governance. Our methodology fits this specific way of doing politics as it is underpinned by an approach that is close to citizens.

The results of our work are interesting and innovative as they allow filling a large gap generated by the fact that existing rating systems are

Table 6
Time needed for the smartness audits (measured in man-days).

	Meetings	Internet Consulting	Database Analysis	Analysis of documents	Field Surveys	Calculation of indicators	Total
Carugate	2.5	2.5	1.5	2.0	1	2.5	12.5
Melzo	1.5	1.5	1.0	2.5	1	2.5	10.0
Pioltello	1.5	1.5	1.5	2.0	2	2.5	11.0

not able to adapt to the real needs and to the reality of small and medium-size cities.

The three municipalities involved in the application of the methodology show to appreciate the participation in the project as this allowed them to collect information organized in the form of indicators. This proved to be useful for monitoring the implementation of policies for the smartness and sustainability. The inclusion of indicators in our methodology already present in the SEAP proved to be useful in monitoring the SEAP.

The indicators we used do not allow providing real-time information on city smart evolution, as we propose an annual update. As argued by Marsal-Llacuna et al. (2015) in order to visualize the achievement of initiatives adopted by Smart cities, synthetic indices that could be updated on the basis of real-time data could be useful. We believe this to be true, especially if considering the availability of smart technology (ICT, IoT, etc.). In this context, our choice, which is based on a "traditional" approach to the assessment of urban smartness, must be considered as a first step towards more evolved forms of indicators' protocols. For example, we can foresee that as soon as the technical skills of municipalities' personnel involved in our study are improved and become more confident with our protocol, it will be possible to hypothesize an evolution of the analysis that takes into account a better exploitation of the technology available in this field.

As the first stage of the methodology applied to three municipalities generated a positive feedback, the proposed methodology will be spread and applied to a core of 50 municipalities in the Lombardy area. This will allow calibrating the ranges of calculation of the indicators and improving the methodology.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.scs.2017.06.021.

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Appendix A *The proposed structure of the system of indicators to assess smart city*

Code	Indicator	Assessment Area	Category	Range code	Source	SEAP	Measurement method	Measurement unit
ECO_01	Unemployment rate	Work	Smart Economy	A	ISTAT		score	%
ECO_02	Percentage of full time employed	Work	Smart Economy	A	ISTAT		score	%
ECO_03	Number of companies per 100 inhabitants	Innovation/ Work	Smart Economy	A	Open data Lombardy Region		score	No. companies/100 inhabitants
ECO_04	Number of IT companies per number of total companies	Innovation	Smart Economy	A	Open data Lombardy Region		score	%
ECO_05	Thematic web portal for culture and tourism	Knowledge and tourism	Smart Economy	C	Website Municipality		yes/no	yes/no
ECO_06	Number of 14001 audits (or similar) per 100 companies	Private company	Smart Economy	B	ACCREDIA website		score	No. audits/100 companies
ECO_07	Number of co-working space per 100 inhabitants	Work	Smart Economy	B	Municipality		score	m^2 coworking/100 inhabitant
ENE_01	Residential electricity consumption per inhabitants	Smart Building	Smart Energy	A	SiReNa	x	score	kWh/inhabitant
ENE_02	Public building electricity consumption per inhabitants	Smart Building	Smart Energy	A	PAES	x	score	kWh/inhabitant
ENE_03	Residential natural gas consumption per inhabitants	Smart Building	Smart Energy	A	SiReNa	x	score	m^3/inhabitant
ENE_04	Public buildings natural gas consumption per inhabitants	Smart Building	Smart Energy	A	PAES	x	score	m^3/inhabitant
ENE_05	Percentage renewable energy production per total energy production	Alternative energy	Smart Energy	A	PAES/ Municipality	x	score	%
ENE_06	Percentage of volume served by the district heating per total buildings volume	Smart Building	Smart Energy	B	Municipality	x	score	%
ENE_07	Public lighting energy consumption per kilometers of illuminated street	Smart Lighting	Smart Energy	B	PAES/ PGTweb		score	kWh/km
ENE_08	Industrial energy consumption per floor area of industry buildings	Smart Building	Smart Energy	A	SiReNa/ PGTweb	x	score	kWh/ Nr of companies
ENE_09	Number of high energy efficiency buildings (from B class) per total of issued certificates	Smart Building	Smart Energy	A	CENED		score	%
ENE_10	Residential kWp photovoltaic installed per 100 inhabitants	Smart Building	Smart Energy	A	ATLAS Sole-GSE		score	kWp/100 inhabitant
ENE_11	Tertiary and industrial kWp photovoltaic installed per 100 inhabitants	Smart Building	Smart Energy	A	ATLAS Sole-GSE		score	kWp/100 inhabitant
ENE_12	Public buildings kWp photovoltaic installed per 100 inhabitants	Smart Building	Smart Energy	B	Municipality/CEM Ambiente		score	kWp/100 inhabitant
ENV_01	Tons CO_2 eq of greenhouse gases emissions per inhabitants	Air quality	Smart Environment	A	SiReNa	x	score	ton CO_2eq/inhabitant
ENV_02	Maximum number of days exceeding the PM10 limit	Air quality	Smart Environment	B	ARPA		score	Nr of days
ENV_03	Residential waste production per inhabitant	Waste management	Smart Environment	A	Province waste obervatory		score	kg/inhabitant
ENV_04	Municipal plans in order to promote smart waste management	Waste management	Smart Environment	C	Municipality website		yes/no	yes/no
ENV_05	Percentage of recycled solid waste	Waste management	Smart Environment	A	Province waste obervatory		score	%
ENV_06	Liters of water consumption in a day per inhabitant	Water management	Smart Environment	B	CAP Holding spa		score	l/days
GOV_01	Percentage of turnout at the municipal election	Citizen involvement	Smart Governance	B	Municipality website		score	%

GOV_02	Trasparency index of municipality website	E-Gov	Smart Governance	B	Portale MagellanoPA 2015	score	%
GOV_03	Interactivity level of municipal activities (such as request for registry office certificate, change of address,…)	E-Gov	Smart Governance	C	Municipality	score	Level 0-4
GOV_04	Municipality's achievement of ISO14001 certification or EMAS registration	Ecoman agement	Smart Governance	C	ISPRA	yes/no	yes/no
GOV_05	Adoption of a Green public procurement or similar initiative	Ecoman agement	Smart Governance	C	Municipality	yes/no	yes/no
GOV_06	Percentage of renewable electricity acquired per total consumption	Energy policies	Smart Governance	B	Municipality	score	%
GOV_07	Monitoring the performance of city services with Energy Management System or similar	Energy policies	Smart Governance	C	PAES	yes/no	yes/no
GOV_08	Drawing up of environmental balances	Land planning	Smart Governance	C	Gazzetta Amministrativ a	yes/no	yes/no
GOV_09	Drawing up of acoustic zoning	Land planning	Smart Governance	C	Municipality website / GIS	yes/no	yes/no
GOV_10	Drawing up of urban traffic plan	Land planning	Smart Governance	C	Municipality website	yes/no	yes/no
GOV_11	Drawing up of Sustainable Energy Actions Plan	Land planning	Smart Governance	C	Municipality website	yes/no	yes/no
GOV_12	Natural disaster prevention policy	Safety	Smart Governance	C	Municipality / Civil protection	yes/no	yes/no
LIV_01	E-health: access to innovative services than regional ones	Health care	Smart Living	C	Municipality	yes/no	yes/no
LIV_02	Joint venture between Municipality and ASL to allow home-based health care	Health care	Smart Living	C	Municipality	yes/no	yes/no
LIV_03	Number of public hot-spot per inhabitant	Connecti vity	Smart Living	B	Municipality	score	n°/100 inhabitants
LIV_04	Users percentage of broadband by fixed/mobile network	Connecti vity	Smart Living	B	Infratel Italia s.p.a. website / Wired website	score	%
LIV_05	Percentage of people with IRPEF taxable income up to € 10,000 per total tax-payers	Poverty	Smart Living	A	Italian Municipalities	score	%
LIV_06	Public square meters per capita for outdoor recreational activities	Recreati onal activities	Smart Living	B	PGT/ISPRA	score	m^2/inhabitant
LIV_07	Public square meters per capita for indoor recreational activities	Recreati onal activities	Smart Living	B	PGT	score	m^2/inhabitant
LIV_08	Number of public nursery application forms approved / Number of application sent	Schools	Smart Living	B	Municipality website	score	%
LIV_09	Digital school: number of students / number of PC	Schools	Smart Living	B	MIUR 2012/ Municipality	score	Nr of PC/Nr of students*100
LIV_10	Digital school: % classrooms connected to Internet (LAN and Wi-Fi)	Schools	Smart Living	B	MIUR/ Municipality	score	%
LIV_11	Number of beds in pensions for elders (residentials and not) every 1000 residents	Welfare_ elders	Smart Living	B	Segesta/ Municipality	score	Nr of beds/1000 inhabitants
LIV_12	Social policies (Index of social integration)	Immigrat ion	Smart Living	B	Municipality	score	Level 0-4
LIV_13	m^2 of urban vegetable garden every 100 inhabitants	Recreati onal activities	Smart Living	B	Municipality website	score	m^2/100 inhabitants
LIV_14	Number of municipal educational activities on the themes of Smart City every 1000 inhabitants	Recreati onal activities	Smart Living	B	Municipality / SEAP	score	Nr of activities/1000 inhabitants
LIV_15	Number of associations every1000 inhabitants	Recreati onal activities	Smart Living	A	Municipality/ ISTAT	score	Nr of ass./1000 inhabitants
LIV_16	Number of sport facilities every 1000 inhabitants	Recreati onal activities	Smart Living	A	Municipality/ ISTAT	score	Nr of sport facilities /1000 inhabitants

LIV_17	Number of initiatives to disseminate the products every 1000 inhab territory (land market, slow food restaurants, promotion of local products, …)	Food farming	Smart Living	A	Municipality7ISTAT	score	Nr of initiatives/1000 inhabitants
PEO_01	% of people with higher education diploma every 100 inhab.	Instruction	Smart People	A	ISTAT	score	Nr of degrees/100 inhabitants
PEO_02	% of people with university degree every100 inhab	Instruction	Smart People	A	ISTAT	score	Nr of degrees/100 inhabitants
PEO_03	% of students who complete secondary education	Instruction	Smart People	A	ISTAT	score	%
PEO_04	Female public employees / total public employees	Equal opportunities	Smart People	B	Municipality	score	%
PEO_05	Female elected politicians / total elected politicians	Equal opportunities	Smart People	B	Municipality/ Ancitel	score	%
PEO_06	Difference between male and female employment rate	Employment	Smart People	B	ISTAT	score	%
PEO_07	Municipal taxes earned / municipal taxes attributed	Welfare	Smart People	B	Municipality	score	%
PEO_08	Number of courses for elders every 100 inhab.	Welfare_ elders	Smart People	B	Municipality	score	Nr of courses/100 inhab
MOB_01	Km of public transport system (underground / train) every 1000 inhab.	Public Transport	Smart Mobility	B	PGT/Trenitalia	score	km/1000 inhabitants
MOB_02	Km of public transport system (bus / tram) every 1000 inhab.	Public Transport	Smart Mobility	B	Municipality / Autoguidovie	score	km/1000 inhabitants
MOB_03	Annual pro capita number of public transport rides	Public Transport	Smart Mobility	B	Municipality / Autoguidovie	score	Nr of rides / inhabitants
MOB_04	% of limited traffic zones	Alternative Transport	Smart Mobility	B	Municipality website/Gis	score	%
MOB_05	Number of bikes (from bike sharing service) every 10 inhab	Alternative Transport	Smart Mobility	B	Municipality website	score	Nr of bikes/100 inhabitants
MOB_06	Km of cycle paths every 100 inhab.	Cycling	Smart Mobility	B	PGT	score	km/100 inhabitants
MOB_07	Number of matching parking every 1000 inhab.	Parking	Smart Mobility	B	Municipality website	score	Nr of car parkings /1000 inhabitants
MOB_08	Number of recharge electric columns every 10000 inhab	Alternative Transport	Smart Mobility	B	Municipality website	score	Nr of charging columns /10000 inhabitants

Appendix B *Comparison between the different sets of indicators that assess the smartness of cities and that are used as reference in the development of the Smart City Protocol*

Code	Indicator	Level	ISO 37120:2014	I City Rate	Smart City Index Between
ECO_01	Unemployment rate	International	X (core)	X	-
ECO_02	Percentage of full time employed	International	X (support)	X	-
ECO_03	Number of companies per 100 inhabitants	International	X (support)	X*	-
ECO_04	Number of IT companies per number of total companies	International	-	X	-
ECO_05	Thematic web portal for culture and tourism	International	-	-	X
ECO_06	Number of 14001 audits (or similar) per 100 companies	International	-	X*	-
ECO_07	Number of co-working space per 100 inhabitants	Regional	-	-	-
ENE_01	Residential electricity consumption per inhabitants	International	X (core)	-	X*
ENE_02	Public building electricity consumption per inhabitants	International	X (core)	-	-
ENE_03	Residential natural gas consumption per inhabitants	International	-	-	X*
ENE_04	Public buildings natural gas consumption per inhabitants	International	-	-	-
ENE_05	Percentage renewable energy production per total energy production	International	X (core)	-	-
ENE_06	Percentage of volume served by the district heating per total buildings volume	International	-	-	X
ENE_07	Public lighting energy consumption per kilometers of illuminated street	International	-	-	X*
ENE_08	Industrial energy consumption per floor area of industry buildings	International	-	-	-
ENE_09	Number of high energy efficiency buildings (from B class) per total of issued certificates	European	-	-	-
ENE_10	Residential kWp photovoltaic installed per 100 inhabitants	International	-	-	-
ENE_11	Tertiary and industrial kWp photovoltaic installed per 100 inhabitants	International	-	-	-
ENE_12	Public buildings kWp photovoltaic installed per 100 inhabitants	International	-	-	X
ENV_01	Tons CO_2 eq of greenhouse gases emissions per inhabitants	International	X (core)*	-	-
ENV_02	Maximum number of days exceeding the PM10 limit	International	X (core)*	X	X
ENV_03	Residential waste production per inhabitant	International	X (core)	-	-
ENV_04	Municipal plans to promote smart waste management	Regional	-	-	-
ENV_05	Percentage of recycled solid waste	International	X (core)	X	X
ENV_06	Liters of water consumption in a day per inhabitant	International	X (core)	-	X
GOV_01	Percentage of turnout at the municipal election	International	X (core)	-	-
GOV_02	Trasparency index of municipality website	Regional	-	X	X*

GOV_03	Interactivity level of municipal activities (such as request for registry office certificate, change of address, etc.)	Regional	-	X	X*
GOV_04	Municipality's achievement of ISO14001 certification or EMAS registration	International	-	X	-
GOV_05	Adoption of a Green public procurement or similar initiative	International	-	X	-
GOV_06	Percentage of renewable electricity acquired per total consumption	International	-	X	-
GOV_07	Monitoring the performance of city services with Energy Management System or similar	International	-	-	-
GOV_08	Drawing up of environmental balances	European	-	X	-
GOV_09	Drawing up of acoustic zoning	Regional	-	X	-
GOV_10	Drawing up of urban traffic plan	Regional	-	X	-
GOV_11	Drawing up of Sustainable Energy Actions Plan	European	-	-	-
GOV_12	Natural disaster prevention policy	International	-	-	X*
LIV_01	E-health: access to innovative services than regional ones	Regional	-	-	X*
LIV_02	Joint venture between Municipality and ASL to allow home-based health care	Regional	-	X*	-
LIV_03	Number of public hot-spot per inhabitant	International	-	X	X
LIV_04	Users percentage of broadband by fixed/mobile network	International	X (core)*	X*	X
LIV_05	Percentage of people with IRPEF taxable income up to € 10,000 per total tax-payers	Regional	-	X	-
LIV_06	Public square meters per capita for outdoor recreational activities	International	X (support)	-	-
LIV_07	Public square meters per capita for indoor recreational activities	International	X (support)	-	-
LIV_08	Number of public nursery application forms approved / Number of application sent	European	-	X	-
LIV_09	Digital school: number of students / number of PC	International	-	-	X
LIV_10	Digital school: % classrooms connected to internet (LAN and Wi-Fi)	International	-	-	X
LIV_11	Number of beds in pensions for elders (residentially and not) every 1000 residents	International	X (core)	X*	-
LIV_12	Social policies (Index of social integration)	Regional	-	X	-
LIV_13	m2 of urban vegetable garden every 100 inhabitants	Regional	-	-	-
LIV_14	Number of municipal educational activities on the themes of Smart City every 1000 inhabitants	Regional	-	-	-
LIV_15	Number of associations every1000 inhabitants	Regional	-	-	-
LIV_16	Number of sport facilites every 1000 inhabitants	Regional	-	-	-
LIV_17	Number of initiatives to disseminate the products every 1000 inhabitant's territory (land market, slow food restaurants, promotion of local products, …)	Regional	-	-	-

PEO_01	% of people with higher education diploma every 100 inhabitants	International	X (support)	-	-
PEO_02	% of people with university degree every100 inhabitants	International	-	X	-
PEO_03	% of students who complete secondary education	International	X (core)	-	-
PEO_04	Female public employees / total public employees	International	X (core)	-	-
PEO_05	Female elected politicians / total elected politicians	International	-	X	-
PEO_06	Difference between male and female employment rate	International	-	X	-
PEO_07	Municipal taxes earned / municipal taxes attributed	International	X (support)	-	-
PEO_08	Number of courses for elders every 100 inhabitants	Regional	-	X*	-
MOB_01	Km of public transport system (underground / train) every 1000 inhabitants	International	X (core)	-	-
MOB_02	Km of public transport system (bus / tram) every 1000 inhabitants	International	X (core)	X*	-
MOB_03	Annual pro capita number of public transport rides	International	X (core)	-	-
MOB_04	% of limited traffic zones	International	-	X	X*
MOB_05	Number of bikes (from bike sharing service) every 10 inhabitants	International	-	X	-
MOB_06	Km of cycle paths every 100 inhabitants	International	X (support)	-	-
MOB_07	Number of matching parking every 1000 inhabitants	International	-	X*	-
MOB_08	Number of recharge electric columns every 10000 inhabitants	Regional	-	-	-