A Bidirectional Research Method to Design a Smart City Evaluation System

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Abstract: This paper develops a two-way research method – both top-down and bottom-up – to define a "standard but tailored" assessment framework for smart cities, based on shared smart city concepts, but designed to respond to different needs of each city. The method aims not to design a measurement standard, but to define a process able to create the best smart city measurement system. It is based on a standard framework but tailored on each city – with its own features, problems, values, and ideas about the quality of life. This method overcomes the limitations of using standard framework, as it links smart city assessment tools to local policies but giving to the tool the authoritativeness deriving from the scientific literature and the robustness acquired from international nest practices. An empirical implementation supports the theoretical background and allows to validate the method, as it has been successfully implemented in Genoa, a medium-sized city in Italy looking for its own performance measurement system that allows comparison with other smart cities at the same time. The bidirectional method is designed by the authors of this paper, and it is a novelty in the international literature about research methodology for business and management studies.

Keywords: Research method, Smart city, Performance, Indicators, Evaluation, Assessment

1. Introduction

During the latest 15 years, smart cities have been spreading all over the world (Dameri, 2013), starting from the largest and most important metropolis (Mora and Bolici, 2017) and involving an even higher number of cities, especially in Europe and North America (Martin et al., 2018).

In the meantime, many measurement systems flourished, aiming at assessing the smart city implementation (Brorström et al., 2018). These measurement systems are based on a set of indicators, collected at the international level, able to compare all the smart cities each other (Sharifi, 2020).

However, these measurement systems share the same weaknesses: they are composed by a set - sometimes very confined - of indicators, chosen arbitrarily or without specifying the underlying theoretical model; they can measure the smartness only of the largest cities in the world, and are opaque, lacking clarity and transparency about the data sources (Gazzeh, 2023).

These aspects imply that such measurement systems are not useful to manage and govern the smart city implementation by the local government. Indeed, these indicators are too general and inadequate to understand the specific situation of each city, as well as not linked with the local policies (Dameri and Rosenthal-Sabroux, 2014).

Given this situation, two research questions arise. The first question regards the dilemma between standard and tailored tools: how to link the smart city measurement tool to local specificities and at the same time allow for comparison with other cities? The second question concerns the quality of the tool: how to define a personalized tool that is robust and authoritative?

The present paper addresses both these research questions. It develops a bidirectional research method to design standard but tailored smart city evaluation systems, including the indicators useful to both assess and communicate the smartness and to support the political decisions of the local government aiming at improving the smart city (Dameri, 2017). Being rooted into the scientific literature and the best international practices, the tool is robust and authoritative and allow the comparison; being developed accordingly to the needs of the city and the feedback of the stakeholders and community, the tool can support local policies and decisions.

The research is based on a case study, investigated through the interventionist approach, as the authors have overseen the implementation of the smart city measurement system in a medium Italian city.

The paper continues as follows. Section 2. examines the extant literature and Section 3 explains the research methodology, Section 4. analyses the case study, Section 5. discusses the findings and Section 6. concludes.

2. Literature Review

Since the beginning of the smart city era, academicians, local governors, and companies tried to define this phenomenon (Dameri and Cocchia, 2013). Even if several different definitions are available, three concepts are at the core of a smart city: the territorial and political aspect, referring to the urban area (Nam and Pardo, 2011); the role of the most innovative technologies (Lee et al., 2013); and the aim of the smart city to improve the quality of life in city (Silva et al., 2018). Given these concepts, it is necessary to align the smart city measurement and assessment system to the smart city aim, that is, the improvement of the quality of life (Lombardi et al., 2012). However, this doesn't always happen.

Performance measurement in smart city is a difficult task, considering the multidimensionality of the smart city and the ambiguous concept of quality of life (Karal & Soyer, 2024). Respect to the first point, smart city measurement systems have often been designed considering multiple values and evaluation dimensions (Albino et al., 2015). Akburak et al. (2023) attempt to reorder all the indicators, after a very thorough investigation of the most popular evaluation models developed to measure the performance of smart cities. They note that there is an open question on how to select and use the right indicators in such a vast context. Recently, Fang & Shang (2024) suggested organizing the dimensions and indicators into two pillars, where the capacity pillar focuses on infrastructure readiness and the performance pillar evaluates the quality of various urban services.

However, the technical aspect of a smart city often prevails respect to the human aspect, and indicators are especially focused on the technological equipment of the city; but to measure the technology means to measure the tools, not the outcomes (Nam and Pardo, 2011). Moreover, the quality of life is not easy to define, and it varies from one city to another. Therefore, a smart city measurement standard is not the best solution to evaluate the smart city performance (White, 2018).

Respect to the link between quality of life and smart city, several academic papers suggest linking the idea of smart city perceived by citizens with the indicators, to individuate smartness drivers and link them with the desired outcomes (Yigitcanlar et al., 2018). Tu (2018) suggests designing subjective scores derived from the experiences and feelings of citizens' insight into their true perceptions of smart cities. However, such a way to work creates bias: these indicators are not immune to contextual factors affecting cities and citizens (deOliveira et al., 2024).

Another problem arising from several works regards how to choose between the huge number of standard tools for smart city measurement. The international literature about smart city assessment tools includes a very high number of so-called standards; Sharifi (2019) selects the most relevant ones: they are 34. Excluding 5 of them, because regarding only a specific aspect of a smart city, the remaining 29 ones are suggested as standard tools, to be applied to all the smart cities. Several tools are not global ones but designed to be applied in a well-defined geographical area. However, smart cities are not the same all over the world, and to apply a standard smart city assessment tool totally neglects the geographical differences and specificities.

Moreover, standard smart city assessment tools are generally addressed to large cities; indeed, Berksova et al (2018) find that there is a relation between the city dimension and the most suitable indicators to measure its smartness; therefore, indicators selected for large metropolis fit badly with medium cities.

Standard smart city assessment tools are generally theoretically designed, starting from the theoretical definitions of smart city. They are defined by a top-down process and appear like a list of indicators, completely disconnected with the local policies and initiatives (White, 2018). On the contrary, effective smart city assessment tools should be conceived not merely like a measurement system, but as a decision-support system. However, smart city assessment is rarely applied to evaluate urban policies, leading to unjustified decisions and unnecessary investments (Fang & Shan, 2024).

Indeed, the city smartness does not increase by itself: as stated by Yandri et al. (2020), city smartness needs a set of well-defined local policies, linking governance to smart projects and expected results. Moreover, if the smart city assessment system is designed to link policies and city smartness, it allows also to focus the smart policies on citizens' needs and expectations and to use the smart city assessment system as an accountability tool (Picioroagă et al., 2018).

Finally, the literature analysis discloses that both scholars and institutions design smart city measurement tools, therefore there are a lot of such frameworks available (Sharifi, 2019). However, these tools have often been designed to compare smart cities each other, and not to define a decision support system for local smart

policies (Borsekova et al., 2018). The suggested tools are generally designed starting from a strong literature analysis and therefore they are theoretically affordable and robust. However, there are no ways to assert that a tool is better than another and no ways also to choose the better tool for a certain smart city (Huovila et al., 2019). Such tools are like a black box for a local government, unable to choose the better one and to link the measurement tool to the local smart initiatives. Such measurement tools remain as superstructures totally separated from local policies (Praharaj et al., 2018).

3. Methodology

The research methodology supporting this paper is a case study investigated though interventionist approach (Roberts et al., 2010). In this case, the researchers are also the persons charged to design and implement the smart city measurement system in Genoa, a medium city in Northern Italy (Dameri, 2014, Bruzzone, 2021).

The longitudinal case study has been starting in 2020, when the Municipality decided to develop a system to measure the smart city performance, tailored on the specific needs of Genoa, but also able to compare the city's results with similar cities in Italy and Europe.

The researchers played two roles concurrently: from the one side, they drove the path to design and implement the smart city measurement system; from the other side, they collected the materials to study the case and generalize the findings.

During the design and implementation phases, the researchers collected materials, especially minutes from the several panels and meetings involving municipal politicians and officials, experts, and citizens. These materials have been manually coded and are the basis for the discussion. The interventionist approach allows the authors to be involved in the case study, to directly observe the behaviours of all the actors, and to collect materials otherwise not available.

4. Implementing a Smart City Measurement System: A Bidirectional Approach

4.1 The Requirements

Genoa is one of the most important cities in Italy, counting around 600.000 inhabitants. Moreover, starting from 2009, Genoa launched a program to become smarter (Grossi and Pianezzi, 2017). Ten years later, despite the high number of projects implemented by the Municipality together with a large set of partners, nothing had been done to measure if and how these projects and efforts created quality of life for citizens.

At the beginning of 2020, the Municipality asked to the University of Genoa, Department of Economics, to start a program to define and implement a performance measurement system, able to respond to several requirements.

- The first requirement was to create a system tailored on the specific needs and problems of Genoa, instead of being the uncritical adoption of a standard method.
- The second requirement was to link the measurement system to the political decisions of the local administrators; the mayor had the specific need to monitor the smart Action Plan designed by the city council and under implementation.
- The third requirement was to design a system able to support the comparison between Genoa and other similar cities in Italy and Europe, as well as able to communicate to the citizens the outcomes of the smart projects implemented in Genoa.
- Moreover, the mayor of Genoa asked to define the measurement system so that it could include data from the latest five years: therefore, data should already exist and not to be collected specifically for the project.

It was immediately clear that the standard measurement systems known worldwide were not suitable. First, they were designed for large cities, and not able to catch the problems and features of a medium city such Genoa is. Moreover, the indicators are not linked with the political goals of the local government, therefore not able to support the political decisions. Finally, they are not clear respect to data sources and the calculation methods, and impossible to replicate at the local level (Patrão et al., 2020).

The decision was to study how to design and implement a system with these features: tailored on the features of Genoa, linked to the local policies, able to compare Genoa with similar cities, and based on existing data.

4.2 The Bidirectional Approach: Top-Down and Bottom-Up

The requirements about the smart city measurement system to be designed were opposite: from one side, a tailored system is required, from the other side, the same system should be enough standard to compare Genoa with other smart cities.

To build such a system, a bidirectional approach has been conceived. From top down, a literature review helped to study standard smart city measurement systems worldwide. From bottom up, smart city local aims, ideas, and priorities have been collected, and finally the two streams of knowledge merged (Dameri, 2015).

The literature survey investigated both academic papers and professional reports regarding tools and frameworks to measure smart city performance. The investigation is based on Sharifi (2019), collecting 34 smart city assessment tools. From these 34 ones, 5 have been excluded from this analysis, as regarding only one aspect of a smart city (for example, IoT, digitalization, and so on). The remaining 29 tools have been analysed and compared each other; indicators have been compared and listed; the same or similar ones have been listed only one time. The resulting list includes 176 indicators and is the basis for the design of the smart city measurement system for Genoa.

In the meantime, a bottom-up approach was followed, involving both policy makers and technicians from the municipality and panels of experts. The panels were three, each of them was organized to face a specific smart theme: environment, infrastructure, and socio-economic aspects.

The panels were conducted in two steps. The first step was based on a brainstorming approach: experts were free to speak about what a smart city is, which its aims are, how these aims really impact on the life of the citizens or on the quality of the city itself. After the first step, the minutes of the panels were manually coded to extract the recurrent keywords; these keywords were used to define the most important smart city themes as they arose from the experts.

During the second step, the keywords were shared with the experts, and they were stimulated to better analyse these keywords respect to Genoa smart city, its dimensions, its goals, and the way to reach them, the benefits for the citizens. At the end of these two phases, the researchers had at their disposal a list of themes, the most important to define a smart city really pursuing the quality of life for its citizens. Each theme included several aspects to be pursued and all the aspects are listed respect to their importance and priority for Genoa.

At the end of the bidirectional approach, the researchers had therefore a list of 176 standard indicators, and a list of themes for Genoa smart city. The smart city assessment tool has been built from the merging of these two aspects.

4.3 The Data

Another important requirement for the smart city measurement system was to have the data to fill in it. This aspect is of capital importance, as several good smart city measurement systems have been well defined on paper, but never implemented owing to the lack of data (Putra et al., 2018).

To solve this problem, the researchers worked as follows. First, all the indicators included into the standard list were analysed; values to fill in these indicators have been searched on authoritative and reliable sources, such as ISTAT (The Italian Statistical Institution), Eurostat and so on. For each indicator, we had three different results:

- We found the data to fill in the indicator.
- We did not find the data to fill in the indicator, but we found data to fill in a proxy of the indicator: the indicator is replaced by its proxy.
- We found neither the data to fill in the indicator, nor proxy data, therefore we cancelled the indicator.

At the end of this process, the smart city measurement system included 160 indicators, filled in with affordable data. 16 indicators have been cancelled as the data for their completion was missing. Comparing with the 29 smart city assessment tools investigated (Sharifi, 2019), 160 indicators are a very high number, therefore, to cancel 16 of them do not affect the quality of the measurement system.

As data have been collected from open databases, it is possible to fill in them for all the 117 Italian provincial capitals and to obtain the comparison requested by one of the requirements.

4.4 The Standard-But-Tailored System

The list of themes and indicators defined in the previous steps can ensure the benchmarking, but not the tailored analysis for Genoa smart city (Brorström et al., 2018; Lombardi et al., 2012). To build a tailored system from the standard data, the aims and priorities should be considered. These priorities define the main aims that Genoa smart city should reach respect to its strengths, weaknesses, and the political direction chosen by the mayor and the municipal council.

For each theme, a subset of the standard indicators has been selected, composing a dynamic and customized aggregation of data about the city smartness. This aggregation can be applied to each of the 117 Italian provincial capitals, ensuring the benchmarking, but the most important result is that such subsets of indicators are the one responding to the city needs and to the political priorities of the local government. It permits to link the local policies with measured performance and to drive the political choice to prioritize the smart city goals more important for Genoa (Dameri, 2014).

For example, Genoa is a city especially weak respect to floods, and resilience priority could address political decisions towards some smart city initiatives, such as to reduce soil consumption and waterproofing (Grossi and Pianezzi, 2017). In the meantime, such indicators can be used to communicate to the citizens both the political choices and the obtained outcomes, and to gain consensus (Grossi et al., 2020). Such a smart city measurement system is therefore also an accountability system because it permits to evaluate the returns on public investments (White, 2018).

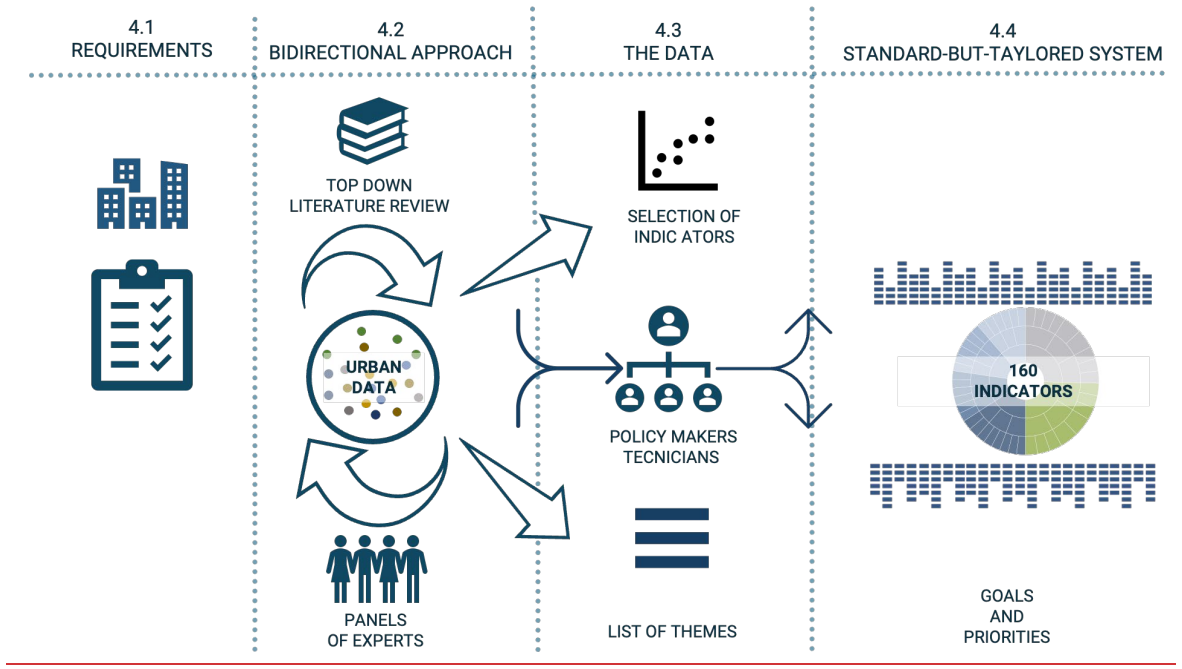

Figure 1: The Smart city measurement system (source: elaboration by the authors)

5. Findings and Discussion

5.1 A Four-Phases Process

The theoretical research linked with the empirical case helped to obtain important findings about how to implement an effective smart city evaluation system. The most important aspect is that the research activity suggested a process instead of a measurement framework. Indeed, both the scientific literature and the empirical implementations offer several examples of smart city measurement systems; however, to adopt a standard method was in contrast with the requirements of the mayor, as a standard measurement system responds to the need to measure a generic smart city and it is not ever suitable with the need of a certain city. And even more, a standard system is rarely conceived to support the local policies of the same city. However, to develop ex-novo a measurement system poses the problem of choosing the indicators.

The answers to these questions are therefore in a process able to start from a standard method but driving the city to adapt it to its own features and needs, through several phases addressed to safeguarding the integrity

of the obtained system. The process arising from this research is composed by four phases, as showed in Figure 1.

1. Requirements: during this phase, then policy makers define the requirements they ask for the system; it is of capital importance, as in this way the system is designed accordingly with the need of the policy makers and it prevents they do not use the tool. This problem is frequent for standard systems, that are not aligned neither with the requirements, nor with the political needs.
2. Bidirectional approach: all the stakeholders are grouped in panels of experts and cooperate to define the features of the measurement system but starting from a proposal made by the researchers and derived from the scientific literature. In this way, the system is authoritative and tailored concurrently.
3. Data selection: given the directions from the panels of experts and seen the scientific literature, is now possible to select data for the measurement system; data should be chosen granting soundness and neutrality, extracting them from authoritative sources able also to deliver data continuously in time.
4. Standard but tailored: the resulting measurement system is designed referring to standards arising from the scientific literature, but tailored respect to the requirements of the policy makers, the prior themes of the city and the availability and soundness of the data. It allows to use the system to support political decisions, to measure the performance of just such decisions, to communicate the results to the citizens accordingly with their expectations linked with the city priorities, and to pursue accountability of the politicians towards their electors.

The four-phases process answer to both the research questions. The first RQ regards how to overcome the dilemma between standard and tailored measurement system. The solution is a process that allows to tailor the systems starting from a standard, giving to the system enough personalization but maintaining the essential forms and features of the starting model. The second RQ regards how to assure enough quality to a tailored system; the answer derives from the method adopted to implement the system, based on three authoritative sources: the scientific literature, that deliver the basis for designing the measurement system; the participation of both the policy makers and the stakeholders, that grant the alignment of the system to the requirements and the priorities of the city; and the authoritativeness of the data sources, that prevent from self-referentiality and bias.

6. Conclusions

Several smart city assessment tools are available in literature, designed by both scholars and institutions. These tools are often conceived to measure the city smartness to create rankings and compare smart cities all over the world, individuating the smarter one. For this reason, they are suitable to large cities and difficult to apply to medium or small cities (Borsekova et al., 2019). Moreover, these tools are often opaque, it is not possible fond the data spurces and to understand why some indicators have been included (and some others not); and it is also impossible to understand the formulas used to calculate the rankings (Sharifi, 2019). For all these reasons, it is very difficult to implement such measurement tools at the local level.

Facing such difficulties in adopting and implementing a smart city assessment tool, several smart cities do not measure their performance (Picioroagă et al., 2018). Consequently, smart policies are not evaluated, political choices are not supported, citizens are not aware about the impact of smart city initiatives on their daily life.

To overcome these problems, the present paper suggests a process that permits to each smart city to develop its own measurement system, starting from a standard set of indicators, but selecting subsets of indicators linked with the specific city needs, priorities, problems, ambitions. The suggested process permits to pursue two aims concurrently: from one side, the assessment tool is robust, because built on the literature and the best practices about smart city measurement tools; from the other side, the assessment tool is customized and flexible, able to support the local policies, to measure the performance, and to communicate to the citizens.

The bottom-up approach permits to involve policymakers, stakeholders, citizens in defining their own smart city assessment system: this system will be something in which all the actors can recognize themselves and not a superstructure. To select specific subsets of indicators is a way to link smart initiatives to expected outcomes and the smart city measurement system also becomes an accountability tool. Such subsets can be further re-selected, accordingly with new priorities or political aims (Silva et al., 2021).

This process has been successfully implemented in Genoa, a medium city in Italy looking for its own smart city measurement system and the comparison with other smart cities concurrently. To better validate the process, further implementations are needed, and the authors are already working for this aim.

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References

Akburak, D., Gürbüz, T., & Alptekin, G. (2023, September). Review of Sustainable Smart City Assessment Models' KPIs. In *2023 IEEE International Smart Cities Conference* (ISC2) (pp. 1-7). IEEE

Albino, V., Berardi, U., & Dangelico, R. M. (2015). Smart cities: Definitions, dimensions, performance, and initiatives. *Journal of urban technology*, 22(1), 3-21.

Angelakoglou, K., Nikolopoulos, N., Giourka, P., Svensson, I. L., Tsarchopoulos, P., Tryferidis, A., & Tzovaras, D. (2019). A methodological framework for the selection of key performance indicators to assess smart city solutions. *Smart Cities*, 2(2), 269-306.

Borsekova, K., Korony, S., Vaňová, A., & Vitálišová, K. (2018). Functionality between the size and indicators of smart cities: A research challenge with policy implications. *Cities*, 78, 17-26.

Brorström, S., Argento, D., Grossi, G., Thomasson, A., & Almqvist, R. (2018). Translating sustainable and smart city strategies into performance measurement systems. *Public Money & Management*, 38(3), 193-202.

Bruzzone, M. (2021). Medium-Sized smart cities: A smart vision for urban centralities and buildings. From the European Case History, to a proposal for the City of Parma, Italy. In: Magnaghi, E., Flambard, V., Mancini, D., Jacques, J., Gouvy, N. (Eds), *Organizing Smart Buildings and Cities*, Springer Nature, 99-123.

Dameri, R. P. (2013). Searching for smart city definition: a comprehensive proposal. *International Journal of computers & technology*, 11(5), 2544-2551.

Dameri, R. P., & Cocchia, A. (2013, December). Smart city and digital city: twenty years of terminology evolution. In *X Conference of the Italian Chapter of AIS*, ITAIS (pp. 1-8).

Dameri, R. P. (2014). Comparing smart and digital city: initiatives and strategies in Amsterdam and Genoa. Are they digital and/or smart?. In: Dameri R., Rosenthal-Sabroux C. (eds) *Smart City. How to Create Public and Economic Value with High Technology in Urban Space.* Progress in IS. Springer, Cham. (pp. 45-88).

Dameri R.P., Rosenthal-Sabroux C. (2014). Smart City and Value Creation. In: Dameri R., Rosenthal-Sabroux C. (eds) *Smart City. How to Create Public and Economic Value with High Technology in Urban Space.* Progress in IS. Springer, Cham, 1-12.

Dameri, R.P (2015). Urban Tableau de Bord: Measuring Smart City Performance. In: Mola, L. & Pennarola, F. & Za, S. (ed.), *From Information to Smart Society*, Springer, 173-180.

Dameri R.P. (2017). Urban Smart Dashboard. Measuring Smart City Performance. In: Dameri R.P., *Smart City Implementation. Creating Economic and Public Value in Innovative Urban Systems* Progress in IS. Springer, Cham.

de Oliveira, J. C., Mazieri, M. R., & Kniess, C. T. (2024). Smart Cities Indicators: How Regional Context and Its Stakeholders Are Essential to Name "The" Smart City. *Journal of Urban Technology*, 1-24

Fang, Y., & Shan, Z. (2024). Optimising smart city evaluation: A people-oriented analysis method. *IET Smart Cities*, 6(1), 41-53.

Gazzeh, K. (2023). Ranking Sustainable Smart City Indicators Using Combined Content Analysis and Analytic Hierarchy Process Techniques. *Smart Cities*, 6(5), 2883-2909.

Giffinger, R., & Gudrun, H. (2010). Smart cities ranking: an effective instrument for the positioning of the cities?. *ACE: architecture, city and environment*, 4(12), 7-26.

Grossi, G., & Pianezzi, D. (2017). Smart cities: Utopia or neoliberal ideology?. *Cities*, 69, 79-85.

Grossi, G., Meijer, A., & Sargiacomo, M. (2020). A public management perspective on smart cities:'Urban auditing'for management, governance and accountability. *Public Management Review*, 22(5), 633-647.

Huovila, A., Bosch, P., & Airaksinen, M. (2019). Comparative analysis of standardized indicators for Smart sustainable cities: What indicators and standards to use and when?. *Cities*, 89, 141-153.

Karal, F. S., & Soyer, A. (2024). A systematic literature review: Setting a basis for smart and sustainable city performance measurement. *Sustainable Development*, 32(1), 555-573.

Lee, J. H., Phaal, R., & Lee, S. H. (2013). An integrated service-device-technology roadmap for smart city development. *Technological Forecasting and Social Change*, 80(2), 286-306.

Lombardi, P., Giordano, S., Farouh, H., & Yousef, W. (2012). Modelling the smart city performance. *Innovation: The European Journal of Social Science Research*, 25(2), 137-149.

Malek, J. A., Lim, S. B., & Yigitcanlar, T. (2021). Social inclusion indicators for building citizen-centric smart cities: A systematic literature review. *Sustainability*, 13(1), 376.

Martin, C. J., Evans, J., & Karvonen, A. (2018). Smart and sustainable? Five tensions in the visions and practices of the smart-sustainable city in Europe and North America. *Technological Forecasting and Social Change*, 133, 269-278.

Mora L., Bolici R. (2017) How to Become a Smart City: Learning from Amsterdam. In: Bisello A., Vettorato D., Stephens R., Elisei P. (eds*) Smart and Sustainable Planning for Cities and Regions.* SSPCR 2015. Green Energy and Technology. Springer, Cham

Nam, T., & Pardo, T. A. (2011). Conceptualizing smart city with dimensions of technology, people, and institutions. In *Proceedings of the 12th annual international digital government research conference: digital government innovation in challenging times* (pp. 282-291).

Patrão, C., Moura, P., & Almeida, A. T. D. (2020). Review of smart city assessment tools. *Smart Cities*, 3(4), 1117-1132.

Picioroagă, I. I., Eremia, M., & Sănduleac, M. (2018, October). SMART CITY: Definition and evaluation of key performance indicators. In 2018 *international conference and exposition on electrical and power engineering (EPE)* (pp. 217-222). IEEE.

Praharaj, S, Han, JH & Hawken, S (2018). Evolving a Locally Appropriate Indicator System for Benchmarking Sustainable Smart Cities in India. *in World Sustainability Series. World Sustainability Series*, Springer, 253-274.

Putra, H. Y., Putra, H., & Kurniawan, N. B. (2018, October). Big data analytics algorithm, data type and tools in smart city: A systematic literature review. In 2018 *International Conference on Information Technology Systems and Innovation (ICITSI)* (pp. 474-478). IEEE.

Roberts, H., Westin, O., & Dumay, J. C. (2010). A critical reflective discourse of an interventionist research project. *Qualitative Research in Accounting & Management*, 7(1), 46-70.

Sharifi, A. (2019). A critical review of selected smart city assessment tools and indicator sets. *Journal of cleaner production*, 233, 1269-1283.

Sharifi, A. (2020). A typology of smart city assessment tools and indicator sets. *Sustainable cities and society*, 53, 101936.

Silva, B. N., Khan, M., & Han, K. (2018). Towards sustainable smart cities: A review of trends, architectures, components, and open challenges in smart cities. *Sustainable Cities and Society*, 38, 697-713.

Silva, J., Mojica, J., Piñeres, A., Rojas, R., Acosta, S., Guliany, J. G., & Sanabria, E. S. (2020). Algorithms for the control of key performance indicators for smart cities. *Procedia Computer Science*, 170, 971-976.

Silva, F. A. C., Villibor, J. P., Almeida, T. A. D. S., Bonatto, B. D., & Ribeiro, P. F. (2021). Smart Cities Criteria: A Discussion About Relevant and Contextualized Indicators for Sustainable Smart Living. In 2021 *IEEE PES Innovative Smart Grid Technologies Conference-Latin America (ISGT Latin America)* (pp. 1-5). IEEE.

Tu, W. (2018). Data-driven QoS and QoE management in smart cities: a tutorial study. *IEEE Commun*. Mag. 56(12), 26–133.

White, J. M. (2018). Politicising smart city standards. In Coletta C., Evans L., Heaphy L., Kitchin R. (Eds) *Creating Smart Cities* (pp. 33-48). Routledge.

Yandri, E., Setyobudi, R. H., Susanto, H., Abdullah, K., Nugroho, Y. A., Wahono, S. K., ... & Nurdiansyah, Y. (2020). Conceptualizing Indonesia's ICT-based Energy Security Tracking System with Detailed Indicators from Smart City Extension. In *E3S Web of Conferences* (Vol. 188, p. 00007). EDP Sciences.

Yigitcanlar, T., Kamruzzaman, M., Buys, L., Ioppolo, G., Sabatini-Marques, J., da Costa, E. M., & Yun, J. J. (2018). Understanding 'smart cities': Intertwining development drivers with desired outcomes in a multidimensional framework. *Cities*, 81, 145-160.