Context-Aware Indicators for Data-Driven Smart City Evaluation: Evidence from the CESMOD Project

Zuzana Hruška[1][a], Janka Marschalková[1][b], Leonard Walletzký[1][c] and Mouzhi Ge[2][d]

[1]*Masaryk University, Faculty of Informatics, Czechia*

[2]*Deggendorf Institute of Technology, Germany*

Keywords: Smart Cities, Performance Indicators, Data Quality, Context-Sensitive Evaluation, Data-Driven Governance.

Abstract: The smart city concept has evolved into a mainstream framework for urban development, however, evaluating the impacts of smart solutions remains a challenge due to cross-domain effects, context dependency, and limitations in data quality and availability. This paper therefore addresses these challenges by presenting the methodology developed within the CESMOD project in the Czech Republic, which aims to establish a robust, data-driven environment for the long-term measurement and comparison of smart city impacts. The methodology proposes a hierarchical and context-sensitive indicator structure aligned with national smart city strategies while prioritizing data availability and interoperability. To demonstrate the approach through selected component-level indicator sets, the paper has shown how strategic objectives can be operationalized into interpretable and scalable indicators across different municipal contexts. The findings contribute to the improvement of policy usability in smart city evaluation frameworks.

1 INTRODUCTION

The concept of the Smart City is no longer a novelty; it has become a well-established framework within both practical urban management and academic research. In contemporary discourse, smart cities are primarily understood as urban settlements that enhance their resilience through the deployment of innovative solutions, fundamentally underpinned by Information and Communication Technologies (ICT) and, increasingly, Artificial Intelligence (AI).

However, a fundamental challenge remains in measuring the impacts and changes induced by the application of these solutions. Smart city interventions, often referred to as "Good Practices," are inherently multifaceted and frequently impact domains beyond their primary focus. For instance, a smart public lighting system primarily serves the energy and security domains, yet it also significantly influences the environment through changes in the light spectrum. This cross-domain complexity makes the evaluation of effects exceptionally difficult, even though various standards and methodologies exist to address urban performance—notably ISO 37120 (Indicators for Sustainable Cities and Communities), ITU-T Y.4903, or the United Nations' Key Performance Indicators for Smart Sustainable Cities.

Furthermore, a critical aspect of this evaluation is the necessity of reliable data. The explanatory power and validity of any indicator set are strictly determined by the quality of the underlying data. Without high-quality, interoperable, and consistent data, even the most sophisticated methodological frameworks and indicator sets fail to provide meaningful decision support.

This paper addresses these challenges by presenting a unique methodology developed within the CESMOD project in the Czech Republic, funded by the Technology Agency of the Czech Republic (TAČR). The project aims (not only) to establish a robust data and information environment that enables the long-term measurement and comparison of smart city impacts. In the following sections, we describe the core methodological pillars of the project, including the basic methodology for creating a hierarchical indicator structure—organized into a specific map of indicators—and its specific focus on context-sensitivity. Although the project is in its early stages, we believe that sharing these initial findings with the scientific com-

[a] https://orcid.org/0000-0003-3996-546X
[b] https://orcid.org/0009-0001-1159-0179
[c] https://orcid.org/0000-0003-4415-7715
[d] https://orcid.org/0000-0002-4107-5303

Hruška, Z., Marschalková, J., Walletzký, L. and Ge, M.
Context-Aware Indicators for Data-Driven Smart City Evaluation: Evidence from the CESMOD Project.
DOI: 10.5220/0014837000004042

In *Proceedings of the 15th International Conference on Smart Cities and Green ICT Systems (SMARTGREENS 2026)*, pages 149-156
ISBN: 978-989-758-830-3; ISSN: 2184-4968

munity at SMARTGREENS 2026 will foster valuable dialogue and provide critical feedback to further develop robust urban evaluation systems.

2 ROLE OF INDICATORS IN SMART CITIES

2.1 Data Driven Cities

The concept of a *data-driven city* defines an urban ecosystem where systematic collection, integration, and data analysis across municipal domains facilitates evidence-based decisions and enhanced resilience (Tsybina et al., 2025). This process involves converting heterogeneous data streams, from sensor networks to citizen platforms, into actionable insights for strategic operations. While these streams offer potential for real-time monitoring, their efficacy is often limited by fragmented ownership and inconsistent data quality, requiring comprehensive governance architectures (Bozkurt et al., 2025b) and standardization to ensure accountability and sustained utility (Bozkurt et al., 2025a).

As demonstrated by UK urban observatories and the Smart Columbus system, robust data infrastructures enable the layered analytical capabilities necessary for both service optimization and long-range policy formulation (Wolf et al., 2025). Ultimately, data-driven cities arise from the intersection of technological innovation and socio-ethical governance, establishing a framework that is operationalized through the specific performance indicators required to measure and evaluate urban "smartness".

2.2 Evaluation through Indicator Sets

Smart city performance is most commonly evaluated through indicator sets that operationalize multifaceted urban concepts into measurable variables, enabling structured assessment and strategic planning (Sharifi, 2020). While indicators are typically grouped into domains like mobility or governance (Table 1), the lack of a unified definition results in non-standardized architectures ranging from broad to compact structures (Lai and Cole, 2023). Selection can also be influenced by city size (Borsekova et al., 2018), and because identical metrics may carry varying policy significance across locations, neglecting these nuances produces results with weak context-relevance. To address these disparities, context-sensitive approaches adapt indicator interpretation through mechanisms such as adjustment weights, locally appropriate benchmarks, and the option to add indicators for place-specific risks or needs (Sharifi, 2019). This helps to support fair, like-for-like evaluation in smart city measuring frameworks by comparing cities with similar backgrounds, for example by grouping cases by population size and by the particular smart-city model they've implemented (Lai and Cole, 2023).

Standardized sets should be treated as a flexible baseline, adapted to the specific developmental phase, spatial scale, and municipal objectives of a city. Ultimately, the reliability of urban policy and management decisions depends fundamentally on the quality and transparency of the underlying data, as measurement choices materially impact performance results (Huovila et al., 2019).

2.2.1 Indicator Types

Indicator characterization varies across multiple methodological dimensions. Lain and Cole (Lai and Cole, 2023) categorize indicators by their relevance into essential (appearing across multiple frameworks as a core baseline), unique (index-specific and underrepresented), and unrelated (weakly connected to performance). This classification strengthens framework design by ensuring sets capture meaningful interconnections.

Sharifi (Sharifi, 2020) differentiates indicators by data requirements, distinguishing between quantitative measures derived from secondary data for objective performance, and qualitative indicators gathered through primary collection to capture citizen perceptions and satisfaction. Integrating both types improves adaptability and expands data-collection opportunities.

Finally, Kitchin et al. (Kitchin et al., 2015) examine the distinction between single indicators, which quantify individual phenomena through direct metrics, and composite indicators, which aggregate multiple measures into derived indices. This approach acknowledges that many urban issues are multidimensional and cannot be represented by any single measure.

2.3 Indicators and Data Quality Ensurance

The efficacy of data-driven governance rests fundamentally on the quality of underlying data, as poor interoperability or incompleteness can invalidate even well-constructed indicator frameworks (Kušniráková, 2022). Consequently, as the volume of published data increases, the primary challenge shifts from data availability to data quality and usability. In the con-

Table 1: Examples of indicators used in Smart city domains (Lai and Cole, 2023; Sharifi, 2020).

Domain	Indicator	Measurement
Economy	ICT employees	Percentage of labor force employed in occupations in the ICT sector
Environment	Waste recycling	Percentage of total amount of solid waste recycled in the city
Mobility	Airport connectivity	Number of yearly incoming flights per 100,000 population
Living	Community safety	Number of crimes per 100,000 inhabitants

text of smart cities, indicators therefore cannot be treated independently from the data infrastructures and quality assurance mechanisms that support them (European Commission: Directorate-General for the Information Society and Media et al., 2015).

Open Formal Norms represent a key instrument for systematically improving data quality and interoperability in the Czech Republic. These norms serve as technical specifications that define common structures, semantics, and data types for specific domains, ensuring that data from different sources can be integrated without manual intervention (Digital and Information Agency, 2026). By defining mandatory elements for automated processing within smart city platforms, OFNs directly enhance the analytical value of indicators (Klímek, 2020).

3 CASE STUDY: CESMOD PROJECT

To bridge the gap between theoretical indicator requirements and the practical reality of governance, the CESMOD project, funded by the Technology Agency of the Czech Republic (TAČR), operationalizes the national smart city strategy into a measurable, data-driven framework (CESMOD, 2026). The project is grounded in the official Smart Cities Concept of the Czech Republic (Ministry of Regional Development, 2021), which is a methodology that organizes urban development into three pillars, Environment, People and Communities, which are supporting an overarching topic of Resilience through smart solutions. Within this architecture, the methodology further identifies 16 specific functional components (e.g., Energy, Mobility, e-Government, Education) that represent the key areas requiring development and maintenance.

The implementation of this methodology is fundamentally shaped by the Czech Republic's fragmented landscape of 6,258 independent municipalities, which often lack the technical and financial capacity to generate high-quality evaluation datasets (Ministry of Regional Development, 2021). To address this, CESMOD reconciles the dual logic of indicator development: the granular, operational needs of local governments (bottom-up) and the aggregated strategic monitoring required by national guarantors (top-down) (Ministry of Regional Development, 2021).

3.1 Role of Indicators in CESMOD

Central to the project's strategy is the CESMOD Information and Data Platform (IDP), designed as a central data, knowledge, and methodological hub that interlinks strategies, indicators, and "Good Practices" across the Czech Republic. IDP aims to simplify the deployment of innovations (smart projects) in municipalities, supporting the transition toward data-driven cities. The primary objective is to ensure that municipal and regional decision-making is evidence-based, efficient, innovative, and repeatable. Within this ecosystem, indicators serve as the empirical link between strategic intent and implementation. (CESMOD project, 2025).

The architecture of the Information and Data Platform is designed to bridge the gap between high-level strategic goals and local implementation. The structure and data flow illustrated in Figure 1 as follows. On the top, there are multiple knowledge bases that will be integrated into the IDP by a unified application interface to ensure data interoperability and accessibility: A database containing the indicator sets developed for the 16 key components in Czech context (as described in this paper); A repository of national methodologies and smart strategic documents specific to the Czech administrative context; A database of "good practice" smart projects already implemented within the Czech Republic, facilitating knowledge transfer and replication; Real-time tracking of available financial grants and support mechanisms to align project recommendations with funding opportunities. The core of the IDP consists of data storage, computational resources, and the use of LLM agents, which act as the analytical engine to perform cross-domain synthesis. These agents will analyze the interlinkages between diverse datasets, interlinking "Good Prac-

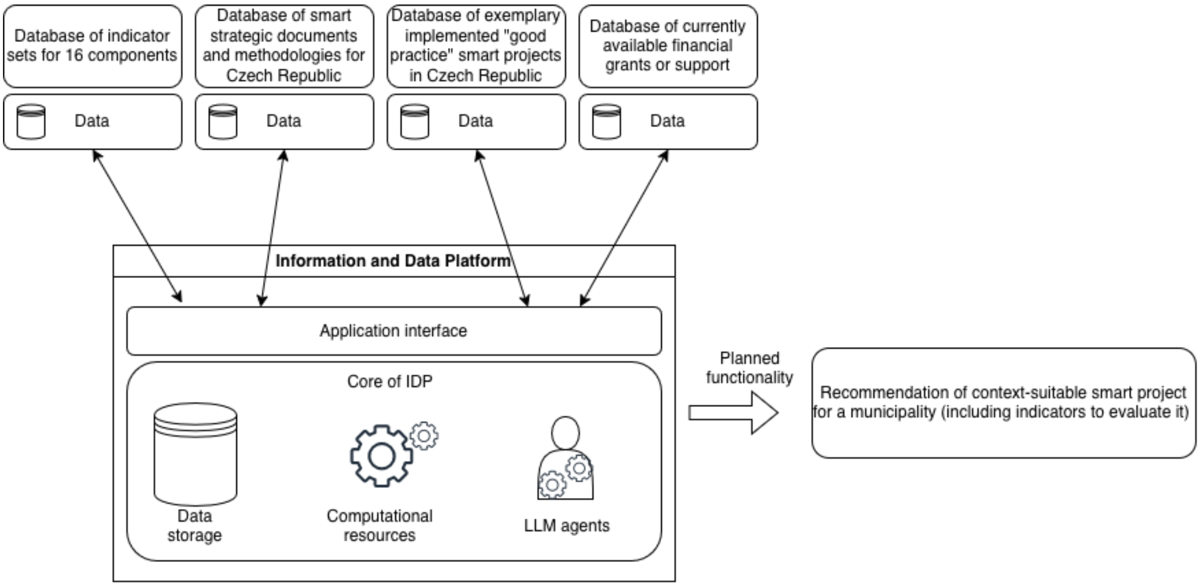

Figure 1: Role of indicator sets in the IDP.

tices" with specific territorial effects to overcome the challenges of fragmented municipal data.

One of the main functionalities of this platform is to provide context-suitable recommendations for municipalities. By analyzing a municipality's specific baseline conditions and strategic priorities, the IDP will identify optimized smart solutions and automatically attach the corresponding indicator sets required for evaluating the long-term success and scalability of the intervention.

The following subsections will introduce the methodology developed for creating the indicator sets for the CESMOD project, which will serve as one of the knowledge bases for IDP (CESMOD project, 2025). Finally, we demonstrate the application of this methodology on two selected components of the smart city architecture: Digital Public Administration (ZPO1) and ICT Infrastructure (B4).

3.2 Methodology for Creating Indicators Supporting the Smart Cities Concept

In the CESMOD project, indicator sets are required to operationalize the national smart agenda by making it possible to evaluate whether the Smart Cities Concept's Implementation Plan (Ministry of Regional Development, 2024) is being fulfilled – how successfully SMART solutions are implemented in the Czech Republic and what their real effects are on residents' quality of life. Because the work is anchored in the current Smart Cities Concept and its Implementation Plan, indicators function as the empirical link between strategic intentions and implementation control: they should enable a summary assessment of progress over time ("are we more SMART than last year?").

Project CESMOD aims to develop indicator sets that are usable, interpretable, and conceptually aligned with the Smart Cities Concept, guided by established methodological principles for indicator selection and formulation (CESMOD project, 2025). First, indicators should be available: priority is given to measures that already exist and do not require new data collection. Second, the set should combine quantitative and qualitative indicators to capture both measurable performance and dimensions that may require situational assessments or expert reporting. Third, every indicator must have a clear linkage to the relevant component goal (defined in the Smart Cities Concept) in a way that it measures substantively meaningful progress rather than "what just happens to be measurable." This linkage requirement is reinforced by coverage criteria: the indicator set should reflect the seven SMART principles of the Smart Cities Concept and explicitly integrate CESMOD priority themes such as resilience, sustainability, local development, communities, and effective actor collaboration. Fourth, the methodology encourages careful handling of simple vs. composite indicators and thematic overlaps, because duplication or poorly specified composites can obscure interpretation. Finally, the set must be context-sensitive and analytically robust: indicators should support understanding of context (the same value may be critical in one setting and acceptable in another) and should be documented together with interlinkages among indicators (correlational or otherwise), since smart-city outcomes often emerge from interactions rather than isolated variables. At the same time, indicator design must respect the Czech settlement structure, meaning indicators need to be interpretable and scalable from small municipalities to larger territorial units.

As part of the research project CESMOD, each of the 16 components is expected to proceed through the defined workflow: (1) conduct a structured review of existing indicator systems, reusable datasets and concepts relevant to their focus; (2) propose a set of qualitative and quantitative indicators (reusing existing ones where possible, proposing new ones where needed) and define their interpretation; (3) specify data characteristics for each indicator (data source, update frequency, priority, links, target values, etc.) and note parameters that cannot be captured via indicators; (4) identify "white spots" for the component goals – which important phenomena are systematically omitted (e.g., because data are unavailable or because complex social goals are hard to capture with a single proxy) – and state where the indicators may be biased or only partially representative. (CESMOD project, 2025). By covering all of the 16 key areas, this will create the base indicator sets for measuring the success of implemented SMART solutions in Czech Republic.

3.3 Example Indicator Sets of Two Components

To illustrate the practical application of the CESMOD methodology, we present a few examples from the base indicator sets created for two distinct components of the Smart Cities Concept: the overarching component ZPO1 (Digital public administration) and a technical component B4 (ICT Infrastructure).

Component ZPO1 envisions a digital public administration that delivers automated citizen services and manages assets through systematic data collection. To overcome local expertise shortages and ensure interoperability, the framework emphasizes unified IT solutions and enhanced cooperation across state, regional, and municipal levels (Ministry of Regional Development, 2021).

Component B4 identifies ICT infrastructure as the fundamental prerequisite for successful digitalization. It prioritizes 5G and fiber-optic networks as integrative platforms to support data-intensive domains like telemedicine and Industry 4.0. To prevent inefficient, fragmented management, the framework advocates for shared central applications and a unified methodological approach (Ministry of Regional Development, 2021).

The illustrative examples of indicators can be found in Table 2. In line with the presented methodology, the example indicators are described through a fixed set of characteristic parameters. These parameters are used consistently for both components and support reproducible monitoring, benchmarking, and implementation planning (CESMOD project, 2025):

Indicator name. Short, human-readable indicator title.

Indicator description. What the indicator measures and how it should be interpreted conceptually.

Data source / link. The primary dataset, registry, portal, or monitoring source from which the indicator can be computed; when relevant, this is given as a link or a named reference source.

Publication date / periodicity. When the indicator is expected to be published (e.g., a specific date) and/or how often it is updated (e.g., annually). The field may therefore contain either a periodicity label or a planned publication term.

Granularity. The general level at which the indicator is produced (e.g., municipal, city level, national).

NUTS / administrative level. A more specific territorial aggregation level, aligned with NUTS logic and/or Czech administrative practice. In this paper, ORP denotes an administrative district of municipalities with extended powers, while other values (e.g., state/region/city) indicate broader aggregation.

Optimal / target value. The desired value (threshold, target share, index value, compliance requirement, or time-to-event bound). When precise targets are not yet established, the table may explicitly state that further research is required or mark the value as not available.

Unit. Measurement unit (e.g., %, days, hours, index/score, qualitative scale).

Priority. The role of the indicator in the set (typically key indicators and complementary indicators).

Example interpretation. A short guidance note illustrating how changes in the indicator should be read, including diagnostic signals and potential pitfalls.

Link to component goal. A direct mapping to the component goal(s) the indicator is intended to operationalise.

Table 2: Consolidated base indicators for components ZPO1 and B4.

Indicator	Parameters
Component ZPO1: Digital public administration	
Share of submissions handled online	**Description:** Share of citizen and business submissions that can be completed fully digitally. **Source:** Czech Statistical Office; **Publication date / Periodicity:** 2025–02–27. **Priority:** Key; **Granularity:** Municipal; ORP. **Target (optimal value):** $\geq$ 80% by 2030; **Unit:** %. **Interpretation:** Increasing trend indicates better practical accessibility of e-government services. **Goal link:** ZPO1.1 – Public administration is executed efficiently and transparently, enabling electronic and automated solutions wherever appropriate (especially in key agendas and life situations);
Number of datasets provided by public entities / local governments	**Description:** Number of open datasets published in the National Open Data Catalogue. **Source:** data.gov.cz; **Publication date / Periodicity:** 2025–12–31. **Priority:** Key; **Granularity:** Municipal; ORP. **Target (optimal value):** More than 10; **Unit:** Count per 1,000 inhabitants. **Interpretation:** More published datasets imply higher transparency and openness of the authority. **Goal link:** ZPO1.2 – Regions, cities, and municipalities maintain sufficient knowledge about the territory they govern (data and information, including hazard-related information) and use it for optimised governance and citizen co-creation;
Citizen satisfaction with public administration services	**Description:** Subjective assessment by citizens of service quality, clarity, and availability. **Source:** Own survey / questionnaire; **Publication date / Periodicity:** Further research required + OFN. **Priority:** Key; **Granularity:** Municipal; ORP. **Target (optimal value):** At least 50% “slightly satisfied” or better; **Unit:** Scale / %. **Interpretation:** Higher satisfaction validates a citizen-/client-oriented approach. **Goal link:** ZPO1.1 – Public administration is executed efficiently and transparently, enabling electronic and automated solutions wherever appropriate (especially in key agendas and life situations);
Component B4: ICT Infrastructure	
Uptime of municipal IoT services	**Description:** Availability (uptime) of municipal IoT data streams. **Source:** City NMS, operational data; **Publication date / Periodicity:** Monthly. **Priority:** Complementary; **Granularity:** City level; ORP / city. **Target (optimal value):** $\geq$ 99%; **Unit:** %. **Interpretation:** A drop in uptime below the target undermines trust in smart services and their operational usability. **Goal link:** B4.2 – Cities, municipalities and regions have the ICT infrastructure needed for their activity.
Share of population with at least basic digital skills	**Description:** Share of population with at least basic digital skills. **Source:** Eurostat, Digital Decade KPIs; **Publication date / Periodicity:** Annually. **Priority:** Key; **Granularity:** National; State / region. **Target (optimal value):** $\geq$ 80%; **Unit:** %. **Interpretation:** Regional differences reveal the need for targeted educational interventions. **Goal link:** B4.1 – Sufficiently dimensioned, modern electronic communications networks are available across the whole territory.
Share of NIS2-scope entities compliant with baseline measures	**Description:** Share of entities within NIS2 scope that meet baseline NIS2 measures. **Source:** NÚKIB, ENISA, national audits; **Publication date / Periodicity:** Annually. **Priority:** Key; **Granularity:** National; State / region. **Target (optimal value):** 100% by 2030; **Unit:** %. **Interpretation:** Non-compliance indicates systemic risk to public and private critical services. **Goal link:** B4.3 — ICT infrastructure enables the secure development of digital services at the local and regional level.

4 DISCUSSION

The CESMOD case study has shown several structural and methodological implications for data-driven evaluation of smart city impacts, e.g. in national contexts of a fragmented municipal structure and heterogeneous data capacities. One promising finding is the gap between strategic plan in national smart city concepts and the practical feasibility of measuring their implementation through indicators. The smart cities concept and its implementation plan define a high-level goal across multiple pillars and components, on the other hand, the case study found that indicator operationalisation is constrained less by conceptual clarity than by data availability and data quality at the local level.

The CESMOD methodology prioritises indicators that rely on existing data sources and do not add additional reporting burdens on municipalities. This design choice reflects a good practice at the component-level work: many municipalities lack the technical, financial, or organisational capacity to generate new datasets, e.g. for qualitative or composite indicators. Thus, indicator frameworks can be operationally ineffective. The CESMOD approach suggests that pragmatism in indicator selection such as favouring robustness and continuity over exhaustive coverage may be a practical way for long-term monitoring on smart city impacts.

The case study further highlights the central role of data quality and standardisation as limiting factors in data-driven governance. That means, data inconsistencies in structure or semantics may prevent their reuse for indicator calculation. This finding indicates that indicators and data infrastructures cannot be treated as separate layers of smart city evaluation. Instead, indicator design implicitly embeds assumptions about data governance and institutional coordination. Furthermore, we found that indicator methodologies can act as diagnostic tools in national and municipal data ecosystems.

Context sensitivity emerges as another critical implication of the case study. We found that identical indicator values may have different meanings. This is particularly relevant in the Czech context and similar European countries, where small municipalities coexist with larger cities within the same evaluation framework. The hierarchical indicator structure can be used for analytical scaling across these contexts and preserving interpretability.

We have also noticed the limitations of indicators as representations of complex urban phenomena. For example, important city goals may be not captured due to data gaps or conceptual ambiguity. Therefore, rather than considering indicators as delegations for performance, we can position them as evolving instruments that will be interpreted along with contextual understanding. This perspective can strengthen the credibility of indicator-based evaluation by making its boundaries explicit and aligning with reflexive smart city evaluations.

5 CONCLUSION

This paper has addressed the challenges associated with evaluating smart city impacts in data-driven urban governance. Through a structured review of existing smart city indicator practices and the CESMOD case study, we have shown that the effectiveness of smart city evaluation frameworks depends not only on conceptual soundness but also on their alignment with real-world data ecosystems. Also, we have concluded that that data quality, interoperability, and standardisation are critical factors in indicator-based evaluation, which should be considered as an integral component of smart city measurement rather than a secondary technical concern.

Furthermore, this paper has shown how national-level smart city evaluation can be designed to be both analytically robust and operationally feasible. While the CESMOD project is still in an early phase, the methodological principles and preliminary results presented in this paper provide indicative insights for other countries and regions who lookfor data-driven and context-aware smart city evaluation frameworks. As future works, we plan to focus on refining indicator definitions, strengthening data quality assurance mechanisms, and testing the long-term applicability of the methodology as smart solutions for evolving urban data practices.

ACKNOWLEDGEMENTS

This article is one of the outputs of the project TQ12000017 titled ” RESEARCH CENTER FOR A RESILIENT, SMART, INNOVATIVE AND SUSTAINABLE SOCIETY,” co-financed from the state budget by the Technology agency of the Czech Republic under the Sigma Program.

REFERENCES

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

Bozkurt, Y., Rossmann, A., Pervez, Z., and Ramzan, N. (2025a). Assessing data governance models for smart cities: Benchmarking data governance models on the basis of european urban requirements. *Sustainable Cities and Society*, 130:106528.

Bozkurt, Y., Rossmann, A., Pervez, Z., and Ramzan, N. (2025b). Development and evaluation of an urban data governance reference model based on design science research. *Government Information Quarterly*, 42(2):102025.

CESMOD (2026). About us. https://cesmod.cz/o-nas/.

CESMOD project (2025). Methodology of creating indicators for the smart cities concept [unpublished project document].

Digital and Information Agency (2026). Open formal norms (OFN). https://data.gov.cz/ofn/.

European Commission: Directorate-General for the Information Society and Media, Capgemini Consulting, con.terra, Fraunhofer Fokus, Intrasoft International, Open Data Institute, Sogeti, Time.lex, and University of Southampton (2015). Creating value through open data: Study on the impact of re-use of public data resources.

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

Kitchin, R., Lauriault, T. P., and McArdle, G. (2015). Knowing and governing cities through urban indicators, city benchmarking and real-time dashboards. *Regional Studies, Regional Science*, 2(1):6–28.

Klímek, J. (2020). Open data and open formal norms. https://data.gov.cz/%C4%8Dl%C3%A1nky/otev%C5%99en%C3%A9-form%C3%A1ln%C3%AD-normy-01-%C3%BAvod.

Kušniráková, D. (2022). Analysis of open data's standardisation. Master's thesis, Masaryk University, Faculty of Informatics, Brno. Supervisor : Leonard Walletzký.

Lai, C. M. T. and Cole, A. (2023). Measuring progress of smart cities: Indexing the smart city indices. *Urban Governance*, 3(1):45–57.

Ministry of Regional Development (2021). Smart cities concept: resilience through smart solutions for municipalities, cities and regions.

Ministry of Regional Development (2024). Smart cities concept: updated implementation plan.

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.

Tsybina, E., Lebakula, V., Zhang, F., Hu, Q., and Laskey, K. (2025). Smart cities: the data to decisions process. *Nature Cities*, 2.

Wolf, K., Stiles, J., Miller, H. J., Dawson, R. J., Mills, J. P., Blythe, P., and Morley, J. (2025). Building enduring smart city data platforms to provide urban management support: lessons learnt from uk urban observatories and the us smart columbus operating system. *Frontiers in Sustainable Cities*, 7:1512847.