

**The management and implementation of information systems at municipal operators for a
SMART CITY concept**

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In a global context marked by accelerated urbanization, climate change, economic pressures and increasingly complex demands from citizens, cities are forced to reinvent themselves. The **smart city** concept emerged as an integrated response to these challenges, offering public administrations the opportunity to transform the way urban services work through technology, innovation and civic participation.

At the heart of this transformation are **the municipal operators** – the entities that provide essential infrastructure and public services, such as water supply, sewerage, energy, sanitation or public lighting. For cities to become truly "smart", it is imperative that these services are managed with the help of **modern information systems**, capable of collecting real-time data, optimizing resources and supporting decision-making effectively.

Internationally, many metropolises have already demonstrated the benefits of implementing these systems – from decreasing water losses in Singapore's urban networks, to optimizing energy consumption in cities such as Copenhagen or Barcelona. However, in Romania, the process of digital transformation of municipal services is still being consolidated, facing challenges such as outdated infrastructure, the lack of a coherent strategy at national level or fragmentation between institutions¹.

Hence The need for professional and strategic management of information systems becomes essential. This PhD thesis aims to investigate and highlight how the implementation of these technologies can support municipal operators in the transition to smart cities, thus contributing to an efficient, transparent and citizen-oriented public administration.

The general objective of the research topic is built on the SMART component **and refers to the elaboration of a macro-systemic development model of smart cities and regions in**

¹ European Commission. (2023). *Digital Economy and Society Index (DESI) 2023 – Country Report: Romania*. Brussels. <https://digital-strategy.ec.europa.eu>

Romania, adapted to the national specificity and built on the basis of the analysis of existing models and European strategic directions in the field of digital and urban transformation.

The paper approaches, in an applicative and interdisciplinary manner, the intersection between information technologies, public services management and the Smart City vision, focusing on adapting these concepts to the national specificity and capitalizing on international good practices.

The researcher's interest in this topic was fueled both by his professional experiences in the field of public services and by the deep conviction that the future of local administration depends on its ability to adopt innovative technologies. At a time when sustainability, energy efficiency and digitalization are becoming strategic priorities at all levels, the researcher identified the need for an applied scientific approach, which analyzes and proposes concrete solutions for the modernization of the municipal infrastructure through the integration of information systems.

This work is, therefore, the result of a double motivation: on the one hand, the desire to contribute to improving the quality of urban life by making public services more efficient, and on the other hand, the commitment to the development of a theoretical and practical framework that supports local authorities in the process of digitization and smart transformation.

The context thus outlined and presented above is marked by the transition to a green, digital and resilient economy, and cities play an essential role in the implementation of European and national policies on sustainable development. The integration of digital technologies in urban governance processes, the modernization of municipal infrastructures and adaptation to the new sustainability requirements represent major challenges, but also strategic opportunities for local administrations.

Starting from these directions and correlating them with the realities of the local public administration in Romania, the present paper aims to analyze, from an applicative perspective, the way in which the management and implementation of information systems at municipal operators can contribute to the development of smart and sustainable cities.

The research program related to this doctoral work is structured in a logical and phased manner, starting from the bibliographic analysis, continuing with the theoretical research and ending with the applicative component, according to the interdisciplinary specificity of the theme.

The objectives of the doctoral thesis are listed below:

O1. Identification of the context and international premises related to the concept of smart city;

O2. Identification of the situation in Romania regarding the initiatives of public administrations to implement smart solutions dedicated to cities and regions;

O3. Inventory of the bibliographic reference based on the most important research carried out in this field;

O4. Study and evaluation of existing models at national and international level and identify factors that contribute to innovative and smart initiatives;

O5. Testing and validation of the proposed model (expressed by the general objective of the doctoral thesis) through a practical application adapted to the local context, materialized in a European project implemented at the level of the Municipality of Caransebeș;

O6. Testing and validating the model on the municipal operators and customizing the model developed at the level of the Municipality of Caransebeș, by implementing innovative software solutions at the municipal operators;

O7. Final development of the model and presentation of the conclusions of the research undertaken.

The first stage is dedicated to bibliographic research, with the objectives of identifying the international context and the conceptual premises related to the development of smart cities **(O1)**, as well as the analysis of initiatives in Romania regarding the implementation of smart solutions at the level of local and regional public administration **(O2)**. In this stage, the main activities consisted in collecting and systematizing the relevant bibliographic resources at national, European and international level, making an inventory of the current state of knowledge in the field and formulating a critical analysis of it. These steps have led to the identification of research and innovation gaps that justify the need for its own scientific contribution in the field.

In continuation of the documentation process, the bibliographic research was extended by inventorying the reference works, based on the most important national and international research **(O3)**, and by studying and evaluating existing models of smart cities **(O4)**. This stage also included the analysis of the research methodologies used in previous studies and the establishment of possible own directions of investigation. Thus, a coherent line of development of the research was outlined, which would allow a solid articulation between the theoretical part and the practical dimension of the work.

The next stage focused on theoretical research, with a focus on the comparative evaluation of the identified conceptual and practical models, as well as on the identification of the factors conducive to smart and innovative initiatives. In this phase, an original research methodology was proposed, theoretically grounded and graphically and mathematically modeled, in accordance with the assumed objectives and the specificity of the theme.

Subsequently, the research was extended at an applicative level, by developing a model of macro-systemic development of smart cities and regions in Romania **(O5)**, built on the basis of the theoretical models previously analyzed, but adapted to the national administrative, technological and cultural specificity. The activities related to this stage included the formulation of the applied research scenario, the collection and analysis of field data, as well as the interpretation of the results obtained in relation to the initial objectives.

Finally, the testing and validation of the proposed model **(O6)** **was carried out** on different entities (municipalities, regions or building operators), in order to customize and adjust the model

according to local realities. Based on this process, the final development of the smart city model **(O7) was achieved**, the research conclusions were formulated, personal contributions were presented and future directions of scientific deepening were proposed.

The doctoral thesis is structured in **eight chapters**, which reflect a phased and logical approach to the researched topic. Starting from the theoretical foundations and the international and national contextualization of the smart city concept, the approach continues with a complex applied research and ends with the validation of the model in a concrete case study, followed by conclusions and future directions.

For a detailed and coherent treatment of the subject, the applied research is carried out during four distinct chapters (chapters 3–6), each with a specific analytical function: presentation of the tool and methodology (Chapter 3), qualitative analysis (Chapters 4 and 5) and quantitative analysis (Chapter 6). This structuring allows for a progressive and layered approach to the data, and supports a rigorous validation of the proposed model. The choice of this methodological separation ensures increased clarity, avoids analytical overlaps and provides better visibility on each research segment. An alternative, by treating the entire application approach in a single chapter, would have made reading difficult and would have affected the coherence and readability of the results obtained.

A summary of each chapter is presented below:

Chapter 1, entitled **Introduction**, presents the general context of the research, the importance of the topic in relation to European policies on digitalization and sustainable development, the motivation for choosing the topic and the objectives pursued. The current challenges of Romanian cities in the digital transformation process are highlighted, with a focus on the role of building operators.

Chapter 2, entitled **Theoretical research on the essential role of public administration management in urban transformation**, includes a detailed analysis of the concept of smart city and its essential components. An explanatory glossary of terms and a critical review of the literature on urban management and new governance paradigms are produced. Also, this chapter establishes the theoretical framework of the research and argues the need to modernize public services through technology.

Among the objectives of this chapter are: to carry out a critical review of the literature; conceptual clarification of the terms associated with the smart city phenomenon; identification of relevant theoretical models and dimensions of smart cities; theoretical substantiation of the role of public administration and management in this process and elaboration of a thematic explanatory glossary structured by groups.

The first major research direction of this chapter is the development of a glossary of terms to substantiate the research undertaken. Smart cities are an emerging paradigm that combines and blends technology, urban innovation and sound management principles to make or transform cities, metropolises and megametropolises into efficient and sustainable entities. In this context, a glossary of terms becomes an essential tool for understanding and exploring the main concepts associated with the concept of smart city and management theory. This chapter gathers and organizes terminology, thus facilitating access to essential information on the development and

deployment of smart cities. Each definition notes technological aspects, management practices and elements specific to the sector and thus forms a comprehensive guide for familiarizing yourself with this field.

An important aspect of this approach is education. SMART education will become a cornerstone in preparing citizens for the challenges and opportunities offered by the digital transformation of cities. It is noted that the integration of science, technology, engineering and mathematics (STEM) and (including the arts) STEAM disciplines in the educational process is becoming essential. Pupils and students must be familiar with the principles of technology, understand the ways in which smart technologies work and develop practical skills that allow them to integrate and contribute to the evolution of smart cities. Also, the implementation of artificial intelligence (AI) in the teaching process and in study programs becomes an imperative necessity. A smart city needs an education that must adapt to technological advances and provide the necessary resources and knowledge to train professionals ready to tackle all these complex challenges. All dimensions of education for smart cities are addressed.

This chapter establishes the theoretical framework of the work and demonstrates the complexity and interdisciplinarity of the smart city concept. It highlights the role of public management in the digital transition of cities and synthesizes relevant international models. The elaborate glossary facilitates the understanding of the technical terminology, and the critical selection of sources confirms the lack of a rigorous adaptation of the concept to the realities of the local administration in Romania

Chapter 3, entitled Applied Research. The analysis of data on citizens' perceptions of the smart city concept, details the mixed methodological approach of the research, justifies the choice of the method and describes in detail the research tool (mixed questionnaire). This third section, together with the investigation plan and the justification of the methodological choices, is the basis for the application of the operational objectives in the empirical approach and allows a coherent validation of the formulated hypotheses.

Chapter 3 is dedicated to the methodological foundation of the applied research and to the detailed description of the instrument used, namely the mixed questionnaire designed by the author. Although, apparently, this chapter seems to directly support only the operational objective related to the inventory of the referential and the construction of the analytical framework (O3), in reality, it has a much broader role. The chapter substantiates the entire subsequent application approach and provides the solid methodological basis for the empirical testing of the proposed model.

The structure of the questionnaire, the justification for the choice of the mixed method and the way of operationalizing each objective through the proposed items contribute essentially to supporting the entire empirical approach. Therefore, this chapter is not limited to the O3 objective, but operationally supports all the applicative objectives of the thesis, constituting the scientific basis for the subsequent validation of the results presented in the analysis chapters.

The applied research within this thesis aims at modern urban development, as a reference point of the smart city concept in all aspects that refer to improving the quality of life of citizens through the use of innovative technologies, both in infrastructure but especially in public services. In the Romanian context, a knowledge-based society today focuses on the implementation of smart city solutions, precisely to align itself with the contemporary context of accelerating digitalization, for sustainable and efficient development.

In order to capture citizens' perceptions of the smart city concept, a mixed questionnaire was designed and applied, comprising 111 items, of which closed items, in order to collect quantifiable data, as well as an open question, with exploratory and interpretative potential. The tool was built to reflect the complexity of the topic and to allow both a statistical analysis and a qualitative exploration of the representations, opinions and suggestions made by the respondents.

The applied research aims to investigate how citizens perceive, understand and evaluate the concept of "smart city", starting from the dimensions relevant to the quality of urban life and the digital transformation of public space. The data collection tool, a blended questionnaire, was designed to capture both quantifiable aspects and personal, contextual and creative perspectives from respondents.

In this sense, the qualitative analysis was not only a complement, but became the central pillar of a methodological strategy meant to highlight the voices of citizens, not just the figures that define them. This methodological choice, to place qualitative analysis before quantitative analysis, is academically valid and supported by the literature, offering an innovative perspective on the collected data. Although it may seem unconventional, this approach is logical and original, demonstrating a significant personal contribution to the understanding of the phenomenon studied and highlighting the importance of citizens' voices in the analysis of perceptions of the concept of smart city.

Chapter 4, entitled Applied Research. Qualitative analysis – Part I, opens the qualitative part of the research and includes the thematic analysis of the open answers from the questionnaire, the proposal of an original qualitative typology and the interpretation of civic participation in the context of the development of smart cities. Relevant groups of citizens ("visionaries" and "invisibles") are identified and a layered view of urban perception is provided.

The objectives achieved by this chapter are: the interpretation of the open answers from the questionnaire through the thematic analysis method; identification of relevant categories of citizens in relation to urban involvement; building an original qualitative typology (visionary, invisible, neutral); substantiating a participatory perspective on urban governance and drawing relevant conclusions for the formulation of a smart civic strategy.

4 hypotheses were established and validated. The analysis of the collected data highlighted that Smart City is perceived as a beneficial concept, but with significant challenges in terms of implementation. The most important aspects identified are: general acceptance of the benefits of technology, but with concerns about security and accessibility, the need for digital education and community involvement for a smoother transition to smart cities, the main barriers are

bureaucratization, lack of funding and reluctance to change and the proposed solutions emphasize technology, but also on clear urban development strategies.

This qualitative analysis highlighted a number of key aspects regarding the perception and implementation of the Smart City concept: smart cities are perceived positively, but require a gradual and well-planned implementation; the main benefits are increased efficiency, sustainability and improved quality of life; major limitations are insufficient infrastructure, lack of funding and data security concerns; the success of the Smart City depends on the involvement of citizens, digital education and the transparency of the authorities' decisions.

Question 15 of the applied questionnaire was open in nature and was meant to collect personal proposals, reflections and ideas from citizens on the development of the smart city.

These results will contribute to the formulation of recommendations for streamlining the implementation of Smart City, with a focus on sustainability and social acceptability.

Chapter 5, entitled Applied Research. Qualitative analysis – Part II, (complementary to groups), continues and deepens qualitative analysis by comparing spontaneous responses with guided perceptions. Conclusions are drawn on citizens' coherence and a model of smart participatory strategy is proposed, anchored in the reality of the collected responses.

This chapter is concerned with comparing the declared perceptions with the spontaneous responses of citizens; identifying the level of coherence and congruence in the civic discourse; arguing for the need for deeper and more genuine citizen engagement; and the foundation of a model of intelligent participatory strategy.

This analysis reveals that participation is a condition for the functioning of any sustainable urban ecosystem. We also believe that the proposed strategy, resulting from the data collected from the questionnaire, must be inclusive, differentiated and dialogic, which builds from the inside out, starts from the realities of the community and listens carefully to the voice of those who, although they are not decision-makers, live the consequences of each urban decision.

The results obtained reveal a significant discrepancy between the opinions declared and those expressed spontaneously by the respondents, suggesting a partial coherence of the civic discourse. A model of intelligent participatory involvement is formulated, built on the basis of qualitative data and oriented towards the real valorization of the citizen in urban decision-making processes.

Chapter 6, entitled Applied Research. Quantitative analysis presents the statistical interpretation of the data from the closed questions of the questionnaire. Descriptive and inferential analysis methods (Chi-square, correlations, pivot tables) are used to correlate the relevant variables and validate the previously proposed typology.

This chapter highlights the statistical analysis of data from the closed questions of the questionnaire; validation of the hypotheses regarding the citizens' perception of the concept of smart city; corroboration of quantitative data with the proposed qualitative typology; identifying

significant relationships between socio-demographic variables and attitudes and supporting a mixed approach as a solid research strategy.

This descriptive statistical analysis was carried out with the help of JASP v0.19.3 software, which is an open-source program dedicated to statistical analysis, with an intuitive interface, automatic generation of tables compliant with the APA style and the ability to produce clear and relevant graphs. We chose this tool because it allows for rigorous data processing and at the same time maintains an important methodological transparency for the reproducibility of the results.

The purpose of this analysis is twofold. First, it provides a clear and concise picture of the sample and the distribution of responses to key questions. Second, it sets the stage for association tests and subsequent correlations, and identifies any regularities, extremes, or dominant trends in the data. The full inclusion of the 51 pages of tables and graphs in the body of the paper, and not in an appendix, is justified by the relevance of these results for the understanding of the phenomenon studied in depth. Each question is analyzed both as absolute and relative frequency, as well as visually, to facilitate intuitive interpretation of the data and to allow the reader to directly observe the response pattern provided by the sample. This section therefore functions as a factual and numerical basis for subsequent analytical approaches, both quantitative (associations and correlations) and qualitative (triangulations and integrated interpretations).

An associative analysis between quantitative variables and qualitative typology is performed. The extent to which the derived qualitative variable (visionary – invisible – neutral typology) is associated with a series of quantitative or categorical variables in the questionnaire was investigated. The objective is to identify significant relationships between the nature of citizen discourse and factors such as education, interest in the smart city, civic engagement or socio-demographic profile. typology and two or more variables simultaneously). Each proposed correlation was accompanied by an assessment of analytical interest, applicability and relevance to the research purpose. However, not all of these correlations will actually be analysed in depth. This narrow selection is motivated by the following considerations: i) the desire to avoid analytical redundancies and overinterpretation; ii) the need to maintain a balance between rigor and conciseness within an applicative chapter; iii) the selection was oriented on the correlations with the greatest explanatory potential, capable of adding meaning to the qualitative typology and substantiating solid hypotheses about citizen behavior in the context of smart cities. Thus, for the analysis of simple correlations, four associations considered essential were selected, and for multiple correlations, two to three relevant combinations are to be selected, which provide a deeper overview of the interaction between the social profile and the perceptual involvement of the respondents.

Multiple analysis, visual descriptive analysis and profile identification present a series of results that will be the foundation of the implemented platform.

Quantitative analysis validates, through descriptive and inferential statistical methods, significant correlations between socio-demographic variables and respondents' perceptions of smart cities. The qualitative typology proposed above is empirically supported and highlights the relevant differences (depending on education, gender, age and interest) for digitization. The data

confirm that the citizen's perception of urban transformation is stratified and conditioned by structural factors, which underlines the importance of formulating differentiated and adapted urban policies.

Chapter 7, entitled Digitalization of Caransebeș Municipality - Case study on the transition to a smart city concept (2015-2025), applies the theoretical model and tools developed in a concrete case – the digitization of municipal services in Caransebeș Municipality. The implemented IT solutions, the results obtained and the conclusions regarding the feasibility of replicating the model in other localities are described.

This chapter includes the practical testing of the proposed theoretical model in the local context; documenting the process of digitization of municipal services in Caransebeș; functional and administrative evaluation of the implemented tools; identifying the challenges and enablers of the local digital transition and formulating applicable conclusions and lessons that can be replicated for other TAUs.

The case study dedicated to the Municipality of Caransebeș concretely illustrates the transition from a traditional public administration to a model of digital local governance, oriented towards efficiency, transparency and accessibility. The implementation of the integrated information system, supported by both local administrative initiatives and the 2021–2027 strategic development framework, has generated a visible impact on the functioning of the administrative apparatus and on the relationship with citizens.

Finally, Chapter 8, entitled Future Directions of Research. Personal contributions. Conclusions, brings together the major conclusions resulting from the research, emphasizes personal contributions and validates the proposed model. Practical recommendations for local administrations and building operators are formulated, as well as future research directions in the field of smart cities, digitization of urban infrastructures and participatory governance.

For chapter 1, with reference to the introduction of the theme and the conceptual foundations, we consider that:

1. The formulation of the theme and the strategic contextualization of smart cities in relation to the green and digital transition, starting from EU and OECD programmatic documents, represents a first personal contribution, through the selection and analytical integration of sources;
2. The lack of an approach centered on municipal operators in the smart city development process has led to the identification of a scientific gap in the Romanian literature;
3. Developing its own synthesis on the strategic correlation between Smart City and the UN, Green Deal and Digitalisation Pact indicators;
4. Structuring one's own perspective on the six pillars of the smart city, integrated into a visual and narrative model.

For Chapter 2, namely for the theoretical research and conceptual glossary, we list the following personal contributions:

5. The creation of a glossary of explanatory terms (technological and managerial) in relation to smart city infrastructure, systematized on four thematic groups, is a didactic contribution of its own
6. The definition and graphic representation of management theory, applied at the urban level, is a contribution of its own;
7. Correlating the concepts of SMART education with the management of smart cities, proposes an integrative, interdisciplinary vision.
8. The formulation of a critique of the classical theories of urbanism, adapted to the new demographic and climatic realities of the twenty-first century, is an original reflexive contribution.

Chapter 3, namely Applied Research and Foundations and Working Tool, we consider to demonstrate the following personal contributions of the author:

9. Elaboration of a mixed questionnaire (with closed questions and an open one with qualitative value – Q15), designed to explore citizens' perceptions of smart city development – original contribution, adapted to the Romanian context.
10. Justification of a mixed approach, with emphasis on qualitative analysis – own methodological choice, theoretically argued.
11. Direct correlation of each objective of the thesis with the structure and items of the questionnaire, highlighted by its own table.
12. Substantiation of its own model of empirical validation, which allows the testing of hypotheses in an applicative and contextualized manner.

For **Chapter 4** and **Chapter 5**, we will refer to Qualitative Research, Part I and Part II, respectively, and the personal contributions are as follows:

13. Building one's own qualitative typology: "visionary", "invisible", "neutral" is an innovation in qualitative research methodology.
14. Double selection of active respondents (through the analysis of the open question), represents a methodological contribution that allows the stratified analysis of urban perception.
15. Comparative analysis of the two groups (visionaries versus invisibles), with a focus on civic participation, discursive coherence and strategic relevance.
16. Proposing an ideal profile of an active smart citizen, which can contribute to the formulation of urban policies.
17. The innovative analysis between the declared perception (Q5) and the real expression (Q15) are representative by the methodological contrast proposed by the author for the evaluation of citizen coherence.
18. Proposing a participatory strategy for smart cities, anchored in the real perceptions of respondents, is an adapted participatory governance model.

19. The methodological justification of the smart engagement strategy is an original contribution with replicable potential.

Chapter 6, respectively in quantitative research, demonstrates the following personal contributions of the author:

20. Visual-descriptive statistical analysis of data, with emphasis on multiple correlations (typology ↔, education ↔, interest in the concept).
21. Use of complex statistical analysis tools (Chi-square, ANOVA, Pearson correlations) adapted to the questionnaire structure – own technical contribution.
22. Quantitative validation of qualitative typology, which is a rare step in interdisciplinary research.
23. Integration of quantitative analysis with thematic analysis, achieving a unique interpretative synthesis.

Case study: Caransebeș Municipality, which is part of **chapter 7**, outlines the following personal contributions:

24. Documentation and analysis of a local European project implemented in Caransebeș (practical applicative contribution).
25. Adaptation of the proposed theoretical model to the technical and institutional conditions of a local administration in Romania (practical engineering contribution).
26. Detailing the applied digital components (Electronic Archive, Interactive Map, Online Payment Management) (direct application of the Smart City concept on building operators).
27. Correlating the implementation of the software with the functional objectives of the Caransebeș TAU, supporting decision-making sustainability.

Originality: The case study is unique in Romanian literature, being prepared directly by the author in collaboration with a public administration.

An aspect of methodological originality is the explicit integration of personal contributions directly within the general conclusions of the work, which allows a logical and direct articulation between the scientific approach carried out and the results obtained. This approach reflects the applicative character of the research and ensures a narrative coherence between the objectives, methods and the practical impact of the thesis. ***Thus, we present below the personal contributions integrated in the Chapter of conclusions, as a novel element of originality:***

28. **Validation of an integrated smart city model** centered on the relationship between administration – municipal operator – citizen.
29. **Formulating future research directions** (including digital twins, AI, blockchain in local governance), own visionary proposal.
30. **Articulating a personalized strategic vision for Romania**, based on solid empirical and theoretical research.

