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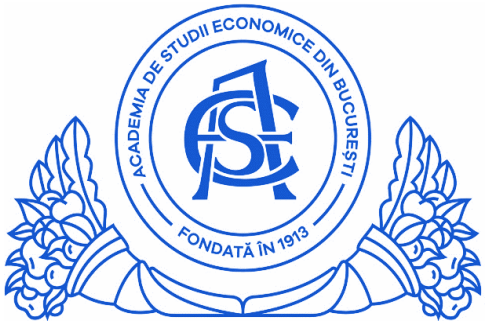

DOCTORAL THESIS

SUMMARY

PhD thesis title:

COMPUTER-BASED SOLUTIONS FOR DEVELOPING RESILIENT SMART CITIES

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Summary of the PhD Thesis

Purpose: The doctoral research took place in a sequence of three distinct stages, focusing on the investigation and development of new perspectives related to the main subjects of interest, which represents topics of relevance to both academic discourse and the public agenda at the global, European, and national levels, more precisely, the *study of smart and resilient cities topics*. By adopting a rigorous and systematic approach based on grounded theorizations, empirical analyses, and experimental studies, the foundation of an in-depth understanding of the examined issues was created. This academic investigation not only brings up previously unexplored aspects but also contributes to knowledge advancement in the field.

Statement of the problem: In recent years, there has been a significant increase in public concern about mass mobility, rural exodus, social inequality, public safety, climate change, environmental pollution, access to public services, and so on. The integration of digitization, technological innovation, artificial intelligence (AI), e-governance, renewable energy promotion, sustainable urban development, high-speed internet connectivity, the automation of daily tasks, and data sharing in government clouds have emerged as elements that are reshaping the modern life landscape, making the transition from traditional to smart cities. As cities evolve into dynamic hubs of connectivity and innovation, the integration of sensors, wireless networks, and automated data processing is becoming a transformative force that can improve various aspects of citizens' lives. In the context of recent global events, the most significant being the COVID-19 health crisis, the critical role of modern technologies in strengthening cities' resilience has also been emphasized. The adoption of smart technologies has become vital for re-evaluating and optimizing urban management strategies. The resilience and responsiveness of cities during crises are directly influenced by their ability to capitalize on emerging technologies to quickly respond to various challenges—natural or anthropogenic shocks and stresses.

Methodological approach: The study of intelligent cities, in the research, began by performing an exploratory analysis of the evolution of cities, from the most rudimentary urban forms to contemporary developments, which led to the need for smart and resilient city concepts. Next, a rigorous evaluation of the specialized literature from scientific databases was performed to substantiate the research, including bibliometric analysis to evaluate the authors and the studies that have adopted the concept in the urban context to surprise niches and directions that are not sufficiently explored, as well as the study of frameworks, strategies, and

projects underlying urban development. The next step was to identify and track some metrics systems for measuring and assessing cities' smartness and resilience, useful for measuring the progress and efficiency of interventions in the direction of transforming cities into entities more adapted to contemporary challenges. This approach falls into the current concerns of creating mirror copies of urban systems known as "digital twins". These digital replicas allow real-time monitoring and analysis of urban infrastructure, facilitating better management of resources and services. They also offer the opportunity to simulate scenarios to anticipate and prevent problems, thus optimizing infrastructure operations and interdependence. Thus, urban planning can be improved by integrating precise and updated data, thus contributing to cities' increasing resilience. In parallel, certain relevant computer-based solutions were investigated from various studies or projects conducted in different countries, because digital technologies play a central role in facilitating this process of urban transformation. Following the analysis of these systems, the need to develop a specific set of indicators of evaluation in Romania was concluded. This empirical and personalized approach followed a multidimensional methodology, applying principal component analysis (PCA) to determine an objective manner of assigning weights in the construction of aggregate indicators and using dashboard representations for interactive comparison of urban areas.

The identification of viable and openly exposed data sources was provocative because no centralized platform openly exposes this type of data at the national-level. To facilitate the automation of the data gathering process, a web-based framework was developed. The extracted data were stored in Mongo DB and then subjected to various analyses.

Results: By searching on the basis of relevant keywords, multiple scientific papers were identified and refined to highlight the most relevant ones. These papers provided a clearer understanding of the subject and deepened the current stage of knowledge. Historical open data sources were investigated for the recent time period (which include the period before the outbreak of the global pandemic, the decrease of the pandemic peak and until the time of declaring the medical emergency end), available in various national institutions, to develop an indicator system that matched the purpose of the research. 4 principal dimensions were formed to cover the Social, economic, and well-being of citizens; Infrastructure, public, and technological utilities; Industry and safety governance; and Climate, environment, and green area. In turn, these dimensions include sub-indicators that reveal multiple urban aspects. In addition, computerized modules have been designed for automatic data collection and extraction, including sources that do not expose data in an accessible format, for which mini-software-robots and scraping were used.

Because the indicators offer an overview of the situation from a certain past period, most often with monthly, semi-annual, or annual frequencies, the research considered finding alternative solutions for real-time understanding of the city-level situation by devising proxy measurements and obtaining data from unconventional sources recognized by the academic world. Through computerized procedures, data were analysed in detail and used for their predictive and prescriptive nature, providing better information over time horizons, where the presence of the effects of shocks or stressors has affected various aspects of cities. Data analysis models were built by applying supervised and unsupervised machine learning algorithms to historical sources and real-time streaming data and were continuously optimized to improve prediction performance and accuracy. The most remarkable results obtained from the application to urban areas in Romania (325 small, medium, and large cities) were highlighted following experimental exercises carried out using data from social networks, sensor networks that expose data related to air quality and meteorological indicators, and citizen mobility-related data, obtaining a snapshot that captured the effects of various rapid-impact trigger events on cities.

The validation of the elements identified in the research was achieved by publishing scientific articles and disseminating the findings at internal and international conferences, as well as in peer-reviewed articles indexed in Web of Science, Scopus and other international databases.

Keywords: smart city resilience, evaluation metrics, digital twin, artificial intelligence, machine learning, natural language processing.