CONTEXTUALIZATION OF SMART CITY DEVELOPMENT: A COMPARISON OF ASIAN AND EUROPEAN CASES

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Abstract

Smart city strategies are increasingly becoming key tools for modernizing administrative units and introducing innovative approaches into public policy. Their emergence and dynamic development are closely linked to the rapid advance of digitalization and energy transitions, both of which have the potential to significantly influence the quality of life of residents. At the core of this concept is the use of digital tools and data-driven solutions that enable cities to better understand developments within their territory, respond to emerging challenges, and manage local processes more effectively. Although modern technologies are often presented as the decisive factor of transformation, the practical implementation of smart cities is always shaped by the specific conditions of individual regions. Therefore, it is important to examine how smart solutions adapt to local political, social, and economic contexts. This article evaluates two approaches to building intelligent models – one in the Indonesian province of Yogyakarta and the other in the Trnava Region of Slovakia. The selected administrative units offer distinct perspectives on the implementation of smart initiatives, with each model grounded in unique territorial and institutional assumptions. The analysis highlights different ways of integrating local context into strategic planning and identifies types of contextualization practices that may enrich current knowledge on Smart City issues from the perspective of real-world application.

Keywords

Smart City, innovations, Trnava region, Yogyakarta province

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INTRODUCTION

The Smart City concept represents an increasingly prominent phenomenon in the modernization of public policies. It also reflects ongoing processes of digitalization and energy transition aimed at improving the quality of life of local communities. As a result, the concept has become a central paradigm of urban innovation, planning, and governance. Its core idea lies in the use of information and communication technologies – in the form of hardware, software, data, and connectivity – as the backbone of cities, enhancing their ability to monitor, anticipate, and address urban challenges. Through ICT-based solutions, cities strive to optimize resource management, improve service delivery, strengthen citizen engagement, and support sustainable development. In many major smart city initiatives, technology is seen as the primary driver of transformation. For instance, the deployment of Internet of Things devices, big data analytics, and cloud infrastructures is often presented as the foundation of urban resilience, mobility, energy efficiency, and governance (Bibri & Krogstie, 2020).

Although the Smart City concept has generally defined criteria, its concrete application within specific administrative units is always shaped by distinctive political, social, and economic factors. From this perspective, it is useful to examine Smart City implementation under differing conditions across Europe and Asia. Based on this, we selected two unique models from Slovakia and Indonesia. The primary objective of this article is to assess the specific approaches to Smart City development in the Indonesian province of Yogyakarta and in the Trnava Region of Slovakia. Both applied Smart City models reflect unique territorial, administrative, political, and economic characteristics. By comparing the implementation of Smart City initiatives in Yogyakarta Province and the Trnava Region, we can extract a typology of local contextualization strategies employed in both settings. This typology can enrich the literature beyond general calls for "context sensitivity" by demonstrating how local contexts are mobilized differently depending on institutional traditions, resource availability, and governance norms.

Methodology

This study adopts a qualitative comparative research design aimed at examining how Smart City strategies are locally contextualized under distinct institutional, cultural, and socio-economic conditions. The methodological approach is exploratory and theory-informed, focusing on understanding mechanisms of contextualization rather than measuring performance or outcomes. The selection of the Trnava Self-Governing Region (Slovakia) and the Special Region of Yogyakarta (Indonesia) followed a purposive case selection strategy. The cases represent a *most-different systems design*, as they differ substantially in geographical location, cultural traditions, governance arrangements, and levels of economic development. At the same time, they remain functionally comparable. Both cases operate at the regional level of public administration, belong among the most socioeconomically developed regions within their respective national contexts, and have adopted formal, strategically anchored

Smart City (or Smart Province) frameworks. This combination of maximum contextual diversity and functional comparability makes the two regions analytically suitable for examining how local contexts shape distinct smart development models.

The primary research method employed in this study is systematic document analysis. The analyzed materials include official Smart City and Smart Province strategies, regional development plans, conceptual and methodological documents, and related policy frameworks at both regional and national levels. These documents represent authoritative sources guiding the planning, implementation, and evaluation of smart initiatives in both regions. To strengthen contextualization, the document analysis was complemented by secondary academic literature on Smart City theory and governance, as well as selected socioeconomic indicators used to characterize the broader development context of the two regions. An important aspect of the data collection process is the direct expert involvement of the authors in the preparation of the analyzed strategic documents. In the Slovak case, Dalibor Mikuš and Richard Brix co-authored the SMART Strategy for the Development of the Trnava Self-Governing Region. In the Indonesian case, Lukito Edi Nugroho co-authored the Smart City Readiness framework that forms the methodological basis for smart development in Indonesia. This involvement provided in-depth contextual knowledge and access to internal strategic rationales. At the same time, the potential risk of normative bias was mitigated through a structured comparative framework and systematic cross-case analysis.

The comparative analysis follows a qualitative, dimension-based comparison. Rather than assessing which model is more successful, the comparison focuses on how different local contexts are translated into distinct Smart City development logics. The cases were compared across several analytical dimensions, including the role of technology, the integration of local values and cultural narratives, governance and coordination mechanisms, institutional arrangements, and the translation of strategic visions into implementation frameworks. This approach allows for the identification of patterns of contextualization and for explaining how specific regional characteristics give rise to distinct smart development models.

The study relies primarily on document analysis, which represents a key methodological limitation. The absence of interviews, surveys, or direct observations restricts the ability to assess how smart strategies are perceived and experienced by local stakeholders and residents. This limitation is partly justified by the exploratory nature of the study and the scope of the article. Future research could extend the findings by incorporating qualitative interviews, participatory observations, or quantitative indicators to examine the societal impacts of different contextualized Smart City models.

Theoretical Reflection on the Issue of Smart Cities

The idea of the Smart City has deep historical roots that can be traced back to early reflections on the concept of an ideal urban space. Although the term Smart City emerged only in the modern era of digitalization, its philosophical and conceptual foundations

reach back to the 19th century, when the first visions of a harmonious, functional, and ecologically balanced city began to appear. Even at that time, architects and urban planners sought to respond to the negative consequences of industrialization and searched for new models of urban life that would connect technological progress with the quality of life of inhabitants.

One of the first researchers who sought to connect social, natural, and technological aspects within urbanism was Geddes (2022), who in his work Cities in Evolution promoted the idea of the city as a living organism. Geddes's approach to urban planning, which emphasizes education, participation and ecological relationships, is considered a precursor to concepts found today within smart cities (Talen, 2019; Batty, 2013). In the second half of the 20th century, the vision of a technologically advanced city as a tool for social development came to the forefront. For example, Jacobs, in her work The Death and Life of Great American Cities (1961), rejected modernist approaches to urbanism and highlighted the importance of diversity, participation, and the spontaneous development of communities. In general, these are elements that resonate today in models such as "Smart Governance" and "Smart People" (Jacobs, 1961; Townsend, 2013).

In the 1960s, Weber (1964) introduced the concept of the "non-place urban realm," referring to the changing relationship between modern technologies, physical space, and social ties. This approach foreshadowed the emergence of Digital Cities and later Smart Cities, where the physical and virtual dimensions form a unified system (Giffinger et al., 2007; Komninos, 2016). From the 1980s onward, urbanism increasingly drew on the principles of sustainability and the integration of information technologies. Hall (1988) and Castells (1996) examined how globalization, communication networks, and digital economies transform the urban environment. In his work The Rise of the Network Society, Castells emphasizes that cities are becoming nodes within a global network of information and data flows, which is understood as one of the key pillars of the entire model (Castells, 1996; Hall, 1988).

If we look at the comprehensive concept of the Smart City in its contemporary understanding, we can identify its grounding in the 1990s, when the need for sustainable development and responsible resource use came to the forefront of urban planning. This shift was a response to growing environmental problems, urbanization pressures, and the globalization of urban structures. A significant milestone was the adoption of the Kyoto Protocol in 1997, which defined the commitments of states regarding the reduction of greenhouse gas emissions and stimulated the emergence of new approaches to urban planning with an emphasis on sustainability and ecological technologies (Joss, 2018; Ahvenniemi et al., 2017).

During this period, the first concepts of digitally interconnected cities began to emerge, linking urbanism with information and communication technologies (ICT). Graham and Marvin (2001), in their work Splintering Urbanism, pointed out that technological infrastructure would begin to shape new layers of urban space, with digital connectivity becoming just as important as the physical transport network. Their predictions were fulfilled at the beginning of the 21st century, when the internet and mobile technologies fundamentally transformed how cities function (Komninos, 2016; Townsend, 2013).

In this context, the development of the internet is objectively considered a decisive milestone in the emergence of smart cities. On a practical level, it enabled the collection, processing, and analysis of large volumes of data in real time. This technological shift created the foundation for the development of concepts such as Digital Urban Governance (Hollands, 2015) or Big Data Urbanism (Kitchin, 2016), which have become pillars of the modern Smart City. From this perspective, Caragliu et al. (2011) emphasize that a truly smart city is not only technologically advanced but, above all, continuously "learning" in the sense of using information to improve quality of life, governance, and the economy.

Another rise in interest in Smart Cities was associated with developments following the global financial crisis of 2008, when cities began to focus on innovative solutions as a means of economic recovery. The crisis itself revealed weaknesses in existing urban management, and in an effort to support economic growth and attract new investment, cities began searching for new Smart City tools. A key role was played by IBM, which introduced the Smarter Planet initiative as a vision for a more efficient functioning of society through the interconnectedness of people, data, and technologies (Nam & Pardo, 2011; Paroutis et al., 2014). This approach popularized the very term Smart City and became a foundation for the strategic programs of many metropolitan areas.

Following the technological initiatives of the private sector, public administration institutions also began to engage in the process. Within its Europe 2020 strategy, the European Commission set the objective of promoting smart, sustainable, and inclusive growth, thereby creating a framework for the development of "smart cities" as key elements of economic and environmental policy (Bibri & Krogstie, 2020; Dameri, 2017; Bihr, 2020; Nastjuk et al., 2022; Voorwinden, 2022). This strategy was followed by initiatives such as the European Innovation Partnership on Smart Cities and Communities (EIP-SCC), which supported knowledge exchange and the creation of pilot projects across Europe (Cocchia, 2014).

At the same time, alternative approaches to the concept of the smart city also began to take shape. Batty (2013) introduced the vision of the "city as a complex system", in which intelligence results from the interconnectedness of data, infrastructure, and resident behavior. Harrison and Donnelly (2011) defined the Smart City as an adaptive ecosystem that uses information flows to continuously improve its functions. This systems-oriented perspective became the foundation for contemporary approaches to data-driven urban management (data-driven governance). After 2010, the Smart City became a global trend that took on various forms depending on regional and cultural contexts. Kitchin (2016) and Shelton et al. (2015) pointed out a problematic element: the term "smart" is often used as a marketing tool without emphasis on social inclusion or the ethical aspects of data use. For this reason, efforts emerged to balance technological and humanistic perspectives through concepts such as Smart Sustainable Cities (Ahvenniemi et al., 2017; Bibri & Krogstie, 2020) or Human-Centered Smart Cities (Yigitcanlar et al., 2021).

As for the definition of Smart City, it still remains a subject of ongoing debate among experts. Despite the frequent use of the term in academic, political, and technological spheres, there is still no single, universally accepted definition. This is primarily due to

the multidimensional nature of the concept, which encompasses technological, social, environmental, economic, and to a large extent also political dimensions. At the same time, it must be noted that its meaning changes depending on the context, region, or the objectives of individual stakeholders (Albino et al., 2015; Yigitcanlar et al., 2021; Ibănescu et al., 2022).

According to Caragliu et al. (2011), a smart city is one that invests in human and social capital, modern communication infrastructure, and sustainable energy management in order to support economic growth and the quality of life of its inhabitants. This approach extends the understanding of the Smart City beyond technology – emphasizing education, citizen participation, and an innovation ecosystem as fundamental pillars of urban development. In contrast, Batty (2013) view the smart city as a complex "system of systems," in which all urban processes – from transport and energy to the economy and governance – are interconnected through data. According to them, a city's intelligence does not lie in the technology itself, but in the way data are interpreted and used for decision-making.

Harrison and Donnelly (2011) define the Smart City as an environment that "integrates physical, digital, and human systems to create sustainable, prosperous, and friendly urban spaces". Their definition emphasizes the interconnectedness between physical infrastructure and the virtual realm, which corresponds to today's trend of data-driven governance, that is, governance based on data.

In recent years, critical and alternative perspectives on the definition of smart cities have come to the forefront. Hollands (2015) emphasizes that a Smart City should not be reduced to technological efficiency and profitability, but should also reflect social justice, the ethics of data use, and equal access to digital services. Similarly, Shelton et al. (2015) argue that Smart City definitions must take into account the political and economic power of technology corporations, which often influence how a city's "intelligence" is interpreted. Current approaches also expand the Smart City concept to include aspects of sustainability and climate resilience. Ahvenniemi et al. (2017) propose linking smart cities with the goals of sustainable development (SDGs), claiming that a "truly smart city" is one that optimizes its resources not only for efficiency but also for long-term environmental balance. Likewise, Bibri and Krogstie (2020) introduce the concept of the Smart Sustainable City, emphasizing that technologies should serve merely as tools for achieving ecological, social, and ethical objectives. The essence of the concept is expressed by Yigitcanlar et al. (2021), who define the Smart City as an adaptive and evolutionary system that changes alongside technological progress, cultural shifts, and political decisions. They argue that the definition of a smart city can never be static, because cities themselves are dynamic organisms that continually adapt to new challenges.

An analysis of the selected regional units – the Trnava Self-Governing Region in Slovakia and the Province of Yogyakarta in Indonesia – indicates the presence of several shared socioeconomic characteristics that guided the selection of these. Both regions demonstrate relatively strong labor markets, robust economic performance, and well-developed human capital, which together provide conducive environments for the adoption of smart innovations.

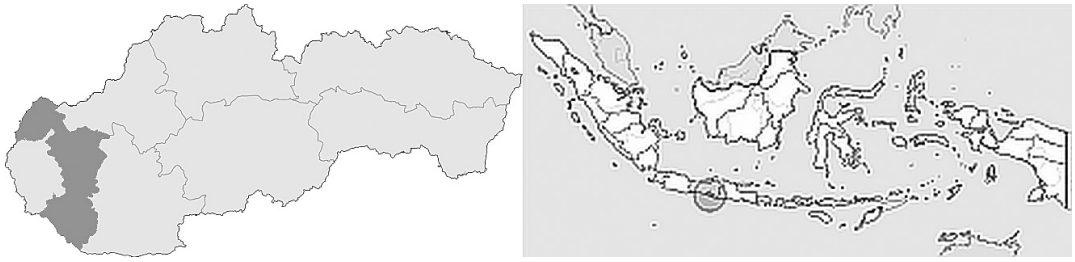
Table 1 Socioeconomic Profile of the Trnava Self-Governing Region and the Special Region of Yogyakarta

Indicator	Trnava Self-Governing Region	Special Region of Yogyakarta
Unemployment rate	2.7 %	3.4 %
GDP per capita	21,403 €	3,315 €
Difference from national average	+ 9.9 %	+ 27 %
Average Salary	1,814 €	1,020 €
Human Development Index (HDI)	0.880	0.8248

Source: Own processing based on Trnavský samosprávny kraj (2023), Government of Yogyakarta (2023).

Table 1 highlights that both the Trnava Self-Governing Region and the Special Region of Yogyakarta represent economically and socially advanced territories within their respective national contexts. Despite operating in different macroeconomic and cultural environments, both regions exhibit favorable labor market conditions, above-average economic performance, and high levels of human development. These characteristics indicate a strong capacity to absorb innovation, implement data-driven governance, and support long-term strategic planning. At the same time, the regions function as important educational and knowledge centers, which strengthens their institutional readiness for the adoption of smart solutions. The combination of economic stability, human capital, and governance capacity creates a supportive environment for experimenting with and implementing Smart City strategies tailored to local conditions. Consequently, the comparison of these two regions enables a meaningful analysis of how smart development can be contextualized across different regional and institutional settings.

Figure 1 Map of the Trnava Self-governing region and Special Region of Yogyakarta



Source: Own processing based on Trnavský samosprávny kraj (2023), Government of Yogyakarta (2023).

Evaluation of the Smart City strategy for the Yogyakarta province

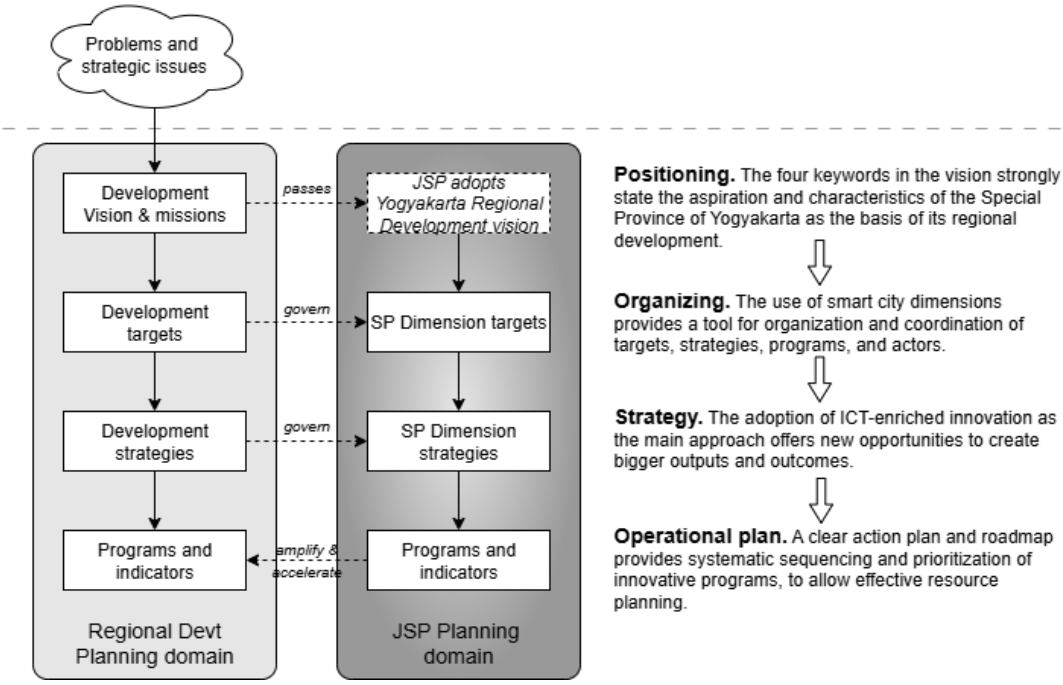
The history of incorporating technology in government processes in Yogyakarta has dated back to 2006 where the Governor of the Special Province of Yogyakarta announced the Governor Decree No. 42/2006 that initiated the implementation of electronic governance in the scope of the Special Province of Yogyakarta (Governor Decree No. 42/2006: Blueprint Jogja Cyber Province, 2006). The initiative, dubbed as Jogja Cyber Province (JCP), marked an era where ICT was considered as a strategic tool for delivering public services. Jogja Cyber Province initiative stepped into the next phase in 2017 when the Government of the Special Province of Yogyakarta launched a fully revamped version of the JCP blueprint. The new master plan expanded the scope of JCP: technology no longer became the focus, but a strategic driver and enabler for a more holistic development strategy (Government of Yogyakarta, 2017). The new program, nicknamed Jogja Smart Province (JSP), also acknowledged innovation as the main component in every action plan.

The second phase of JSP started in 2023 when the Government of the Special Province of Yogyakarta launched the updated version of the master plan document. The document was written in collaboration with the Ministry of Communication and Information, as part of the National Smart City/Province Movement. Since 2017, the movement has assisted more than 200 cities and districts in Indonesia to develop a master plan for smart city development, including all cities and districts in the Special Province of Yogyakarta.

A unique case of JSP is its underlying vision. As articulated in the master plan, JSP vision is derived from the regional development vision. It reflects a strong local contextualization strategy by grounding technological development within the region's cultural, social, and historical values (Government of Yogyakarta, 2023). It emphasizes the achievement of *Pancamulia*, a holistic long-term aspiration that integrates social justice, economic inclusivity, cultural harmony, democratic governance, and dignified public service. The notion of 'social harmony' underscores the centrality of community as active agents in development, promoting collaborative and participatory governance. The commitment to use innovative technologies highlights the strategic use of digital technologies not as an end in themselves, but as tools to accelerate institutional reform and spatial transformation. Lastly, the 'culture and character' principle affirms the importance of preserving Yogyakarta's cultural identity and philosophical values as guiding norms in the formulation and implementation of smart initiatives. Together, these elements frame a vision that balances technological advancement with cultural integrity and social cohesion.

Bringing local contextualization of smart city development into realities is difficult. Not only local contextualization itself is an abstract concept (i.e., what does local context really mean? How is it related to smart city?), its scope can be very broad and divergent, making its implementation a daunting task. JSP approaches this problem using a framework that decomposes the difficult task into simpler ones with clearer objectives. The framework consists of a layered structure that transforms abstract ideals into concrete, implementable actions. Figure 1 illustrates the framework for contextualizing smart city development in JSP.

Figure 2 The framework for local contextualization of smart province development in JSP



Source: Own processing based on Jiang et al. (2023)

As a development strategy, JSP fits smoothly with the Regional Medium-Term Development Plan which becomes the sole official reference for all government bodies/offices in planning their programs and budget. Local contextualization starts from the vision level, since vision is the best place to define the context to be brought to smart province development. At the vision level, JSP adopts the overarching vision for Yogyakarta regional development in the development plan document. As stated previously, the vision puts technology as a development engine on top of local values and realities rooted from the spatial and social existence of Yogyakarta. Consequently, these also become the basic pillars of the design, plan, and implementation of JSP.

Since local contexts are typically unstructured, diverse, and complex, bringing them into smart city development requires effective structuring, allowing the development process to be more convergent. JSP presents an organization structure based on smart city dimensions widely used in many smart city implementation (Giffinger et al., 2007). This organization is used to cluster and coordinate operational strategies, action plans, and roadmap of innovative programs that become the heart of JSP and form solution elements for Yogyakarta's major problems. Choosing smart city dimension as an organizing tool is necessary since JSP will have to be in collaboration with smart city initiatives run by Yogyakarta City, Bantul, Kulon Progo, Sleman, and Gunung Kidul, since many of Yogyakarta Province's problems are also shared with these cities and districts.

The next layer, strategy, deals with methods and approaches in solving the problems. As in other smart city initiatives, JSP also relies on ICT as the spearhead element in designing solutions. However, JSP adopts "innovation before ICT" principle: ICT is considered as enablers and accelerators for innovative programs that are specifically designed to solve existing problems. Problem solving should start with innovative solution ideas, which are then realized or accelerated using ICT. The emphasis of placing innovation and creativity over technology aims at maximizing the opportunity to seek for the most optimum solution. Placing solution optimization at the idea level would give more holistic, technology-unbounded perspective.

Finally, action plans and roadmap organize JSP's innovative programs into manageable execution sequences. This allows careful planning and prioritization of resource allocation for program implementation.

Due to its enormous scale and complexity, the implementation of JSP needs to be carried out in several stages. However, at the same time both the Government and Yogyakarta people need to be convinced about the feasibility of the JSP concept. A quick win program is needed, and the Government choose to run a small-scale implementation called the *"Cosmological Axis Smart Area"*.

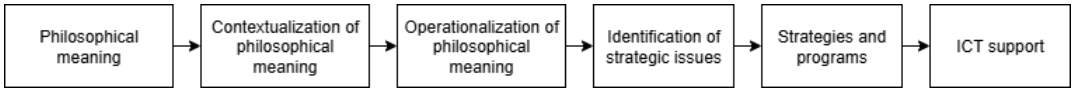
The Cosmological Axis of Yogyakarta represents a unique spatial and philosophical conception of urban design rooted in Javanese cosmology. This linear, imaginary axis extends from Mount Merapi in the north, through *Tugu Pal Putih*, *Kraton Yogyakarta*, and *Panggung Krapyak*, to the Indian Ocean at Parangtritis in the south. Each component of this alignment holds both spatial and symbolic significance: Mount Merapi symbolizes the realm of the gods (spiritual power), the Kraton signifies the human world and center of earthly governance, while the Indian Ocean represents the domain of nature and the mystical Queen of the South Sea. Collectively, these elements form a sacred axis that embodies the Javanese worldview of cosmic harmony between the divine, human, and natural realms. Philosophically, the axis reflects the concept of *hamemayu hayuning bawana*, the ethical imperative to nurture and maintain the harmony of the universe through balanced governance and moral leadership. Thus, the axis is not merely a spatial arrangement but a manifestation of Javanese metaphysical and cultural values, deeply embedded in Yogyakarta's identity and daily life.

Following the establishment of JSP phase 1 in 2017, the Cosmological Axis is promoted as a pilot project for JSP implementation. The reason is simple: it covers an area of 268 hectares, quite manageable for a small-scale smart province implementation, but the most important reason is that the Cosmological Axis embodies a strong cultural value, a perfect candidate for local contextualization of smart province development.

The biggest challenge of the Cosmological Axis Smart Area (CASA) project is to connect two widely separated domains: technology and philosophy. Only after this issue is resolved can ICT support be built on top of it, to address existing problems. This framework, illustrated in Figure 2, is designed as a cascade, beginning from high-level normative guidance, down to operational strategies and implementable action plans (Governor Decree No. 42/2006: Blueprint Jogja Cyber Province, 2006). The flow goes from normative to strategic and to operational layer, ensuring that technological innovation does not stand apart from, but is harmonized with, Yogyakarta's sociocultural

and spatial identity. This approach enables the Smart Province initiative to preserve local wisdom while simultaneously adopting modern, ICT-driven innovations for sustainable development. It can also be seen that the CASA framework inherits the structure of the JSP framework, with the positioning and organizing elements are represented by the first three steps of the CASA framework.

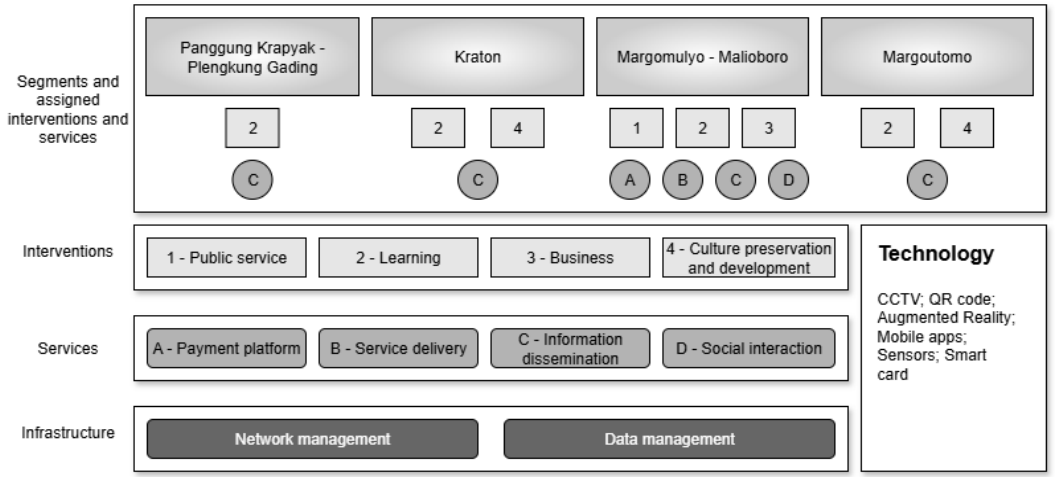
Figure 3 The framework for the Cosmological Axis Smart Area project



Source: Own processing

The CASA framework is realized by an implementation model that consists of 4 layers. The first layer defines philosophical meanings embodied by 4 road segments located in the axis. The segments become the unit of development where strategies, programs, and ICT support are designed and implemented. The second layer describes the form of intervention domain required to operationally realize a segment's philosophical meaning. The intervention domain can be considered as the "work area" where technological solutions will be implemented. The third layer describes services that technological solutions will be implemented. These services are generic, and their concrete forms are tailored to the conditions on the ground. For example, a service for information dissemination could take form of a website, push applications, or digital displays. Finally, the bottom layer is the ICT infrastructure layer which implements the various technological solutions to be built. The CASA implementation model is shown in Figure 3. It should be noted that the model can be viewed as a generic platform for developing a wide range of ICT support for philosophical meanings. This model is also flexible to changing needs due to its modular nature and the ability to mix and match building blocks.

Figure 4 The implementation model of the Cosmological Axis Smart Area



Source: Own processing

Evalution of the Smart city strategy for the Trnava region

The Trnava Region is one of Slovakia's eight regions and represents one of the country's important economic, cultural, and historical centers. Due to its unique geographical location bordering Hungary, Austria, and the Czech Republic, it is a natural hub for development. SMART solutions have been adopted gradually in the region over the past decade, but they lacked a conceptual long-term solution. A prerequisite for such an approach is the adoption of conceptual material, which was successfully implemented in 2023 when the self-governing region adopted a document entitled SMART Strategy for the Development of the Trnava Self-Governing Region.

The SMART Strategy for the Trnava Self-Governing Region represents a comprehensive framework for the modernization of public policies that responds to current megatrends in digitization, climate change, energy transformation, and the need to improve quality of life. The Trnava Region has a strong economic base, a favorable geographical location, and developed infrastructure, but at the same time faces uneven development of individual districts, varying levels of digitization of local governments, and the absence of a unified data and innovation ecosystem (Finka et al., 2014).

It is therefore necessary to systematically develop all key areas of the SMART agenda, with an emphasis on coordination between the region, cities, and municipalities. The Trnava Region should strengthen partnerships and networking throughout the region. This means building a professional governance model that will enable the interconnection of local governments, companies, universities, and professional institutions. The region needs to create an innovation cluster similar to those operating abroad and support processes of

data sharing, joint projects, and coordinated decision-making. A unified methodology for SMART projects and a support platform for municipalities will create the basis for a harmonized approach across the region. Another important area is data management and the development of digital services. The Trnava region needs to build a central data ecosystem that will enable the effective collection, analysis, and use of data across public policies. The digitization of public administration services, increasing cybersecurity, and training employees in digital skills are key prerequisites for increasing the efficiency and transparency of the functioning of the region and municipalities. In the area of healthcare, the region is facing a growing number of senior citizens, unevenly distributed capacities, and a lack of modern infrastructure. SMART solutions such as the Internet of Medical Things (IoMT), telemedicine, intelligent hospital process management, and data planning for provider networks can significantly contribute to increasing the availability and quality of healthcare services (Adamovský et al., 2019).

The region should support the digitization of workplaces, the interconnection of information systems, and the creation of integrated health services. Similarly, in the social sphere, it is necessary to respond to the aging population and growing demands for care. Modern technologies can improve client monitoring, increase the safety of seniors, and support the development of field and community services that make life easier for residents. Intelligent capacity planning based on demographic trends will enable effective investment in social infrastructure. Education is a strategic pillar of the region's development. The Trnava Region should modernize vocational education, strengthen links between schools and the labor market and universities, and support the development of STEM skills. It is also important to expand the use of digital tools in teaching and modernize school facilities to reflect the demands of the changing labor market. Integrated transport is another key element of SMART development. The region should continue to digitize transport services, introduce intelligent management systems, smart stops, traffic monitoring, and develop cycling. Strengthening IDS, multimodal transfers, and low-emission solutions will improve the mobility of residents and contribute to reducing the environmental burden (Trnavský samosprávny kraj, 2023).

The environment also plays an important role. The region can use smart sensors for air monitoring, intelligent waste management systems, support renewable energy sources, energy communities, and intelligent building management. Data-driven approaches will strengthen the region's ability to adapt to climate change and increase energy efficiency. In the field of culture, the aim is to digitize cultural services and make them accessible to the public through modern platforms. The region should support the digitization of archives, museums, and galleries and introduce interactive tools for visitors, thereby increasing the attractiveness of cultural heritage. Regional development must focus on strengthening the innovative potential of small and medium-sized enterprises, improving the absorption of funds, and supporting exports and economic diplomacy. The creation of a strong innovation ecosystem will enable the region to remain competitive and develop high value-added industries. Tourism has significant potential in the region, mainly thanks to Piešťany, the Danube area, the Little Carpathians, and other tourist attractions. SMART solutions can support intelligent destination management, visitor monitoring, digital marketing tools, and interactive tourist applications. Modern, data-driven tourism will

increase visitor numbers and strengthen the economic contribution of the sector. Spatial planning is an important tool for coordinated regional development. The digitization of land-use plans, modern GIS platforms, the use of BIM, and interconnected data models will enable more accurate planning of infrastructure, energy, and transport development. Strengthening inter-municipal cooperation is essential, especially in rapidly growing parts of the region. The overall objective of the SMART strategy is to strengthen the region's resilience, increase its competitiveness, and create a harmonized framework for cooperation between the region and local governments. The introduction of SMART principles will enable effective management of public policies, support innovation, and create an environment that improves the quality of life for all residents of the Trnava Self-Governing Region (Trnavský samosprávny kraj, 2023).

The center of the region is the city of Trnava, which, in addition to the adopted strategy for the region as a whole, is also undertaking activities for its own development. The city of Trnava hosts a significant concentration of business entities, primarily in the engineering and automotive industries. A considerable share of the local economic base is also formed by research and academic institutions. The city closely cooperates with non-governmental and civic organizations to connect people through various activities. However, it has not yet fully utilized the potential of involving these actors in its developmental initiatives (Majerčák, 2014).

As a member of Energy Cities, Trnava has had its own energy manager since July 2017. The energy manager is responsible for managing the city's energy management system, monitoring energy consumption in municipal buildings, and identifying effective measures to reduce it. The main reason for introducing this position was that, in the past, each municipal building managed its own energy affairs independently, which proved unsustainable in the long term in terms of energy efficiency, organization, and finances. The city therefore aims to establish a unified system for all municipal buildings, which is expected to generate annual savings of approximately 50,000 euros. One of the main challenges in this field is the development of a methodological guide for obtaining financial resources to support green construction projects. Such projects contribute to mitigating urban heat islands during the summer months and improving air quality through natural filtration. The energy manager also represents the city of Trnava in the Energy Cities association, whose main objective is to promote sustainable energy use. Trnava became the first Slovak city to join this network. The headquarters of Energy Cities are located in Besançon, France, and Brussels, Belgium. Mayor Peter Bročka personally visited Brussels, where he met with the coordinator of the Smart Cities initiative to discuss advisory and financial support for implementing this concept in Trnava (Lacinák & Ristvej, 2018).

The city recognizes that within the Energy Cities and Covenant of Mayors communities, there are numerous energy-advanced cities. Therefore, Trnava believes that for any new project it initiates, it will likely find partners with relevant experience who can provide assistance – either in financial or implementation aspects. The Concept for the Development of Static Transport represents one of the steps on Trnava's path toward becoming a Smart City. Its main goal is to sustainably regulate the development of static transport while considering all functional components of the urban area. The city intends to record parking capacities through a geographic information system and

apply modern digital tools for operational management. The implementation of this concept should promote pedestrian and non-motorized transport, particularly in the city center, prioritize residential parking in housing estates, and optimize parking fees. This would create new financial resources for the development of both static and public transport. Since the arrival of the new mayor, Trnava has become increasingly focused on sustainable urban mobility, energy management, and environmental protection. Within environmental initiatives, the city has installed semi-underground waste containers in selected areas. A key element of public participation and environmental education is the annual Eko Fest, a benefit festival established in 2008 and unique in Slovakia. The proceeds from the festival are used to build green infrastructure in the city, involving broad public participation each year (Mestský úrad Trnava, 2018).

Another step toward smart solutions has been the replacement of city buses with eco-buses powered by compressed natural gas. These vehicles produce 95% fewer harmful emissions compared to the previous fleet, thereby reducing negative environmental impacts and improving air quality. The city also strives to ensure the interconnection of municipal, suburban, and railway transport so that all lines are well coordinated. Due to the growing congestion of traffic routes, Trnava has also strengthened cycling transport in recent years. In the field of energy, the city is gradually replacing outdated public lighting – especially in the city center – with LED lamps, which offer higher energy and lighting efficiency as well as lower operating costs. Urban development in Trnava focuses primarily on the sustainability of urban mobility, social capital, and human resources. In the area of social capital, a potential lies in establishing a public space in the city center dedicated to the development of social innovations and technologies that enhance communication between the municipality and residents. Another objective is to support public education and increase civic participation in creating and implementing Smart City strategies. In terms of transport infrastructure, potential development includes connecting the network of cycling routes and installing monitoring devices in public bicycle parking areas. Reducing the number of cars on the roads could be achieved by extending cycling routes between residential and industrial zones and promoting pedestrian mobility.

An analysis of educational facilities in Trnava revealed a large number of kindergartens and elementary schools, where encouraging walking to and from school could have a positive impact on traffic conditions, air quality, and overall quality of life. The Smart City Trnava concept targets the general public with the aim of involving citizens in both the creation and implementation of Smart City strategies and initiatives. It emphasizes the development of cycling and pedestrian transport as well as the enhancement of social capital. In the communication between the municipality and citizens, the concept envisages the use of smart technologies to improve the quality of urban life. The concept also includes the creation of a multifunctional public space for social integration, education, social innovation, and both active and passive leisure. At the same time, it seeks to preserve existing infrastructure while expanding facilities dedicated to public education and community integration (Trnavský samosprávny kraj, 2023).

CONCLUSION

The comparison of smart city development in the Special Region of Yogyakarta and the Trnava Self-Governing Region demonstrates that the effectiveness and character of Smart City strategies depend less on the level of technological sophistication and more on the degree to which smart initiatives are embedded within local institutional, cultural, spatial, and socio-economic contexts. This finding aligns with critical strands of Smart City literature that challenge technologically deterministic interpretations of urban intelligence and emphasize governance, human-centered approaches, and contextual sensitivity. The analysis shows that local context does not merely influence the implementation phase of smart initiatives, but fundamentally shapes the underlying logic of Smart City models. In the case of Yogyakarta, smart development is deeply rooted in cultural continuity, philosophical traditions, and participatory governance norms. The Jogja Smart Province framework demonstrates how abstract cultural values, such as social harmony and cosmological balance, can be systematically translated into strategic priorities, governance structures, and ICT-supported solutions. This value-driven and culturally embedded model supports existing arguments that smart cities can function as instruments for preserving local identity while facilitating modernization and institutional transformation.

In contrast, the Trnava Region represents a predominantly system-oriented Smart City model characteristic of the European governance context. Here, smart development is shaped by the need for institutional coordination across fragmented territorial structures, compliance with European policy frameworks, and pressures to enhance efficiency, competitiveness, and service quality. The emphasis on data ecosystems, inter-municipal cooperation, and sectoral modernization reflects a governance- and performance-driven logic in which smart technologies serve as tools for regional integration and policy coordination rather than as carriers of cultural narratives.

The existence of these distinct models is not accidental. Rather, it emerges from deeply embedded regional characteristics. Strong cultural capital, historical continuity, and societal cohesion in Yogyakarta enable a normatively grounded and participatory smart model. Conversely, the administrative complexity, multi-level governance environment, and policy-driven nature of regional development in Trnava foster a system-based and data-driven approach. These findings contribute to the Smart City literature by moving beyond general calls for context sensitivity and by empirically demonstrating how specific contextual factors translate into concrete Smart City development logics.

Overall, the article contributes to current debates on Smart City governance by illustrating that smartness is not a universal or transferable blueprint, but a contextual construct shaped by local values, institutions, and development trajectories. Recognizing these differences is essential for both policymakers and researchers seeking to design, evaluate, or transfer Smart City strategies across diverse regional settings.

References

Adamovský, P., Bobovnický, A., Kozmon, F., Mišutka, M., & Mühl, M. (2019). *Inovačný potenciál krajov SR*. Slovenská inovačná a energetická agentúra. Retrieved October 11, 2025, from https://www.inovujme.sk/files/dokumenty-np-zivse/Inovačný%20potenciál%20krajov%20SR_DIGITAL.pdf

Ahvenniemi, H., Huovila, A., Pinto-Seppä, I., & Airaksinen, M. (2017). What are the differences between sustainable and smart cities? *Cities*, *60*(2), 234–245.

Albino, V., Berardi, U., & Dangelico, R. M. (2015). Smart cities: Definitions, dimensions, performance, and initiatives. *Journal of Urban Technology*, *22*(1), 3–21. http://cl.uw.edu.pl/dok/smart_cities.pdf

Batty, M. (2013). Big data, smart cities and city planning. *Dialogues in Human Geography*, *3*(3), 274–279.

Bibri, S. E., & Krogstie, J. (2020). Data-Driven Smart Sustainable Cities of the Future: A Novel Model of Urbanism and Its Core Dimensions, Strategies, and Solutions. *Journal of Futures Studies*, *25*(2), 77–94.

Bihr, P. (2020). *Smart cities: A key to a progressive Europe*. Foundation for European Progressive Studies. Retrieved November 9, 2025, from https://feps-europe.eu/publication/718-smart-cities-a-key-to-a-progressive-europe/

Caragliu, A., Del Bo, C., & Nijkamp, P. (2011). Smart cities in Europe. *Journal of Urban Technology*, *18*(2), 65–82.

Castells, M. (1996). *The rise of the network society*. Blackwell.

Cocchia, A. (2014). Smart and digital city: A systematic literature review. In R. P. Dameri & C. Rosenthal-Sabroux (Eds.), *Smart city* (pp. 13–43). Springer.

Dameri, R. P. (2017). *Smart city implementation: Creating economic and public value in innovative urban systems*. Springer.

Finka, M., Petríková, D., Tóth, A., & Ondrejička, V. (2014). Participatívne plánovanie. In J. Schöffel, Ľ. Jamečný, & S. Ondrejičková (Eds.), *Participatívne plánovanie na úrovni samospráv* (pp. 39–59). Road / Spectra centrum excelencie STU.

Geddes, P. (2022). *Cities in evolution: An introduction to the town planning movement and to the study of civics*. Legare Street Press.

Giffinger, R., Fertner, C., Kramar, H., Kalasek, R., Pichler-Milanović, N., & Meijers, E. (2007). *Smart cities: Ranking of European medium-sized cities*. Centre of Regional Science. Retrieved November 7, 2025, from http://www.smart-cities.eu/download/smart_cities_final_report.pdf

Government of Yogyakarta. (2017). *Jogja Smart Province Master Plan 2017–2022*. Retrieved November 4, 2025, from https://fcep.uii.ac.id/wp-content/uploads/2017/12/Rencana%20Pembangunan%20Manusia%20DIY%20Tahun%202017-2022_ni%20made.pdf

Government of Yogyakarta. (2023). *Smart Province master plan – Special Province of Yogyakarta*. Retrieved October 11, 2025, from https://jsp.jogjaprov.go.id/

Governor Decree No. 42/2006: Blueprint Jogja Cyber Province. (2006). Retrieved November 10, 2025, from https://jdih.jogjaprov.go.id/produk-hukum/peraturan-perundang-undangan/preview/blueprint-jogja-cyber-province-pemerintah-provinsi-diy_1768885936-79

Graham, S., & Marvin, S. (2001). *Splintering urbanism: Networked infrastructures, technological mobilities and the urban condition*. Routledge.

Hall, P. (1988). *Cities of tomorrow: An intellectual history of urban planning and design since 1880*. Blackwell.

Harrison, C., & Donnelly, I. A. (2011). A theory of smart cities. *Proceedings of the 55th Annual Meeting of the ISSS – 2011, Hull, UK*, *55*(1). https://journals.isss.org/index.php/proceedings55th/article/view/1703

Hollands, R. G. (2015). Critical interventions into the corporate smart city. *Cambridge Journal of Regions, Economy and Society*, *8*(1), 61–77. https://doi.org/10.1093/cjres/rsu011

Ibănescu, B.-C., Pascariu, G. C., Bănică, A., & Bejenaru, I. (2022). Smart city: A critical assessment of the concept and its implementation in Romanian urban strategies. *Journal of Urban Management*, *11*(2), 246–255. https://doi.org/10.1016/j.jum.2022.05.003

Jacobs, J. (1961). *The Death and Life of Great American Cities*. Vintage Books.

Jiang, H., Geertman, S., & Witte, P. (2023). The contextualization of smart city technologies: An international comparison. *Journal of Urban Management*, *12*(1), 33–43. https://doi.org/10.1016/j.jum.2022.09.001

Joss, S. (2018). Future cities: Asserting public governance. *Palgrave Communications*, *4*, Article 36. https://doi.org/10.1057/s41599-018-0087-7

Kitchin, R. (2016). *Getting smarter about smart cities: Improving data privacy and data security*. Data Protection Unit, Department of the Taoiseach. https://mural.maynoothuniversity.ie/id/eprint/7242/1/Smart

Komninos, N. (2016). Smart environments and smart growth: connecting innovation strategies and digital growth strategies. *International Journal of Knowledge-Based Development*, *7*(3), 240–263. https://doi.org/10.1504/IJKBD.2016.078536

Lacinák, M., & Ristvej, J. (2018). Inteligentné mestá v Slovenskej republike a informačné požiadavky krízového manažmentu. *Mladá veda*, *6*(3), 38–47.

Majerčák, P. (2014). Prínosy a koncepcia Inteligentných dopravných systémov ako nástroja riadenia a regulovania dopravy v rámci Slovenskej republiky. *Logistický monitor*, 3–7.

Mestský úrad Trnava. (2018). *Trnava je na ceste k Smart Cities nielen na bicykli*. Retrieved October 11, 2025, from https://www.trnava.sk/aktualita/10325/trnava-je-na-ceste-k-smart-cities-nielen-na-bicykli

Nam, T., & Pardo, T. A. (2011). Conceptualizing smart city with dimensions of technology, people, and institutions. In *Proceedings of the 12th Annual International Conference on Digital Government Research* (pp. 282–291).

Nastjuk, I., Trang, S., & Papageorgiou, E. I. (2022). Smart cities and smart governance models for future cities. *Electronic Markets*, *32*(4), 1917–1924.

Paroutis, S., Bennett, M., & Heracleous, L. (2014). A strategic view on smart city technology: The case of IBM Smarter Cities during a recession. *Technological Forecasting and Social Change*, *89*, 262–272.

Shelton, T., Zook, M., & Wiig, A. (2015). The 'actually existing smart city'. *Cambridge Journal of Regions, Economy and Society*, *8*(1), 13–25.

Talen, E. (2019). *Neighborhood*. Oxford University Press.

Townsend, A. M. (2013). *Smart cities: Big data, civic hackers, and the quest for a new utopia*. W. W. Norton & Company.

Trnavský samosprávny kraj. (2023). *Smart stratégia rozvoja regiónu Trnavského samosprávneho kraja*. Retrieved October 11, 2025, from https://trnava-vuc.sk/oddelenie-cezhranicnej-spoluprace/smart-strategia/

Voorwinden, A. (2022). Regulating the smart city in European municipalities: A case study of Amsterdam. *European Public Law*, *28*(1), 155–180.

Weber, M. (1964). *The Theory of Social and Economic Organization*. The Free Press.

Yigitcanlar, T., Corchado, J. M., Mehmood, R., Li, R. Y. M., Mossberger, K., & Desouza, K. (2021). Responsible urban innovation with local government artificial intelligence (AI): A conceptual framework and research agenda. *Journal of Open Innovation: Technology, Market, and Complexity*, *7*(1), 1–16, Article 71. https://doi.org/10.3390/joitmc7010071

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