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The Role of the EU Mission Cities Program in Advancing Climate-Neutral Smart Cities in Central Europe

ABSTRACT

The study examines the role of the European Union's "Climate-Neutral and Smart Cities" Mission (Mission Cities) in advancing climate-neutral and smart urban development in Central Europe, with particular attention to the Hungarian Mission Cities (Budapest, Miskolc, and Pécs). The research is based on a qualitative methodology combining content analysis of Climate City Contract documents with semi-structured interviews conducted with city leaders and development professionals. The findings indicate that in the examined cities, smart solutions primarily appear as technological and project-based interventions, while their implementation as integrated, data-driven governance models remains limited. The success of climate-neutrality efforts largely depends on institutional capacity, financial stability, and the quality of societal participation. The study concludes that although the Mission Cities programme functions as an important catalyst, its impact in Central European cities is currently better interpreted as a strategic adaptation rather than as a deep structural urban transition.

Keywords: climate neutrality; mission cities; smart cities; urban development; urban governance

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INTRODUCTION

By the beginning of the 21st century, cities had become the primary spatial arenas for social and economic processes, while simultaneously playing a pivotal role in the impacts of climate change and its associated governance challenges. European urban areas are concurrently responsible for a significant share of energy consumption and greenhouse gas emissions, as well as for the innovation and governance resources that can enable the transition toward climate neutrality (European Commission, 2021). The latest synthesis report of the Intergovernmental Panel on Climate Change (IPCC) points out that urban areas are particularly vulnerable to heatwaves, flash floods, and infrastructure overload; at the same time, the effectiveness of mitigation and adaptation interventions can be highest within these spaces (IPCC, 2023). Consequently, cities are not merely sites of concentrated environmental problems, but also potential laboratories for climate policy innovation.

Urban planning and governance are increasingly focusing on digitalisation and the application of information technologies, which are becoming key elements in smart urban development and enhancing competitiveness (Nick et al., 2018). Over the past decade, the "smart city" concept has become a central element of urban policy discourse (Orłowski & Szczerbicki, 2019), which can now be interpreted as a complex, data-driven governance model. The ITU-T Focus Group on Smart Sustainable Cities (ITU-T FG-SSC) defines a smart sustainable city as an urban space that leverages ICT tools to improve quality of life, increase resource efficiency, and strengthen competitiveness, while meeting the needs of present and future generations (ITU-T FG-SSC, 2014). The rise of artificial intelligence further reinforces this process, offering new opportunities to optimise energy, transport, and urban management systems, and to reduce emissions (Szpilko, 2023). In this interpretation, smart solutions are not autonomous development goals, but instruments supporting the climate-neutral transition.

This approach is reflected in the EU's "Climate-Neutral and Smart Cities" mission (Mission Cities), which, as a flagship implementation framework of the European Green Deal, treats cities as experimental testbeds for climate policy innovation. The objective is to achieve climate neutrality in at least one hundred European cities by 2030 through the creation of adaptable models (European Parliament, 2020; European Commission, 2021).

The aim of this study is to examine how and to what depth Budapest, Miskolc, and Pécs—cities that have joined the Mission Cities program—integrate climate-neutral and smart approaches into their development strategies, particularly within their Climate City Contract documents. The research investigates whether the smart city concept emerges as a technological narrative or as a comprehensive governance model, and how it aligns with Central European urban development patterns. To contextualise these in-depth domestic findings within a broader Central European framework, we also analyse the integration of climate neutrality and smart solutions into the urban development practices of five other participating cities in the region (Cluj-Napoca, Klagenfurt, Košice, Kranj, and Zagreb).

Therefore, the central question of this study is not whether climate-neutral and smart urban development is necessary, but rather under what organisational and governance conditions Hungarian

Mission Cities are capable of asserting these goals within their strategic documents and development practices. Accordingly, the research seeks to find answers to the following questions.

1. In what manner and to what depth do climate neutrality and smart city goals manifest in the strategic documents of the Hungarian Mission Cities, particularly within their Climate City Contracts?
2. Which institutional and governance factors facilitate or constrain the practical realisation of smart and climate neutrality objectives in the examined cities?
3. Does alignment with EU policy frameworks result in a structural urban transition or primarily in a strategic adaptation for the Hungarian Mission Cities?

The hypotheses related to the research questions examine the institutional and governance conditions underlying the relationship between smart tools and climate neutrality goals:

1. In the strategic documents of the Hungarian Mission Cities, smart solutions predominantly emerge as a technological development narrative, whereas their application as an integrated governance model remains limited.
2. The actual realisation of smart and climate neutrality goals depends primarily not on the level of technological advancement, but on local institutional capacities and the quality of urban governance collaborations.
3. Alignment with EU policy frameworks results in a strategic adaptation rather than a deep structural urban transition for the Hungarian Mission Cities.

These research questions and hypotheses provide the interpretive frame for the theoretical and empirical literature reviewed below, situating Hungarian and Central European smart city development within the broader post-socialist urban governance debate.

LITERATURE REVIEW

The foundation for interpreting Central and Eastern European urban development was laid by the works of György Konrád and Iván Szelényi, who described the socialist city as a product of state redistribution and political rationality (Konrád & Szelényi, 1971, 1989). According to Szelényi's subsequent analyses, the market transition following the regime change did not result in an automatic convergence; instead, in several cases, it reinforced new spatial and social inequalities (Szelényi, 1990, 1996). To this day, these interpretations provide a defining framework for examining post-socialist urban development trajectories, emphasising the model-following and adaptation challenges of our region—issues that are resurfacing today in relation to smart urban development.

Regarding domestic approaches to the local smart city discourse, several researchers have emphasised that the characteristics of the "smart city" as a political and institutional framework often emerge within public policy narratives. Furthermore, implementation typically depends directly on opportunities tied to government and EU funding, while local socio-economic factors, institutional capacities, and local resources may remain limited. Indeed, domestic analyses illustrate that regional

and local institutions frequently implement the institutionalised practices of digital transition and smart governance only partially or symbolically—which aligns with imported narratives while simultaneously reflecting the specific endowments of the given areas (for instance, in the context of Miskolc and the Hungarian–Slovak border region) (Csaba, 2016; Józsa & Kneisz, 2019; Gyimesi & Somlyódyné Pfeil, 2021).

In terms of domestic funding and implementation structures, the dominance of EU financing is clear. However, the capacity constraints of regional and local institutional systems, alongside the difficulties in practically executing city-centric narratives, significantly influence the effectiveness of developments and local growth (Póla et al., 2023; Halász, 2018; Csaba, 2016; Gyimesi & Somlyódyné Pfeil, 2021).

According to the literature emphasising the governance dimension of urban development, strategic planning is a multi-actor, institutionally embedded process in which decision-making is closely intertwined with the political and social context (Healey, 1997; Faludi, 2000). This perspective is also reflected in the European Union's urban policy, where integrated, sustainable, and participatory urban development has become a central element of cohesion policy (European Commission, 2016, 2020). However, Lange and Knieling (2020), as well as Ibănescu et al. (2020), point out that EU frameworks are often normative in nature, while the success of implementation depends heavily on local and member-state organisational capacities—a dynamic that is particularly relevant for initiatives targeting climate neutrality and smart urban development, such as the Mission Cities program.

A critical approach to the smart city concept was articulated by Hollands (2008), who argues that smart city discourse is frequently narrowed down to technological solutions, ignoring social and governance dimensions. In contrast, Batty et al. (2012) and Sallai (2018) interpret the smart city as an integrated, data-driven governance model. In the domestic context, Szalai (2020) argues that the smart city concept cannot be considered a universally applicable recipe and that its successful implementation requires strategic planning tailored to local geographical and social conditions. In our study, we seek to answer precisely this question: to what extent can European practice become "organic" and institutionalised within the domestic environment and in regional contexts that have followed a similar trajectory?

Numerous studies demonstrate that the application of information technologies can contribute to increasing the efficiency of urban resource management, reducing emissions, and improving the quality of services (Harrison & Donnelly, 2011), while the indicator systems developed to measure smart city performance also reflect this multidimensional approach (Giffinger et al., 2007). However, the successful application of smart city technologies cannot be separated from the presence of adequate digital skills and appropriate organisational resources. The Central and Eastern European region—including Hungary—can still be classified in several respects as part of the "digital periphery," which limits the widespread adaptation of data-driven solutions (Budai & Tózsa, 2020; Budai, 2022; Budai et al., 2023; Tóth & Nagy, 2023).

In Hungary, smart city development and climate-neutrality efforts are mainly linked to the EU's cohesion policy and the Sustainable Urban Development Strategies system. In the 2021–2027

programming period, the "Digital City" chapters formally ensure the integration of smart tools (Döbrente & Földi, 2021); however, their content and embeddedness in climate policy show significant variation across cities (Berkecz & Trócsányi, 2023).

In the Central and Eastern European context, the smart city approach often manifests at a normative-strategic level, while actual implementation remains highly differentiated, depending on access to funding and governmental capacity. For settlements located along the post-socialist urban development trajectory, dependence on EU funding and limited capacities result in fragmented, project-based adaptation (Ibănescu et al., 2020), and our investigation aligns with these findings. The territorial embeddedness of the circular economy is also emphasised by Mezei and Varjú (2019), who, in examining the transformation of domestic municipal waste management services, substantiate that development opportunities based on local resources are narrowed by centralisation processes and institutional capacity constraints. A similar conclusion is reached by Barr and Devine-Wright (2012), who argue that sustainable transitions can only be effective if technological, governance, and social dimensions develop in a coordinated manner.

Empirical research also shows that small and medium-sized towns—due to their limited resources and limited external exposure—are particularly vulnerable to global economic and environmental challenges, and their resilience cannot be measured solely by quantitative indicators (Pirisi et al., 2025). Despite this, within domestic urban development practice, there remains a scarcity of empirical analyses examining how resilience, the circular economy, and smart urban development actually manifest in strategic documents.

At the same time, public openness is perceptible. According to a 2022 questionnaire survey conducted in Budapest, the most critical concerns for urban residents are primarily environmental, particularly air pollution and the urban heat island effect. However, familiar smart city solutions are predominantly linked to public transport and possess limited environmental relevance, pointing to deficiencies in the social and environmental dimensions of the digital transition (Fekete, 2023).

The common lesson from the literature review is that smart and climate-neutral urban development cannot be interpreted merely as a technological intervention; rather, the success of urban transitions is determined by organisational embeddedness, governance capacities, and the quality of collaborations. Based on this, it is justified to examine whether the smart city approach yields real structural transformation in the case of the Hungarian Mission Cities, or whether it emerges rather as a strategic adaptation in service of climate-neutrality goals.

METHODS

The intertwining of climate change and urbanisation brings clearly perceptible challenges not only globally but also within our region. Even after the intensive deindustrialisation that took place in our region, our cities are still characterised by concentrated emissions; at the same time, due to their post-structural-realignment conditions, endowments, and size, they are the areas most exposed to the

impacts of climate change and remain indispensable for intervention. It is precisely this concentrated energy and resource consumption, along with the vulnerability of infrastructures, that justifies the prioritised examination of urban-level interventions. Our sample areas simultaneously provide excellent examples of the larger population concentrations in the EU's eastern region that have experienced intensive structural crises and transformations, and have been affected first by deindustrialisation and subsequently by reindustrialisation—spaces where socio-economic-institutional endowments presuppose a more innovative attitude and engagement.

The European Union's urban and climate policy framework—particularly the European Green Deal and the "Climate-Neutral and Smart Cities" mission—interprets cities as pivotal actors in the climate-neutral transition (European Parliament & Council of the European Union, 2021). In this approach, digital and smart solutions are not autonomous technological developments, but components of an integrated toolkit serving emission reduction, adaptive capacity, and the improvement of quality of life. However, both the literature and policy documents emphasise that the realisation of these goals depends heavily on local institutional capacities, governance structures, and the maturity of urban development practices.

Hungarian cities—especially university hubs—find themselves in a specific position: while they are active participants in the climate-neutral and digital transition stimulated by EU funding and policy frameworks, government and capacity constraints stemming from the post-socialist legacy significantly influence the actual integration of smart solutions into strategic documents and urban governance practices.

Building on the research questions and hypotheses outlined in the Introduction, the empirical approach, based on document analysis and semi-structured interviews, enables an assessment of the extent to which climate-neutral and smart urban development is being implemented in the Hungarian Mission Cities, as well as how it aligns with Central European urban development patterns.

The research is built on a qualitative, multi-source methodological approach aimed not at statistical generalisation, but at uncovering the institutional, governance, and strategic conditions under which climate-neutral and smart urban development is realised in the Hungarian Mission Cities. The investigation focuses on how smart solutions manifest within strategic documents and how they are interpreted and applied in the practice of urban management. The application of a qualitative approach is justified by the fact that the central questions of this research examine governance mechanisms, organisational capacities, and decision-making processes rather than technological performances.

The study focuses on the Hungarian cities participating in the Mission Cities program: Budapest, Miskolc, and Pécs. Through their participation in the EU's "Climate-Neutral and Smart Cities" program, these settlements can be interpreted within a comparable policy and methodological framework, making them suitable for examining the domestic adaptation of climate neutrality and smart aspirations. To allow for an interpretation embedded in a broader regional context, the analysis also incorporates the Mission Cities of neighbouring countries—Cluj-Napoca, Klagenfurt, Košice, Kranj, and Zagreb—based on the qualitative content analysis of their publicly available Climate City Contract (CCC) documents. A central element of the study's secondary research methods was the

qualitative content analysis of strategic documents. The analysis covered the following document types:

- Sustainable Urban Development Strategies (SUDS—FVS in Hungarian) and TOP Plus Urban Development Program Plans (TVP in Hungarian),
- Climate City Contract documents,
- Related EU policy frameworks, with particular regard to the Mission Cities initiative.

During the analysis, we examined how the documents address smart city solutions, climate-neutrality goals, resilience, and governance mechanisms, and the extent to which they form a coherent, executable, and institutionally grounded development framework. Rather than focusing on formal compliance, the document analysis emphasised strategic depth and internal coherence. We sought to nuance the insights gained from the document analysis through primary empirical investigations. Within this framework, a total of ten semi-structured expert interviews were conducted (N=10) between 2023 and 2025. The interview partners can be classified into three groups: city leaders (2 persons), senior municipal officials (5 persons), and development experts (3 persons). The thematic blocks of the interviews covered the following areas: the alignment of the Mission Cities strategy with urban development plans and the reality of climate commitments; the governance model and political commitment; the funding structure and preferred fields of intervention; and forms of public participation alongside the long-term institutional embedding of Net Zero targets. The coding categories applied during the content analysis were organised around four thematic axes: technological solutions and digitalisation; funding models and risks; public participation and governance innovation; and institutional capacities and professional staff shortages. In some instances, the interviews were supplemented with contextualising consultations to gain a more precise understanding of the socio-spatial dimensions of the issue. The interviews, conducted between 2023 and 2025, aimed to uncover how smart and climate neutrality goals manifest in the everyday practice of urban management and planning, and what institutional, political, and resource-related factors influence their feasibility. Although the interviews do not cover the entire urban network under investigation, in several cases, they enabled a qualitative interpretation of the patterns identified during the document analysis, as well as the uncovering of discrepancies between strategic intentions and actual implementation. Given the limited sample size of the primary data, our primary aim was to identify qualitative patterns rather than to achieve statistical generalisation. The empirical data collection took place between 2021 and 2025, aligning with the strategy-making processes of the 2021–2027 EU programming period. Spatially, the study focused primarily on the urban regions of Hungary, complemented by a comparative interpretation of Central European Mission Cities. It was a deliberate methodological choice that the analysis did not strive for a comprehensive international comparison, but rather prioritized an interpretation embedded within the regional context.

The qualitative nature of the research limits the statistical generalisability of the findings; however, our primary objective was to explore the institutional and governance conditions under which climate-neutral and smart urban development can become operational in Hungarian cities. Methodological limitations were addressed through the combination of document analysis and semi-structured

interviews, as well as by applying multi-stakeholder perspectives. This reflexive approach allowed for a critical examination of climate-neutral and smart urban development narratives, with particular regard to the gaps between strategic goals and actual practice.

RESULTS

The climate neutrality and smart city aspirations of the cities participating in the Hungarian Mission Cities program can only be meaningfully interpreted within a regional comparison. Accordingly, we have also included the Mission Cities of neighboring countries in our analysis, relying on the qualitative content analysis of their publicly available Climate City Contract (CCC) documents.

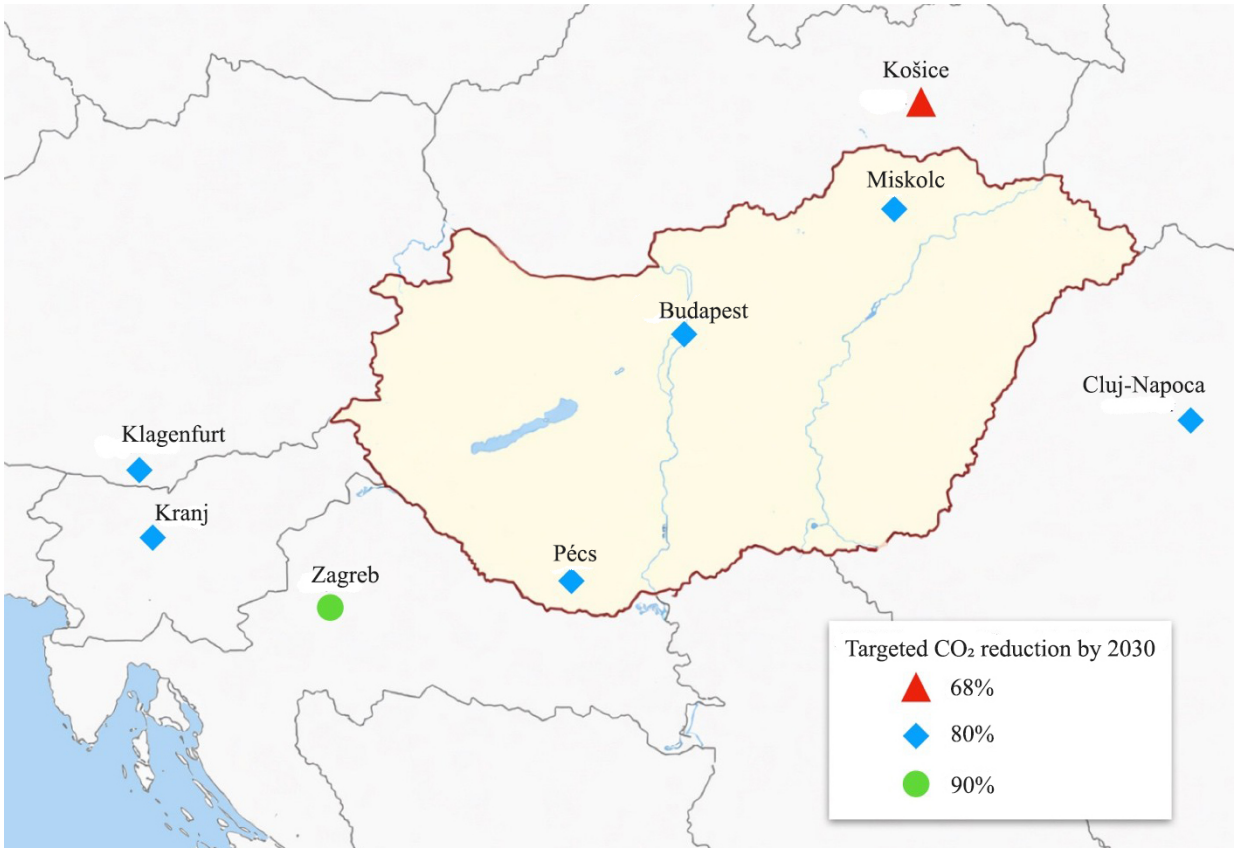
Emission Structures and Targets

Based on the analysed CCCs, the greenhouse gas (GHG) emission structures of the examined cities display a marked sectoral convergence. Emissions tied to the building stock –particularly heating and cooling—typically account for 40–55% of total emissions, while the share of the transport sector generally ranges between 20–40%. The cases of Košice and Cluj-Napoca deviate from this pattern, as the proportion of transport is lower, while industrial and energy consumption structures carry greater weight (Mesto Košice, 2023; Primăriei Municipiului Cluj-Napoca, 2023). This structure dictates the priorities of interventions: all cities identify the deep renovation of the building stock, the decarbonisation of district heating systems, and the restructuring of transport systems as the primary instruments of transition (Budapest Főváros Önkormányzata, 2023; Miskolc MJV Önkormányzat, 2023; Pécs MJV Önkormányzat, 2023; Mestna Občina Kranj, 2023; Landeshauptstadt Klagenfurt am Wörthersee, 2023).

At the same time, the ambition level of commitments for 2030 shows significant variations. Budapest, Miskolc, Pécs, Kranj, Klagenfurt, and Cluj-Napoca envisage an 80–100% emission reduction (Budapest Főváros Önkormányzata, 2023; Miskolc MJV Önkormányzat, 2023; Pécs MJV Önkormányzat, 2023; Mestna Občina Kranj, 2023; Landeshauptstadt Klagenfurt am Wörthersee, 2023; Primăriei Municipiului Cluj-Napoca, 2023), whereas Košice considers a maximum reduction of 68% realistically achievable through current measures (Mesto Košice, 2023). Zagreb targets a nearly 90% reduction in territorial emissions by 2030 through the targeted management of residual emissions (Grad Zagreb, 2023).

However, the expert interviews nuance the overall picture in Hungary. One of the interviewed experts indicated that a significant gap exists between the committed targets and the realities of domestic implementation: given the financial and organisational capacities of Hungarian municipalities and the current level of public readiness, the 2030 deadline can hardly be considered realistic.

Figure 1. Committed CO_2 Reduction Targets by 2030 Among Participating Mission Cities



Source: authors' own compilation

This finding resonates with the phenomenon of "strategic adaptation" widely identified in the literature: due to their limited local resources and heavy dependence on EU funding, Central and Eastern European cities typically align their documents with EU expectations without the institutional and financial conditions necessary for implementation actually being in place (Ibănescu et al., 2020; Lange & Knieling, 2020). In the Hungarian case, this is further exacerbated by the "digital periphery" status: the lack of necessary digital competencies and organisational capacities at both the municipal and societal levels emerges as a structural constraint (Budai & Tózsa, 2020; Tóth & Nagy, 2023).

Spatially, this duality is most conspicuous in the cases of Miskolc and Pécs: both cities have committed to ambitious reduction targets, while standalone smart city developments do not appear as reinforced items on the TVP project lists of either municipality.

Technological Trajectories and Smart City Tools

Smart solutions are primarily linked to energy and mobility systems: an expanding photovoltaic capacity is a common element across all examined cities, but marked regional specialisations also emerge. Hungarian cities are chiefly building on biomass-based district heating and energy community models for decarbonisation (Miskolc MJV Önkormányzat, 2023; Pécs MJV Önkormányzat, 2023;

Budapest Főváros Önkormányzata, 2023). Geothermal energy plays a defining role for Košice, Miskolc, and Zagreb (Mesto Košice, 2023; Miskolc MJV Önkormányzat, 2023; Grad Zagreb, 2023), whereas Cluj-Napoca emphasises the utilisation of biogas and sewage gas, alongside digital twin solutions (Primăriei Municipiului Cluj-Napoca, 2023).

In the transport sector, the electrification of public transport fleets, the promotion of active mobility modes, and the adaptation of the "15-minute city" concept all manifest (Budapest Főváros Önkormányzata, 2023; Mestna Občina Kranj, 2023; Grad Zagreb, 2023). However, in several cities, these appear as project-level solutions rather than components of an integrated, data-driven urban management system.

During a discussion with a city leader from Kranj, it was noted that in Slovenia, the smart meter rollout on the electricity grid is practically complete, and the system can identify consumption anomalies, which meaningfully supports consumption optimisation even outside the Mission Cities program. In contrast, experts working with Hungarian cities complained that when planning specific investments intended to optimise consumption, human resource shortages and the obsolescence of infrastructure systems present a severe disadvantage.

> When we talk about digital metering in certain public institutions, they just stare at you, because Uncle Pista goes over, reads the electricity meter, and calls it in to the municipality, where in a best-case scenario it is entered into Excel, and in a worse case, onto squared paper; [meaning] we are starting from a point at these municipalities where there is no suitable professional, so if they were to build the new system, they wouldn't be able to manage its operation (smart city development expert, personal communication, November 18, 2025).

This quotation well illustrates the structural gap that lies between the digital infrastructural maturity presupposed by the Mission Cities program and the reality of Hungarian municipalities. Data-driven decision support and real-time monitoring, which are considered prerequisites for the success of smart city developments, require not only technological investment but also an organisational culture and human resources that are currently available only to a limited extent in the examined cities.

This finding is closely linked to the "digital periphery" approach: Hungary—and particularly its smaller towns and cities—lags consistently behind the Western European average in terms of digital readiness, which structurally hampers the widespread adaptation of data-driven solutions (Budai & Tózsa, 2020; Tóth & Nagy, 2023). The phenomenon identified by Szalai (2020)—namely, that the domestic implementation of the smart city concept requires strategically oriented planning tailored to local geographical-social conditions—is especially applicable to cases where neither the basic infrastructure nor the organisational capacity is in place.

Spatially, the contrast is most vivid between the cases in Kranj and Hungary: while in Slovenia the smart meter network already functions as an operational system for consumption optimisation, in Hungarian cities even this baseline level is not met, pointing to an increasing regional divergence between technological development trajectories.

Governance Innovations and Institutional Patterns

Based on the comparison of governance structures, one of the most significant added values of the Mission Cities program is the emergence of new types of multi-stakeholder governance models. In the cases of Kranj, Cluj-Napoca, and Budapest, the CCCs establish clear organisational frameworks, dedicated "mission team" or "transition team" structures, alongside regular monitoring and feedback mechanisms (Mestna Občina Kranj, 2023; Primăriei Municipiului Cluj-Napoca, 2023; Budapest Főváros Önkormányzata, 2023).

In contrast, for Miskolc and Pécs, governance solutions bear a more consultative and project-based character, depending more heavily on state and EU funding cycles (Miskolc MJV Önkormányzat, 2023; Pécs MJV Önkormányzat, 2023). This is reinforced by the fact that on the final UDPP/TVP project list for the 2021–2027 programming period, standalone smart city projects do not feature for either city, with Pécs appearing only on the reserve list. Based on the semi-structured interviews and contextualising discussions conducted with the city leadership of Pécs and Miskolc, the emerging picture indicates that they intend to rely on direct EU funds linked to the Mission Cities framework when implementing smart city developments, rather than on the broader-use FVS/SUDS & UDPP/TVP funding streams.

The spectrum of public participation associated with the Mission Cities programs is broad: Budapest and Kranj approach the higher rungs of Arnstein's ladder of participation (Arnstein, 1969), whereas several cities—including Miskolc and Pécs—rely primarily on informative and consultative tools (Miskolc MJV Önkormányzat, 2023; Pécs MJV Önkormányzat, 2023).

The expert interviews reveal that creating and operating dedicated "mission team" structures is not merely a question of funding: success depends heavily on the personal commitment and strategic vision of city leaders, as well as the attitude of the expert teams surrounding them. Where smart city and climate-neutrality goals emerge as genuine priorities in the city leadership's mindset, organisational frameworks are built meaningfully; where this is absent, Mission Cities participation becomes more of a formal compliance exercise.

This finding echoes Healey's (1997) collaborative planning approach, according to which strategic decision-making can only be successful if it is underpinned by genuine inter-institutional cooperation and sustained organisational commitment—rather than coordination tied solely to project cycles. Lange and Knieling (2020) reach a similar conclusion in their study of EU smart city initiatives: the tension between the normative expectations of EU frameworks and local organisational reality often culminates in cities formally complying with program requirements, while the actual institutionalisation of governance innovation fails to materialise. In the case of the Hungarian Mission Cities, this is further reinforced by the limited depth of participatory mechanisms: based on Arnstein's ladder of participation (1969), the majority of the examined cities—Miskolc and Pécs—operate mostly at the levels of information and consultation, while meaningful citizen engagement and co-decision-making appear only exceptionally.

Spatially, this difference is sharpest when comparing Kranj with the Hungarian cities: the Slovenian CCC provides not only organisational frameworks but also concrete feedback and monitoring mechanisms, whereas in Miskolc and Pécs governance innovation remains largely at a declarative level.

Funding Models and Risks

An analysis of the funding structures indicates that Central European Mission Cities—particularly the Hungarian cases—depend heavily on EU cohesion and structural funds, as well as instruments from the EIB and the EBRD; these are supplemented by local budgetary contributions and ad hoc PPP solutions. At the same time, the CCCs clearly point out that financial dependency, energy poverty, and limited institutional capacities present structural risks to the ambitious decarbonisation trajectories committed to for 2030. In this context, the Just Transition Fund, energy communities, and socially targeted renovation programs emerge not as supplementary, but as crucial stabilising factors.

During the expert interviews, it was repeatedly mentioned that operational and maintenance obligations beyond the project sustainability period, coupled with the instability of municipal financing, significantly influence Hungarian decision-makers when considering innovative, long-term, return-on-investment smart city development projects; respondents cited concrete examples from both Budapest and Pécs. These same interviews also highlighted that smart technological investments outside of EU support that require local budgetary funds—especially geographic information systems (GIS), traffic management systems, and other high-capital-cost systems—frequently fail to secure decision-maker backing due to fiscal considerations.

> Without EU development funds, municipalities have resources for little more than putting out fires; if a tree falls or the roof of an institution caves in, they have to fix it, but otherwise, they do not possess the resources to implement innovations or developments (expert involved in the planning of smart city tools for several Hungarian cities, personal communication, August 28, 2025).

The semi-structured and contextualizing interviews conducted with city leaders and experts indicate that the volatility of the regulatory and funding environment within the Hungarian municipal system—particularly the shifting division of powers and resources between central and local levels—emerges as a key uncertainty factor in planning long-term strategic investments, which may indirectly affect the predictability of implementing Mission Cities programs.

Taken together, the above interview excerpts suggest that the funding logic of Hungarian municipalities is fundamentally reactive and short-term: available resources are primarily tied up by immediate operation and maintenance obligations, while smart city developments—which offer long-term returns but require high upfront investment—are systematically crowded out from decision-making priorities. This mechanism is not a uniquely Hungarian phenomenon, but rather

a structural characteristic identifiable across a wide range of Central and Eastern European cities: heavy dependence on EU funds coupled with a narrow local fiscal headroom collectively result in urban development capacity aligning predominantly with the rhythm of funding cycles rather than long-term strategic plans (Ibănescu et al., 2020).

Lange and Knieling's (2020) Hamburg case study links this phenomenon to the normative logic of EU smart city funding: EU frameworks favour project-level interventions, which structurally hampers the implementation of integrated, system-level developments. In the case of the Hungarian Mission Cities, this effect is amplified because the regulatory and financial uncertainty of the local government system—especially the variability in the division of powers and resources between central and local levels—presents an additional factor of unpredictability in planning long-term investments.

Spatially, the cases of Budapest and Pécs are the most illustrative: in both cities, experts provided concrete examples demonstrating that decision-maker support for innovative smart city developments is typically withheld when the involvement of municipal own-source revenue becomes unavoidable—whereas the willingness to decide is significantly higher for projects funded exclusively through EU resources.

At the same time, the analysis of financial and institutional constraints draws attention to the fact that the conditions for implementing the Mission Cities program are not shaped solely at the urban level. The development headroom of local governments is significantly influenced by the national regulatory and financial environment, particularly the system of resource allocation, the trajectory of local revenues, and the structure of municipal tasks and competences. Consequently, the feasibility of climate neutrality and smart urban development goals depends not only on local strategic intentions and capacities, but also on the extent to which the national-level institutional environment supports long-term, innovative urban investments.

Generalisable Results

Based on the comparative analysis, it can be concluded that the climate neutrality and smart city commitments of the examined Hungarian Mission Cities formally align with the frameworks of the European Union's Mission Cities program (European Commission, 2021; NetZeroCities, 2023). The target systems and technological trajectories outlined in the documents are consistent with the general decarbonisation and digitalisation paths of Central European cities.

However, in the examined cases, the smart city approach manifests primarily as project-based development packages rather than as part of an integrated, data-driven governance model. The gaps between strategic ambitions and implementation feasibility become visible, particularly in the areas of energy and transport transition, as well as urban data management.

The results suggest that the success of climate neutrality aspirations is closely linked to funding diversity, organisational capacities, and the institutionalisation of participatory mechanisms. Together, these factors determine the extent to which commitments can transcend mere strategic declarations.

Consequently, distinct "transition configurations" emerge among Central European Mission Cities, differing not only in their level of ambition but also in their specific combination of technological trajectories, governance innovations, and funding models. In cases like Kranj and Cluj-Napoca, an integrated approach built on smart metering systems, digital platforms, and dedicated mission teams is more strongly pronounced. Conversely, in Hungarian cities, climate neutrality and smart goals are pursued in a more fragmented, project-like manner, accompanied by a heavy dependence on EU funding. This duality indicates that, despite the uniform framework of the Mission Cities program, the depth of actual urban transitions is fundamentally determined by local institutional embeddedness and the specific characteristics of the national municipal system.

At the same time, funding and human resource conditions markedly narrow the scope of feasible transition pathways. In the case of the Hungarian Mission Cities, heavy dependence on EU funds, the tightness of municipal budgets, project sustainability risks, and the lack of professional staff required to operate digital systems collectively contribute to smart solutions often appearing as island-like, short-term investments. All of this indicates that achieving the goals committed to in the Mission Cities program depends heavily on a long-term, stable financial foundation and the strengthening of local professional capacities.

It is also worth evaluating the position of the examined cities over a longer time horizon. In the smart city ranking compiled nearly two decades ago by Giffinger et al. (2007), which encompassed 70 European medium-sized cities, those current Mission Cities participants that were included in the ranking—Pécs (65th), Miskolc (67th), Košice (54th), and Zagreb (35th)—presented a mixed picture. The Hungarian cities featured particularly weak Smart Governance and Smart Environment values, while Košice and Zagreb occupied somewhat more favourable positions in these dimensions. This baseline is relevant in two respects: first, it indicates that the structural lagging of the examined cities is not a recent phenomenon, and the Mission Cities program represents an attempt to catch up from a long-term disadvantageous position; second—and this is the most critical conclusion of this study—the dimensions that performed weakest in the ranking nearly twenty years ago (governance, environment) are precisely those where the CCC documents reveal the most structural deficiencies today. This suggests that the Mission Cities program, on its own, without appropriate institutional and financial conditions, is incapable of inducing a rapid paradigm shift in cities where governance and environmental capacities have decades-long backlogs and remain structurally unchanged.

This long-term lag is also reflected in the interviews. The overall picture from the expert interviews—conducted throughout 2024–2025—testifies to a restrained optimism and, in several cases, pronounced scepticism. The majority of respondents, including those who personally witnessed the advancement of Western European cities at international Mission Cities forums (such as the NetZeroCities conference in Vilnius, 2025), explicitly stated that the fiscal and operational headroom of Hungarian municipalities has narrowed continuously in recent years. Resource withdrawals, including the deduction of solidarity tax, the centralisation of competences, and the erosion of local budgetary autonomy, have created a structural environment in which the financial backing for the

2030 climate-neutrality goals remains unmapped. According to the experts, the adaptation of best practices successfully applied in other member states is hampered not only by technological or capacity gaps, but also by the fact that municipalities in those cases possess substantially greater financial and decision-making autonomy—a difference that is a generally identifiable structural characteristic of cities in the CEE region (Ibănescu et al., 2020; Lange & Knieling, 2020).

This context does not merely nuance the performance of Hungarian Mission Cities, but also highlights that the effectiveness of the frameworks offered by the program is not solely an urban-level issue: the operational conditions of the national municipal system fundamentally determine the extent to which a climate-neutral and smart urban transition can remain a strategic declaration or become a genuine structural change (Józsa & Kneisz, 2019; Szalai, 2020). For Hungarian cities situated along a post-socialist urban development trajectory, this structure of dependency is not new: Szelényi (1996) and Konrád & Szelényi (1971) already described the mechanism regarding socialist cities in which local development capacity is rooted in dependency on state redistribution—a mechanism that was not fully dissolved even throughout the past more than 35 years.

All of this implies that for the Mission Cities program to become a genuine catalyst, it would require not only urban-level strategic commitment but also the structural renewal of the national municipal system.

CONCLUSIONS

The aim of this study was to examine the organisational and governance conditions under which Hungarian Mission Cities can integrate climate neutrality and smart urban development goals into their strategic documents and development practices. Based on the empirical analysis, the impact of the Mission Cities program is currently perceptible primarily at the levels of strategic planning and discursive positioning. At the same time, it is important to emphasise that due to methodological limitations (qualitative approach, limited sample size, and incomplete interview coverage), the results serve analytical rather than statistical generalisation.

The first hypothesis, suggesting that smart solutions manifest primarily as technological development narratives and are only fragmentarily integrated into an institutionalised, data-driven urban management system, was fully confirmed. The second hypothesis was also supported: the fulfilment of climate neutrality commitments depends crucially on local organisational capacities, collaborative structures, and financial stability. The third hypothesis was partially supported, as alignment with EU frameworks can currently be captured as a strategic adaptation rather than a structural urban transition. The reason for this partial support is that elements of a structural transition are already observable in certain cities (particularly in the cases of Kranj and Cluj-Napoca).

Overall, the findings imply that in the Central European context, climate-neutral and smart urban development is not primarily a question of technological innovation, but rather a process of governance and institutional learning. The technological toolkit alone does not guarantee the success of the

transition; what remains decisive is the creation of flexible management frameworks, a long-term, predictable funding environment, and the targeted strengthening of local professional capacities. The Mission Cities program establishes a policy framework capable of stimulating a climate-neutral, smart transition, but its depth and durability depend fundamentally on local institutional embeddedness and the specific characteristics of the national municipal system.

All of this further underscores that the frameworks offered by the Mission Cities program can only lead to a deeper urban transition if the national-level municipal financing and capacity policy environment supports long-term, experimental developments. The institutional embedding of climate neutrality and smart goals cannot, therefore, be interpreted solely as an urban-level governance issue, but is intrinsically linked to national public policy conditions, particularly in the areas of local fiscal stability, professional staff replenishment, and digital competency development.

A task for future research is to explore under what conditions the current patterns of strategic adaptation can give rise to a deeper, more conscious urban institutional transformation. In addition to all this, efforts must be made to assist municipalities interested in smart city development not merely with technological solutions, but also through organisational development proposals and capacity-building programs that further enable them to adapt these innovative processes even more effectively.

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Author contributions
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All data supporting the findings of this study are included in the article and its supplementary materials.

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Not applicable: this study did not involve human participants, animal experiments, or sensitive personal data requiring ethical approval.

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REFERENCES

Arnstein, S. R. (1969). A ladder of citizen participation. *Journal of the American Institute of Planners*, *35*(4), 216–224. https://doi.org/10.1080/01944366908977225

Barr, S., & Devine-Wright, P. (2012). Resilient communities: Sustainabilities in transition. *Local Environment*, *17*(5), 525–532. https://doi.org/10.1080/13549839.2012.676637

Batty, M., Axhausen, K. W., Giannotti, F., Pozdnoukhov, A., Bazzani, A., Wachowicz, M., Ouzounis, G., & Portugali, Y. (2012). Smart cities of the future. *European Physical Journal: Special Topics*, *214*(1), 481–518. https://doi.org/10.1140/epjst/e2012-01703-3

Berkecz, B., & Trócsányi, A. (2023). A smart city eszközökhöz való viszony három hazai kisvárosban a fenntartható városfejlesztési stratégiák vizsgálata alapján [Attitudes towards smart city tools in three Hungarian small towns based on the analysis of sustainable urban development strategies]. *CITY.HU Várostudományi Szemle*, *3*(1), 95–118.

Budai, B. B. (2022). The growing role of digital literacy. *Pro Publico Bono—Hungarian Public Administration*, *10*(2), 30–59. https://doi.org/10.32575/ppb.2022.2.2

Budai, B. B., Csuhai, S., & Tózsa, I. (2023). Digital competence development in public administration higher education. *Sustainability*, *15*(16), 12462. https://doi.org/10.3390/su151612462

Budai, B. B., & Tózsa, I. (2020). Regional inequalities in front office services—Focus shift in the e-government front office and its regional projections in Hungary. *Regional Statistics*, *10*(2), 206–227. https://doi.org/10.15196/RS100212

Budapest Főváros Önkormányzata. (2023). *Climate City Contract—Budapest. Mission 100 Climate-Neutral and Smart Cities by 2030.* Európai Bizottság.

Csaba, D. (2016). Egy okos Pécs felé [Towards a smart Pécs]. *Információs Társadalom*, *16*(3), 23–82. https://doi.org/10.22503/inftars.XVI.2016.3.2

Döbrente, K., & Földi, Zs. (2021). *A Fenntartható Városfejlesztési Stratégiák kézikönyve 2021–27* [Handbook of Sustainable Urban Development Strategies, 2021–27]. Pénzügyminisztérium.

European Commission. (2016). Urban Agenda for the EU. Publications Office of the European Union.

European Commission. (2020). Smart cities and communities. Author.

European Commission. (2021). Climate-neutral and smart cities mission. Publications Office of the European Union.

European Commission. (2023). Living-in.EU: Digital twins for cities. Publications Office of the European Union.

European Parliament. (2020). European Green Deal: Towards a climate-neutral and sustainable EU. https://www.europarl.europa.eu/news/en/headlines/society/20200618STO81513/european-green-deal-towards-a-climate-neutral-and-sustainable-eu

European Parliament & Council of the European Union. (2021). Regulation (EU) 2021/1119 establishing the framework for achieving climate neutrality.

Faludi, A. (2000). The performance of spatial planning. *Planning Practice & Research*, *15*(4), 299–318. https://doi.org/10.1080/713691907

Fekete, K. A. (2023). Budapest residents' views on smart city developments as revealed by a questionnaire survey. *Modern Geográfia*, *18*(2), 17–33. https://doi.org/10.15170/MG.2023.18.02.02

Giffinger, R., Fertner, C., Kramar, H., Kalasek, R., Pichler-Milanovic, N., & Meijers, E. (2007). Smart cities: Ranking of European medium-sized cities. Vienna University of Technology. https://www.smart-cities.eu/download/smart_cities_final_report.pdf

Grad Zagreb. (2023). Climate City Contract—Zagreb. Mission 100 Climate-Neutral and Smart Cities by 2030, Európai Bizottság.

Gyimesi, Á., & Somlyódyné Pfeil, E. (2021). Az adat és a kormányzás jelentősége az okos város stratégiai alapú értékteremtési folyamatában—Magyar nagyvárosok összehasonlítása egy szintetizáló ökoszisztéma modell keretében [The significance of data and governance in the strategy-based value-creation process of the smart city—A comparison of Hungarian large cities within a synthesising ecosystem model framework]. *Tér és Társadalom*, *35*(3), 59–86. https://doi.org/10.17649/tet.35.3.3339

Halász, L. (2018). *Városfejlődési pályák és válságkezelési alternatívák. Miskolc, Ózd és Kazincbarcika rendszerváltozás utáni társadalmi, gazdasági és térszerkezeti átalakulása* [Urban development trajectories and crisis-management alternatives: The post-transition social, economic, and spatial transformation of Miskolc, Ózd, and Kazincbarcika]. https://doi.org/10.15476/elte.2018.246

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). Retrieved from https://journals.isss.org/index.php/proceedings55th/article/view/1703

Healey, P. (1997). Systemic institutional design for collaborative planning. In P. Healey, *Collaborative planning. Planning environment cities*. Palgrave, London. https://doi.org/10.1007/978-1-349-25538-2_9

Hollands, R. G. (2008). Will the real smart city please stand up? *City*, *12*(3), 303–320. https://doi.org/10.1080/13604810802479126

Ibănescu, B.-C., Bănică, A., Eva, M., & Cehan, A. (2020). The puzzling concept of smart city in Central and Eastern Europe: A literature review designed for policy development. *Transylvanian Review of Administrative Sciences*, *61*(E), 70–87. https://doi.org/10.24193/tras.61E.4

Intergovernmental Panel on Climate Change. (2023). Climate change 2023: Synthesis report. IPCC.

ITU-T Focus Group on Smart Sustainable Cities. (2014). *Smart sustainable cities: An analysis of definitions* (Technical Report). International Telecommunication Union. https://www.itu.int/en/ITU-T/focusgroups/ssc/Documents/Approved_Deliverables/TR-Definitions.docx

Józsa, V., & Kneisz, I. (2019). Okos valóság Magyarországon? Okos programok megvalósításának esélyei Miskolcon és a magyar–szlovák határ menti térségben [Smart reality in Hungary? The prospects for implementing smart programmes in Miskolc and the Hungarian–Slovak border region]. *Tér és Társadalom*, *33*(1), 66–82. https://doi.org/10.17649/tet.33.1.3099

Konrád, Gy., & Szelényi, I. (1971). A késleltetett városfejlődés társadalmi konfliktusai [The social conflicts of delayed urban development]. *Valóság*, *14*(12), 19–35.

Konrád, Gy., & Szelényi, I. (1989). *Az értelmiség útja az osztályhatalomhoz* [The Intellectuals on the Road to Class Power]. Gondolat.

Landeshauptstadt Klagenfurt am Wörthersee. (2023). *Climate City Contract—Klagenfurt. Mission 100 Climate-Neutral and Smart Cities by 2030*. Európai Bizottság.

Lange, K., & Knieling, J. (2020). EU smart city lighthouse projects between top-down strategies and local legitimation: The case of Hamburg. *Urban Planning*, *5*(1), 107–115. https://doi.org/10.17645/up.v5i1.2531

Mestna Občina Kranj. (2023). *Climate City Contract—Kranj. Mission 100 Climate-Neutral and Smart Cities by 2030*. Európai Bizottság.

Mesto Košice. (2023). *Climate City Contract—Košice. Mission 100 Climate-Neutral and Smart Cities by 2030.* Európai Bizottság.

Mezei, Cs., & Varjú, V. (2019). A helyi erőforrásokon alapuló helyi fejlesztés lehetőségei az átalakuló hazai hulladékgazdálkodási közszolgáltatásban [The possibilities of resource-based local development in Hungary's transforming municipal waste-management public service]. *Tér és Társadalom*, *33*(2), 41–61. https://doi.org/10.17649/TET.33.2.3089

Miskolc MJV Önkormányzat. (2023). Climate City Contract—Miskolc. Mission 100 Climate-Neutral and Smart Cities by 2030, Európai Bizottság.

NetZeroCities. (2023). Pathways to climate neutrality. European Commission.

Nick, G., Pongrácz, F., & Radács, E. (2018). Interpretation of disruptive innovation in the era of smart cities of the fourth industrial revolution. *Deturope*, *10*(1), 53–70.

Orłowski, A., & Szczerbicki, E. (2019). Smart blue cities. *EUROPA XXI*, *36*, 77–88. http://doi.org/10.7163/Eu21.2019.36.7

Pécs MJV Önkormányzat. (2023). Climate City Contract—Pécs. Mission 100 Climate-Neutral and Smart Cities by 2030, Európai Bizottság.

Pirisi, G., Berkecz, B., Enkhtamir, N., Merza, P., Trócsányi, A., & Máté, É. (2025). The Central-European small town: interpretations, challenges and resilience in Hungary. *Journal for Geography*, *20*(2), 51–72. https://doi.org/10.18690/rg.20.2.5201

Póla, P., Pálné Kovács, I., & Gibárti, S. (2023). Pécs, egy periféria centruma [Pécs, the centre of a periphery]. *Tér és Társadalom*, *37*(3), 148–175. https://doi.org/10.17649/tet.37.3.3493

Primăriei Municipiului Cluj-Napoca. (2023). *Climate City Contract—Cluj-Napoca. Mission 100 Climate-Neutral and Smart Cities by 2030*. Európai Bizottság.

Sallai, G. (2018). Az okos város koncepciója [The concept of the smart city]. In G. Sallai (Szerk.), *Az okos város (Smart City)* (pp. 13–34). Dialóg Campus Kiadó.

Szalai, Á. (2020). Az okosváros-koncepció kritikai földrajzi vizsgálata—elméleti háttér és lehetséges kutatási irányok [A critical geographical analysis of the smart-city concept—Theoretical background and potential research directions]. *Tér és Társadalom*, *34*(2), 88–107. https://doi.org/10.17649/TET.34.2.3201

Szelényi, I. (1990). *Városi társadalmi egyenlőtlenségek. Tanulmányok* [Urban social inequalities: Studies]. Akadémiai Kiadó.

Szelényi, I. (1996). Cities under socialism—and after. In G. Andrusz, M. Harloe, & I. Szelenyi (Eds.), *Cities after socialism* (pp. 286–317). Blackwell. https://doi.org/10.1002/9780470712733.ch10

Szpilko, D., Naharro, F. J., Lăzăroiu, G., Nica, E., & Gallegos, A. D. L. T. (2023). Artificial intelligence in the smart city: A literature review. *Engineering Management in Production and Services*, *15*(4), 53–75. https://doi.org/10.2478/emj-2023-0028

Tóth, B., & Nagy, Gy. (2023). Digital skill-based centre-periphery differences in Europe. *Regional Statistics*, *13*(4), 583–616. https://doi.org/10.15196/RS130401

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