

STRATEGIC CONNECTIVITY FOR SMART CITY POLICY: A THEORETICAL EXTENSION OF GIFFINGER'S MODEL

Krzysztof RACZAK^{1*}, Krzysztof CELUCH²

¹ Doctoral Seminar in the Discipline of Management and Quality Studies, Vistula University, Warsaw;
krzysztof.raczak@gmail.com, ORCID: 0009-0000-6460-0249

² Faculty of Economic Sciences and Management, Nicolaus Copernicus University in Toruń, Toruń;
kceluch@umk.pl, ORCID: 0000-0002-5307-2900

* Correspondence author

Purpose: This paper extends Giffinger's Smart City model by integrating strategic connectivity to explain how cross dimensional interactions support coherent strategy formulation and policy coordination in urban management systems.

Design/methodology/approach: The study employs a qualitative, critical literature review of sources on smart cities and connectivity, supported by secondary data and illustrative case examples to contextualise the conceptual extension of Giffinger's model.

Findings: The analysis shows that connectivity acts as a transversal, integrative layer in smart cities, enabling coordination and interoperability across technological, organisational, and social subsystems within all six dimensions of Giffinger's model. When implemented in a fragmented or purely technical way, without coherent governance and stakeholder integration, connectivity limits the effectiveness, sustainability, and participatory quality of smart city development.

Research limitations/implications: This study is limited by reliance on secondary sources, highlighting the need for future research using primary data and comparative empirical analysis.

Practical implications: The findings suggest that policymakers should move from fragmented, technology-centered initiatives toward integrated connectivity strategies embedded in governance frameworks to improve service efficiency, stakeholder coordination, and the overall performance of smart city development.

Social implications: The findings indicate that treating connectivity as an integrative and socially embedded dimension of smart city development can enhance citizen participation, reduce digital exclusion, and improve quality of life by enabling inclusive, transparent, and responsive urban governance and services.

Originality/value: This paper's originality lies in conceptualising connectivity not merely as technical infrastructure but as a transversal, integrative dimension that extends Giffinger's smart city model by explicitly linking technological, organisational, and social systems, offering value to scholars and urban policymakers concerned with coherent and human centred smart city governance.

Keywords: Connectivity, Smart City, Giffinger's Model, Strategic Management.

Category of the paper: Research paper.

1. Introduction

A city belongs to the group of public sector organisations and is oriented towards the provision of public goods and services. Consequently, it requires an efficient system of governance, both in functional and institutional terms (Stawasz, 2016). It is also increasingly emphasised that cities rely to a growing extent on advanced institutional capacities, democratic governance, and effective management. These capabilities are required to address increasingly complex and interrelated economic, social, and environmental challenges, while simultaneously benefiting from new technological opportunities (LSE). A defining characteristic of contemporary strategic planning in urban contexts is its evolution into an integrative and context-sensitive approach that coordinates land use, infrastructure, governance, and environmental objectives through collaborative and adaptive frameworks supporting urban sustainability, resilience, and social equity (Balsas, Piracha, 2025). Smart city governance constitutes an institutional framework through which public administration, empowered by digital technologies, coordinates regulatory, participatory, collaborative, and decision support functions to deliver public value, enhance transparency and accountability, mitigate technological risks, and steer sustainable urban development within complex socio-technical environments (Pereira et al., 2026). Contemporary smart city governance constitutes one of the most complex areas of reflection on urban development, requiring the integration of technology, communities, and institutional structures into a single, coherent system of action (Firszt, Jabłoński, 2023).

2. The city in the context of smart development

The discussion begins with a clarification of the concept of the city, followed by a brief outline of the historical evolution of European cities. The term ‘city’, derived from the notion of a place, is defined as “a large, densely and deliberately built-up area” (PWN). A city is a product of civilisation and represents a specific form of population concentration within a defined space, shaped by the historical process of the deepening social division of labour (Ginsbert-Gebert, 1984). Since the earliest stages of civilisational development, cities have served as sites of accumulation of socio-economic activities and phenomena, enabling the satisfaction of both existential and social needs of urban communities (Stawasz, 2016). Depending on their size, cities have assumed leadership roles either at the regional level, in the case of large cities, or at the local level, in the case of smaller urban centres.

The earliest cities and the first organised communities under the rule of early authorities emerged in areas that today belong to Iraq, Syria, Lebanon, and Israel (Kostrzewa, 2013).

The oldest settlements exhibiting urban characteristics, such as Çatal Höyük and Jericho, initiated the urbanisation process of the Near East, which intensified during the fourth and third millennia BCE in Mesopotamia, the Indus Valley, and along the Nile. This process led to the formation of complex spatial and social structures. In the European context, urban development began in the Aegean and Greek regions, where from the Minoan period through the Hellenistic era cities evolved from spontaneous settlements into planned polis structures based on deliberate urban composition. This tradition was subsequently adopted and transformed by the Etruscans and Romans, whose regular urban layouts and extensive settlement networks became the foundation of urbanisation across large parts of Europe. The collapse of the Roman Empire, followed by the development of medieval and early modern cities, resulted in a highly differentiated morphology of European cities, which have continued to evolve under the influence of political, economic, social, and technological factors.

2.1. Smart city concept

The term ‘smart city’ has a relatively short history in both academic discourse and practical application (Dominiak, Gawkowski, Wasielewski, 2022). It first appeared in 1992 to describe a model of urban development oriented towards technology, innovation, and globalisation, in the publication „The Technopolis Phenomenon: Smart Cities, Fast Systems, Global Networks” by David V. Gibson, George Kozmetsky and Raymond W. Smilor (Moura, de Abreu e Silva, 2021). As the comprehensive definition of the smart city continues to evolve, it is conceptualised in various ways by different authors and organisations. There is no universally accepted definition of the smart city concept. Initially, it was primarily associated with the use of technology by cities, but it is currently understood in a broader, interdisciplinary sense. In recent literature, the term 'smart sustainable city' has also emerged as an extension of the original concept of the 'smart city'. Below, several attempts to conceptualise and describe the smart city are presented.

„A smart city or community aims to improve the well-being of its inhabitants, businesses, visitors, organisations and administrators by providing digital services that contribute to a better quality of life. These smart services can help to better manage resources like energy or water (Borowski, 2020; 2025), to monitor and reduce local traffic and pollution or in the work towards greener ways to light and heat buildings. They can also mean a more interactive and responsive city administration, engagement and participation of citizens in decision and policy-making, safer public spaces and meeting the needs of an ageing population and people with disabilities” (European Union).

„A smart sustainable city is an innovative city that uses ICTs and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects” (UNECE).

„A smart city is a city governed in a wise and informed manner, in which digital and telecommunication technologies are employed to enhance the efficiency of networks and services, improve the quality of life of residents, and ensure sustainable development” (Warsaw).

The term ‘smart city’ is not defined in a single, universally accepted manner however, a common denominator across most attempts to conceptualise it is the enhancement of residents’ quality of life. Different organisations and authors emphasise various aspects, including the efficiency of urban services, competitiveness, quality of life, and the inclusiveness of applied solutions. The evolution of the smart city concept reflects the growing importance of integrating technology with urban policy, sustainable development, and social participation.

3. Methodology

This research was conducted using the desk research method, which relies on existing sources such as books, reports, databases, and internet resources. This approach is generally more cost effective and time efficient than primary research methods, while providing essential background, context, and a foundation for further investigation. Desk research enables access to a wide spectrum of secondary data, including academic publications, industry and government reports, statistical databases, and press materials. Its strength lies in the ability to integrate diverse information sources into a coherent analytical framework. However, the accuracy and reliability of the findings depend on the careful selection, evaluation, and credibility of the sources used (Sulek, Borowski, 2024).

4. Rudolf Giffinger’s six dimensions smart city model

One of the most widely recognised smart city frameworks is the concept developed on the basis of benchmarking medium sized European cities by a research team led by Rudolf Giffinger from the Vienna University of Technology. This model identifies six key domains of smart city functioning, namely:

- smart economy (competitiveness), understood as an innovative economy, encompassing such factors as innovation capacity, entrepreneurship, economic promotion, productivity, a flexible labour market, economic internationalisation, and the ability to adapt to change,

- smart people (social and human capital), referring to engaged and empowered citizens, including factors such as educational attainment, willingness to engage in lifelong learning, social and ethnic diversity, flexibility, creativity, international orientation understood as openness to the world, and citizens' participation in public life,
- smart governance (participation), denoting informed and inclusive governance, encompassing factors such as citizen participation in decision making processes, the quality of public and social services, transparency of public authorities, and forward-looking strategic development planning,
- smart mobility (transport and ICT), referring to intelligent mobility systems, including well organised public transport, national and international transport accessibility, the provision of information and communication technology infrastructure, and sustainable, modern, and safe transport systems,
- smart environment (natural resources), relating to environmental quality, including factors such as the attractiveness of natural conditions, pollution levels, environmental protection efforts, and sustainable resource management,
- smart living (quality of life), referring to residents' wellbeing, encompassing factors such as cultural infrastructure, access to healthcare, personal safety, quality of housing infrastructure, access to education, tourism attractiveness, and social cohesion (Smart cities ranking, 2007; Dominiak, Gawkowski, Wasielewski, 2022).

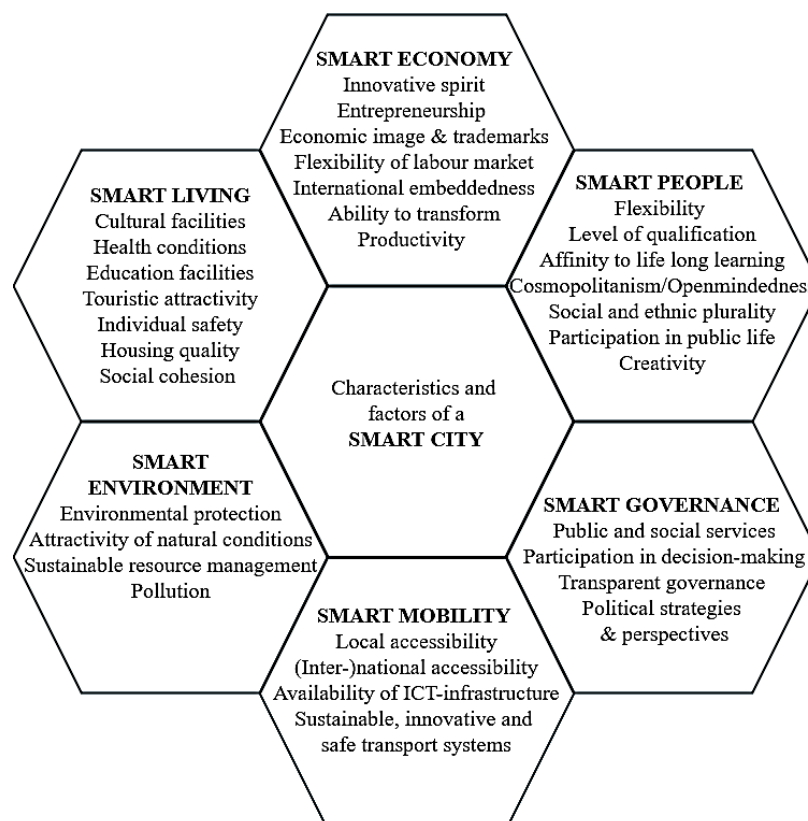


Figure 1. Giffinger's six dimensions: characteristics and factors of a smart city.

Source: Prepared by the authors based on Giffinger et al., 2007.

5. Connectivity as a key dimension of the smart city

The concept of connectivity is defined as „the ability of systems, platforms and applications to be connected to each other” (Oxford). In the context of the smart city, connectivity is implemented through:

- network and telecommunication infrastructure, including fibre optic networks, municipal networks, urban access points, and mobile networks,
- urban sensing infrastructure, comprising sensors, urban actuators, and LPWAN (Low Power Wide Area Network) systems,
- urban data and interoperability platforms, including integrated municipal platforms enabling data exchange and system integration,
- urban mobility services, encompassing intelligent transport systems, micromobility solutions, and shared vehicle systems,
- smart urban energy and environmental infrastructure, including dynamic management of energy demand and supply, smart metering, and real-time environmental monitoring,
- emerging technologies, such as digital twins, edge computing combined with artificial intelligence, and mesh networks (Authors’ own elaboration).

5.1. Examples of connectivity applications in smart cities

Connectivity plays an integrative role in German smart cities by linking data, institutions, and users into coherent urban systems. In cities such as Berlin, Hamburg, and Dresden, it underpins smart governance, sustainable mobility, and urban resilience through platforms integrating digital twins, sensor networks, and data-driven decision making (Bichueti et al., 2025).

The city of Porto in Portugal represents a smart city case in which connectivity integrates urban mobility, environmental management, governance, and citizens through digital solutions. Systems such as Andante, real-time transport information, IoT applications, and data-driven platforms support coordinated mobility services, environmental monitoring, and citizen participation, contributing to a more sustainable and interconnected urban system (Baptista, Bezerra, 2025).

Rome exemplifies a smart city where connectivity enables participatory governance by integrating institutions, stakeholders and citizens through digital platforms such as the Consulta Roma Smart City Lab, the Roma Data Platform and the AI assistant Giulia, facilitating coordinated data flows, transparent decision making and co-creation within an inclusive, data-driven urban framework (Romolini, Meleo, Sances, 2025).

5.2. Challenges and risks associated with the implementation of connectivity in smart cities

From a theoretical perspective, connectivity constitutes an integrative analytical category linking technical, organisational and social dimensions, grounded in systems thinking and complexity theory, where relational structures enable information flows, coordinated action and the emergence of new organisational forms. However, as highlighted by Haven, smart city development is constrained by fragmented implementations and insufficient institutional coordination, meaning that connectivity, when not embedded in coherent governance and social frameworks, fails to function as an integrative backbone and instead amplifies interoperability gaps, cybersecurity risks and barriers to effective urban transformation (Haven, 2020). As Borowski notes, digitalization plays a huge role in this effective transformation process (Borowski, 2022).

6. Discussion

The results of the research conducted using the desk research method reveal recurring patterns of fragmentation and integration within urban systems, particularly in the context of connectivity. The conducted review indicates that connectivity is perceived not only as an element of technological infrastructure, but also as a mechanism shaping relationships between governance, society, and economic structures. The obtained results provide a basis for further theoretical considerations of connectivity as a systemic and human-centred phenomenon.

Neuhofer, Magnus and Celuch introduced the „(...) novel term ‘Technology-mediated Life Ecosystems’ This humancentric ecosystem recognises AI-supported life realities of the end-user that cross and permeate all life domains”(Neuhofer, Magnus, Celuch, 2020, p. 10). This concept reframes connectivity by shifting attention from technology as a tool to technology as a lived environment, where connectivity functions not merely as infrastructure but as a condition enabling complex, interdependent relationships among social, economic and institutional systems.

An important element of the theoretical understanding of connectivity is its role in the transformation of governance and management models. As noted by A. Rzepka, M. Kocot and E. Jędrych, „The 21st century is a time of computerization, digitization, and electronization of flows and virtualization of management activities. The development of IT has contributed to the fact that in the field of management, many activities can be carried out using electronic means of communication, in particular the Internet, without the physical involvement of those involved in the transaction” (Rzepka, Kocot, Jędrych, 2021, p. 346). This finding supports the thesis that connectivity redefines core management categories like presence, control and

coordination, making high connectivity a prerequisite for the shift from hierarchical to network based governance in smart cities.

Connectivity plays a pivotal role in the ongoing transformation of the transport sector, a sector that is fundamental to the functioning of all smart cities. „(...) element of improving the transport system is intelligent systems that can monitor and analyse traffic data and road conditions in real time. Based on this information, they can adjust traffic lights, optimizing the duration of the lights and changing them depending on the current situation. This helps to avoid unnecessary congestion and slowdowns, which lowers fuel consumption and emissions” (Borowski, 2024, p. 178).

7. Summary

Connectivity constitutes a transversal and integrative dimension permeating all six components of Giffinger’s smart city model, functioning as the structural logic that binds smart economy, people, governance, mobility, environment and living into a coherent system. It extends beyond technical infrastructure by enabling continuous data flows, coordination among actors and interoperability of urban subsystems, without which economic innovation, participatory governance and efficient mobility remain fragmented. Connectivity supports smart people through digital platforms facilitating learning, participation and creativity, while reinforcing smart environment and smart living via real time monitoring, data-driven resource management and responsive urban services. Consequently, the theoretical extension of Giffinger’s model underscores connectivity as the connective tissue conditioning the functionality, maturity and effective governance of contemporary smart cities.

References

1. An official website of the European Union. *Smart cities and communities*. Retrieved from: <https://digital-strategy.ec.europa.eu/en/policies/smart-cities-and-communities>, 01.05.2026.
2. An official website of the United Nations Economic Commission for Europe. *Smart Sustainable Cities*. Retrieved from: <https://unece.org/housing/smart-sustainable-cities#> 01.05.2026.
3. Balsas, C.J.L., Piracha, A. (2025). Strategic Planning for Urban Sustainability. *Land*, Vol. 14, 1458, doi: <https://doi.org/10.3390/land14071458>

4. Baptista, M.D.F., Bezerra, M.R.V.D.D.M. (2025). Smart City: The Future Of Cities With A Focus On The City Of Porto, Portugal. *Revista de Gestão Social e Ambiental*, Vol. 19, No. 7. pp. 1-12, doi: <https://doi.org/10.24857/rgsa.v19n7-030>
5. Bichueti, R.S., Leal Filho, W., Gomes, C.M., Kneipp, J.M., Costa, C.R.R.d, Frizzo, K. (2025). Climate Change and Urban Resilience in Smart Cities: Adaptation and Mitigation Strategies in Brazil and Germany. *Urban science*, Vol. 9, No. 179, pp. 13-15, doi: <https://doi.org/10.3390/urbansci9050179>
6. Borowski, P.F. (2024). Efforts Of The Transport And Energy Sectors Toward Renewable Energy For Climate Neutrality. *Transport Problems*, Vol. 19, No. 2. pp. 177-190.
7. Borowski, P.F. (2022). Digital transformation and prosumers activities in the energy sector. In: C. Karhaman, E. Haktanir (Eds.), *Intelligent Systems in Digital Transformation: Theory and Applications*. Springer International Publishing, pp. 129-150.
8. Borowski, P.F. (2020). Nexus between water, energy, food and climate change as challenges facing the modern global, European and Polish economy. *AIMS Geosci*, Vol. 6, No. 4. pp. 397-421.
9. Borowski, P.F. (2025). Economic and Technological Challenges in Zero-Emission Strategies for Energy Companies. *Energies*, Vol. 18, No. 4. 898, doi: <https://doi.org/10.3390/en18040898>
10. Dominiak, B., Gawkowski, K., Wasielewski, Z. (2022). *Cyfrowe miasto - bezpieczna czy niebezpieczna przyszłość*. Warszawa: Uczelnia Techniczno-Handlowa im. Heleny Chodkowskiej w Warszawie, p. 12.
11. Firszt, D., Jabłoński, M. (2023). Implementacja idei smart city w zarządzaniu miastem. Ocena i oczekiwania mieszkańców na przykładzie studentów krakowskich uczelni. *Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu*, Vol. 67, No. 4, pp. 51-64, doi: 10.15611/pn.2023.4.05
12. Gibson, D.V., Kozmetsky, G., Smilor, R.W. (1992). *The Technopolis phenomenon: smart cities, fast systems, global networks*. San Francisco: Lanham, Md.: Rowman & Littlefield Publishers.
13. Giffinger, R., Fertner Ch., Kramar H., Kalasek R., Pichler-Milanović, N. (2007). *Smart cities Ranking of European medium-sized cities*. Vienna: Centre of Regional Science, pp. 11-12.
14. Ginsbert-Gebert, A. (1984). *Polityka komunalna*. Warszawa: PWE, p. 11.
15. Haven, A. (2020). What are the Challenges of Building a Smart City? *Technology Innovation Management Review*, Vol. 10, No. 9. pp. 38-48, doi: <http://doi.org/10.22215/timreview/1388>
16. Ishaq, H., Dincer, L., Crawford, C. (2022). A review on hydrogen production and utilization: Challenges and opportunities. *International Journal of Hydrogen Energy*, Vol. 47, No. 62, pp. 26238-26264.

17. Kostrzewska, M. (2013). *Miasto europejskie na przestrzeni dziejów*. Gdańsk: Politechnika Gdańska, pp. 5-6.
18. Moura, F., de Abreu e Silva, J. (2021). Smart Cities: Definitions, Evolution of the Concept, and Examples of Initiatives. In: W. Leal Filho, A.M. Azul, L. Brandli, A. Lange Salvia, T. Wall (Eds.), *Industry, Innovation and Infrastructure. Encyclopedia of the UN Sustainable Development Goals*. Springer, Cham, pp. 989-997, doi: https://doi.org/10.1007/978-3-319-95873-6_6
19. Neuhofer, B., Magnus, B., Celuch, K. (2020). The impact of artificial intelligence on event experiences: a scenario technique approach. *Electronic Markets*, Vol. 31, pp. 601-617, doi: <https://doi.org/10.1007/s12525-020-00433-4>
20. Oxford Advanced Learner's Dictionary. *Definition of connectivity*. Retrieved from: <https://www.oxfordlearnersdictionaries.com/definition/english/connectivity>, 01.05.2026.
21. Pereira, G.V., Ciesielska, M., Rizum, N., Alexopoulos, Ch. (2026). Exploring adverse effects from technological change in the context of smart city. *Journal of the knowledge economy*, Vol. 17, pp. 5476-5507, doi: <https://doi.org/10.1007/s13132-025-02875-7>
22. Polityka cyfrowej transformacji m.st. Warszawy. *Zarządzenie nr 1626/2022 Prezydenta m.st. Warszawy z 26 października 2022 r.*
23. PWN Słownik Języka Polskiego. *Miasto - znaczenie i definicja*. Retrieved from: <https://sjp.pwn.pl/slowniki/miasto.html>, 30.04.2026.
24. Romolini, A., Meleo, L., Sances, M. (2025). Participatory Governance in the Digitalization Process of a Smart City: The Case of the Municipality of Rome. *Sustainability*, Vol. 17, No. 9995. pp. 1-25, doi: <https://doi.org/10.3390/su17229995>
25. Rzepka, A., Kocot, M., Jędrych, E. (2021). Implementation and Use of Green Computing in Polish Companies versus Implementation of Features Characteristic of Teal Organizations. In: O.P. Jena, A.R. Tripathy, Z. Polkowski, *Green Engineering and Technology Innovations, Design, and Architectural Implementation* (pp. 343-356). Boca Raton: CRC Press.
26. Stawasz, D. (2016). *Współczesne dylematy zarządzania rozwojem miasta*. Łódź: Wydawnictwo Uniwersytetu Łódzkiego, p. 185.
27. Sułek, A., Borowski, P.F. (2024). Business Models on the Energy Market in the Era of a Low-Emission Economy. *Energies*, Vol. 17, No. 13, 3235, doi: <https://doi.org/10.3390/en17133235>
28. The London School of Economics and Political Science. *New Urban Governance: Urban complexity and institutional capacities of cities*. Retrieved from: <https://www.lse.ac.uk/cities/research/urban-governance/New-Urban-Governance>, 02.05.2026.
29. Tuwien. *The smart city model*. Retrieved from: <https://www.smart-cities.eu/?cid=2&ver=4>, 01.05.2026.