

Resilience as a Key Feature of Smart Cities Supporting Sustainable Urban Development

Resilencja jako kluczowa cecha inteligentnych miast wspierających zrównoważony rozwój obszarów miejskich

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Abstract

Rapid urban growth coupled with the rising scale of complex city-level risks require new approaches to sustainable urban development and urban governance. Contemporary cities must not only improve the quality of life of their inhabitants but also ensure long-term stability, safety and sustainable development. In this context, the concepts of the smart city and the resilient city have emerged as pivotal themes in both scholarly discourse and urban governance.. The aim of this article is to analyse the conceptual synergy between these two concepts and to demonstrate that resilience should be considered one of the key features of a smart city and is in compliance with Sustainable Development Goal 11.

The research is based on a leading academic publications concerning smart cities and urban resilience. The analysis focuses on identifying the main assumptions of both concepts and examining their areas of convergence. Based on its findings, a conceptual framework linking smart city development, urban resilience and sustainable urban development is proposed.

The results of the analysis indicate that the smart city and resilient city concepts are complementary rather than competing approaches. Smart city strategies, based on technology, participatory governance and efficient resource management, provide a structural foundation for building urban resilience. At the same time, resilience strengthens the capacity of cities to respond to threats, adapt to changing conditions and maintain essential urban functions. The study concludes that resilience should be seen as an essential feature of smart cities, supporting their sustainable development.

Key words: smart city, resilient city, urban resilience, sustainable urban development, urban governance, SDG 11

Streszczenie

Szybki rozwój miast w połączeniu z rosnącą skalą złożonych zagrożeń na poziomie miejskim wymaga nowych podejść do zrównoważonego rozwoju miast i zarządzania nimi. Współczesne miasta muszą nie tylko poprawiać jakość życia swoich mieszkańców, ale także zapewniać długoterminową stabilność, bezpieczeństwo i zrównoważony rozwój. W tym kontekście koncepcje inteligentnego miasta i miasta odpornego stały się kluczowymi tematami zarówno w dyskursie naukowym, jak i w zarządzaniu miastami. Celem niniejszego artykułu jest analiza synergii koncepcyjnej między tymi dwoma pojęciami oraz wykazanie, że odporność powinna być traktowana jako jedna z kluczowych cech inteligentnego miasta, zgodna z 11 celem zrównoważonego rozwoju.

Badania opierają się na wiodących publikacjach naukowych dotyczących inteligentnych miast i odporności miejskiej. Analiza koncentruje się na zidentyfikowaniu głównych założeń obu koncepcji oraz zbadaniu obszarów ich zbieżności. Na podstawie uzyskanych wyników zaproponowano ramy koncepcyjne łączące rozwój inteligentnego miasta, odporność miejską i zrównoważony rozwój miast.

Wyniki analizy wskazują, że koncepcje inteligentnego miasta i miasta odpornego uzupełniają się, a nie konkurują ze sobą. Strategie inteligentnego miasta, oparte na technologii, zarządzaniu partycypacyjnym i efektywnym gospodarowaniu zasobami, stanowią strukturalną podstawę do budowania odporności miejskiej. Jednocześnie od-

porność wzmacnia zdolność miast do reagowania na zagrożenia, dostosowywania się do zmieniających się warunków i utrzymania podstawowych funkcji miejskich. W badaniu stwierdzono, że odporność należy postrzegać jako istotną cechę inteligentnych miast, wspierającą ich zrównoważony rozwój.

Słowa kluczowe: inteligentne miasto, miasto resilientne, resilencja miast, zrównoważony rozwój miast, zarządzanie miastami, SDG 11

1. Introduction

Today's cities face various threats that affect their inhabitants, natural resources or infrastructure. A natural reaction is therefore to create solutions that strengthen the city and prepare it to cope with situations that are dangerous to its functioning and development. Defense mechanisms are not a modern discovery, otherwise cities with centuries-old traditions would not survive. Nowadays, however, the population of cities is constantly growing, so it is becoming necessary to look for new solutions for their functioning. The starting point is an analysis of the smart city concept and the resilient city concept, which are in compliance with sustainable development concept. The smart city concept identifies the potential of the city in all aspects of its functioning and finds ways to use it for the development of the city. It involves its citizens in the decision-making process, making them co-responsible for its development. The concept of the resilient city, on the other hand, emphasises the city's ability to cope with various disruptions and to prepare for crisis, extreme situations, which are increasingly affecting states, including cities, in varying degrees of negativity. These are therefore concepts that do not compete with each other, but complement each other. The aim of this article is to analyse these concepts in terms of their theoretical assumptions developed in the literature. Based on the results of this analysis, it was proposed that a smart city, in addition to feature such as efficiency, flexibility, effectiveness, innovation, participation, and having a vision of city development, should also be resilient. The article supplements theoretical research aimed at better understanding the intelligence and resilience of cities.

Contemporary cities, apart from ensuring economic development and improving the quality of life of their inhabitants, also need to pursue the principles of sustainable development. Sustainable urban development requires the harmonisation of various areas of city functioning, while ensuring the stability and security of urban systems. In this context, the concepts of smart cities and urban resilience are increasingly seen as complementary and simultaneously supporting the implementation of sustainability in cities. It is possible especially through realization of Sustainable Development Goal (SDG) 11: sustainable cities and communities, which emphasises the building of inclusive, safe, resilient and sustainable cities.

The research conducted in this article is based on a review of the widely cited literature on smart and resilient cities. Part one deals with findings related to the smart city concept. Part two is devoted to the assumptions of the resilient city concept. Part three assesses the extent to which the smart city and resilient city concepts are related, as well as areas of connection between the concepts. The final part of the article is the conclusion that resilience is a feature of the smart city that gives the city the strength to overcome difficulties and develop.

The aim of this article is to examine whether and to what extent the concepts of a smart city and a resilient city are interrelated, and to determine whether resilience can be considered a key feature of a smart city. The analysis aims to answer the following research question: to what extent can the principles of the smart city concept contribute to shaping and strengthening urban resilience and supporting sustainable urban development? The article also proposes a conceptual framework linking the characteristics of a smart city with urban resilience and sustainable development.

2. Literature review

2.1. *The smart city concept*

The smart city is a concept relating to the functioning of cities, which involves developing them in various areas to make them friendly and attractive places to live. The smart city concept has been the subject of many years of scientific research. However, in spite of this, no generally accepted assumptions of the concept have been developed, no universal definition of a smart city has been adopted. Various authors put modern technology at the centre of the smart city concept, (Carvalho, 2015, Santangelo, 2016) or treat the smart city as a city that puts people, the community, at the centre of the concept (Prado, Moreira Da Costa, Zilinski Furlani, & Yigitcanlar, 2016). There are also definitions that place increasing emphasis on the governance aspect of the city and the contribution of citizens to its development (Dameri, 2013, Letaifa, 2015, Caragliu, Del Bo, & Nijkamp, 2011). According to Rudolf Giffinger's concept in the report entitled Smart cities. Ranking of European medium-sized cities, the factors of a smart city are: smart economy, smart people, smart governance, smart mobility, smart environment and smart living. However, Giffinger does not define the term 'smart', but provides descriptive definitions for each smart city factor. (Giffinger, 2007).

The smart city concept evolves with new experiences, needs and threats that a city has to face. In view of the dynamic and continuously changing conditions in which contemporary cities operate, it is justified to identify a set of general characteristics of a smart city that may be applied irrespective of a city's size, population, investment capacity or the particular challenges it currently faces. These characteristics include:

- a) effectiveness, understood as the ability of the city to recognise and respond to the needs of its inhabitants;
- b) flexibility, reflected in the capacity to react promptly to emerging circumstances and to adjust to changing conditions;
- c) efficiency, expressed in the rational and sustainable use of available resources;
- d) innovativeness, understood as the conscious search for and implementation of new solutions and technologies aimed at addressing urban problems and improving residents' quality of life;
- e) participation, involving the active engagement of inhabitants in shaping the urban environment and enabling them to participate meaningfully in decision-making processes;
- f) a clearly defined development vision, articulated in strategic documents, accepted by the local community and implemented through coordinated actions undertaken by the city and its inhabitants.

From this perspective, a smart city should be understood as an urban system capable of assessing its own operational potential, identifying the needs of its residents, diagnosing urban challenges and selecting appropriate instruments to address them, while considering the views of the local community. It is also a city that can translate its strategic vision of development into practical measures. These qualities may characterise a smart city regardless of its territorial scale, demographic structure, financial capacity or the number of technological solutions implemented. A smart city is therefore distinguished not merely using advanced technologies, but above all by its ability to mobilise knowledge, institutional capacity and social potential in support of balanced and harmonious development. It is also capable of adapting to technological, economic, political and social transformations occurring in its external environment (Kisala, 2021).

The actions taken by the city provide information about its potential, strength, development opportunities, but also about the areas that require changes and improvements to operate effectively. This is the starting point for identifying and implementing mechanisms that will strengthen the city in areas that require it. Therefore, a smart city, in order to survive and develop, should also develop a feature of resistance to various threats.

The concept of a smart city is also increasingly linked to the idea of sustainable urban development. A smart city uses intelligent solutions, including digital technologies, data-driven management and innovative infrastructure systems, to optimise urban services and support sustainable development. As a result, smart city initiatives contribute to the implementation of sustainable development principles at the local level.

2.2. The resilient city concept

With a growing urban population, resulting in a concentration of the population in a limited area, it is becoming increasingly important to guarantee the safety of the population and infrastructure. Consequently, new solutions are being sought to help cities counteract and cope with the negative effects of undesirable events should they occur. Therefore, a modern city should also be resistant to shocks and hazards. The concept of resilience has been the subject of many years of scientific research. In scientific literature, the concept of resilience first appeared in 1973 in Crawford S. Hollings' article *Resilience and Stability of Ecological Systems*. He defined resilience as an ecosystem's ability to maintain its basic functional characteristics in view of the occurrence of certain disturbances (Holling, 1973).

An overview of the definitions of *resilience* and the resilient city was presented in the article *Defining urban resilience: A review, Landscape and Urban Planning*. Summarising the different approaches to urban resilience analysed in this article, the authors formulate a definition of urban resilience which, according to them, *remains flexible enough to be adopted by a range of disciplines and stakeholders*. According to this definition, *urban resilience refers to the ability of an urban system – and all its constituent socio-ecological and socio-technical networks across temporal and spatial scales – to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change, and to quickly transform systems that limit current or future adaptive capacity* (Meerow, Newell, & Stults, 2016). Resilient city is understood as a complex, multidimensional system with adaptive capacity (Lang, 2011, Koliou, van de Lindt, Mcallister, & Ellingwood, 2018). Like any system, it is subject to constant transformation, which is driven by various factors: demographic processes (ageing population, influx of migrants from abroad), the phenomena of poverty and social exclusion, susceptibility to global economic crises, energy problems, the state of the environment and natural disasters (Czachor, 2019).

There is also a view in the literature that there are two sides of resilience theory that should be translated into urban management and sustainability planning: the principle of rebound (rebuilding), which should work in the very short term (for example, to save human lives from disaster), and the learning loop and subsystem transformation, which are the milestones of any medium- and long-term decision (Chelleri, 2012). It is therefore necessary to further strengthen the participation and coordination of all relevant stakeholders, including public authorities at different levels, private sector entities, public institutions and civil society organisations. Such an integrated approach constitutes an essential condition for transforming economic, social and environmental models towards

greater sustainability by 2030 (Benito, Guillamón, & Ríos, 2023). The literature also identifies the characteristics of a resilient city. Resilient city tends to be redundant, diverse, efficient, autonomous, strong, interdependent, adaptable, and collaborative (Foster, 1997). A city should develop mechanisms to counteract threats, prepare for their occurrence and maintain or restore a state of stability (Sienkiewicz-Małyjurek, 2020). Resilience is a measure of a city's ability to absorb negative changes and ensure its continued functioning (Berkes, 2007). However, it's worth noting that this disaster recovery doesn't necessarily restore the system to its original state (Meduri, Singh, & Manoharan 2024).

To sum up the above considerations, it can be stated that resilience is a concept with a large semantic capacity. The analysis shows that resilience can be related to all aspects of the functioning of a city. A resilient city is a city that has potential in the material and non-material dimension, which it can effectively activate in the event of forecasting and the occurrence of disruptions in its functioning. This means that by using its facilities, it is able to prevent, minimize and rebuild its potential, adapt to new conditions, maintaining the ability to perform public tasks and ensuring the safety of its residents. A city's capacity to maintain resilience will vary, just as the circumstances of each city will vary. Building resilience is based on structured, comprehensive, planned actions that ultimately aim to keep the city safe and thriving. This is why the concept of a smart and resilient city is increasingly the subject of joint research.

Despite numerous studies analysing smart cities and urban resilience separately, there are still few publications addressing the question of whether, and to what extent, resilience can be considered an inherent feature of smart cities. There is therefore a need to develop a conceptual framework that integrates the principles of these approaches within the context of sustainable urban development.

3. Research methodology

This study adopted a qualitative research model based on a literature review conducted to identify the key tenets of the theories of smart cities and urban resilience, as well as the potential links between these two concepts. A conceptual analysis was conducted to examine the relationship between the concepts of the smart city and the resilient city, and to assess whether resilience can be considered a key feature of smart cities.

The source selection process primarily included peer-reviewed articles, monographs, and reports from 2000–2024, while also including classic works on resilience theory (e.g., Holling, 1973). The literature search was conducted using major scientific databases including Scopus, Web of Science, and Google Scholar. Particular attention was paid to highly cited works that contributed to the conceptualisation of smart cities and urban resilience (e.g. Caragliu et al., 2011; Meerow et al., 2016).

The analysis of selected publications focused on identifying the main characteristics of smart cities, the key elements of urban resilience, and the points of connection between these two paradigms. First, the literature on the concept of the smart city was analysed to identify its key characteristics and directions of development. Next, the literature on urban resilience was analysed to determine how resilience is implemented in urban systems. In the third stage, the results of both analyses were compared to identify common ground between these two concepts.

The final stage of the research was conceptual synthesis, on the basis of which the main thesis of the article was formulated: resilience should be treated as an additional feature of a smart city, complementing other commonly identified features such as effectiveness efficiency, flexibility, innovativeness participation and a strategically defined and socially accepted vision of urban development, implemented through coordinated actions undertaken by the city and its inhabitants.

4. Results: smart city and urban resilience as complementary concepts

Based on the literature, the main areas of correlation between the concepts of the smart city and urban resilience have been identified. The results of this analysis indicate that both approaches address similar aspects of urban development and can reinforce one another.

The concepts of smart city and urban resilience are complementary and in compliance with sustainable development concept. Implementing their assumptions allows the city to develop harmoniously. The smart city concept is the starting point for other measures. Firstly, it is universal, which means that it targets the development of the city in different areas. Its assumptions allow for the development of a strategy on how to effectively operate on the city's potential and what can be improved so that the city can develop taking into account the needs and voice of its citizens. Secondly, smart city action should be based on identifying its strengths and weaknesses. In this way, city authorities obtain concrete data that demonstrate their individual potential. Having such knowledge is the basis for developing planning and strategic documents, but also for preparing solutions and procedures in the event of undesirable situations. A smart city therefore has the potential to build resilience.

Cities face various threats. Building resilience may have a different scope and scale for each city. In order to identify areas that should be strengthened, a smart city should ask itself what and to what extent it should be resistant. Only by answering this question will it be possible to determine what actions need to be taken in specific

cases to strengthen it and thus begin the process of building its resilience. For building resilience, the context in which the city operates will therefore be crucial.

Boyed Cohen proposed an indicator framework consisting of six fields used for a broad and deep evaluation of the attribute of smart cities named the *Smart city wheel*, which are smart Government, Economy, Environment, Mobility, People, and Living. Each field is divided into three subfields, including 62 indicators to assess more accurately the level of intelligence achieved by each city (Cohen, 2013). When assessing the resilience of a city, it was assumed that resilience can relate to different areas of city functioning. A distinction was made between social resilience, infrastructural resilience, economic resilience, Institutional resilience, Environmental resilience (Zhu, Li, & Feng, 2019). The aim of both concepts is to improve the quality of life (Papa, Galderisi, Majello, & Saretta, 2015). Comparing the areas of development of a smart city and a resilient city, it can be stated that they are similar thematically. These areas have been defined in a general way and can be specified in the case of the functioning of a specific city, as well as new threats related to civilization development. Examples of specifically defined types of resilience include: resilience to cyberattacks, resilience to terrorist attacks or epidemiological resilience. The first argument that makes it possible to examine the two concepts together is therefore the convergent object of consideration of the two concepts. It can be stated that city resilience can be built in every area of a smart city.

The possibility of combining the two concepts can also be considered from the point of view of using smart technologies. Smart city technologies may serve as one of the key instruments for strengthening urban resilience. Analyses of urban development trends clearly indicate that a city's technological capacity is closely related to its ability to respond effectively to changing conditions (Baron, 2012). Many cities are currently implementing smart technologies and integrated systems designed to enhance connectivity both within and between social, physical and environmental urban subsystems. This interconnectivity creates new forms of interaction between inhabitants and urban infrastructure, including digital public services, real-time information on traffic flows and transport performance, as well as smart housing solutions capable of adapting to users' needs through machine-learning mechanisms. It also enables the deployment of sensor-based infrastructure in natural systems, thereby supporting real-time monitoring of significant environmental changes. Enhancing the reliability of smart technologies and improving interactions across social, infrastructural and environmental domains may contribute to making cities more efficient, sustainable, inclusive and, ultimately, more resilient. Moreover, investments in sensor-based technologies and smart urban systems may support all stages of disaster management, namely mitigation, preparedness, response and recovery (DesRoches & Taylor, 2018, Sahamies, Haveri, & Anttiroiko, 2022). The effectiveness of a local governance network depends, to a significant extent, on the way in which local authorities exercise leadership, as well as on the structural characteristics of the network itself (Uster, Vashdi, & Beerli, 2022). Systemic approach enables better management of a city under conditions of complexity and uncertainty (Mierzejewska, 2017).

Information and communication technologies, artificial intelligence and IoT-based systems play an important role in strengthening urban resilience by enhancing situational awareness, improving the intelligence of urban systems and supporting citizen participation (Arafah, Winarso, & Suroso, 2018). At the same time, smart cities that depend on complex digital networks for the management of numerous urban systems and public services are exposed to cybersecurity risks, since any software-based device may constitute a potential point of vulnerability. The main challenge therefore lies in translating the principles of smart governance into practical mechanisms of smart and resilient urban governance, embedded in the day-to-day functioning of the city (Shahrabani & Apanavičienė, 2022).

The effects of recent natural disasters demonstrate that insufficient or outdated infrastructure substantially limits the capacity of cities to respond effectively to extreme weather events. In response to these and other environmental hazards, cities increasingly recognise the need to modernise ageing water supply, energy, telecommunications and transport systems by replacing them with smarter, more reliable and more efficient infrastructure solutions (DesRoches & Taylor, 2018). They can be used in building a resilient city in the context of alerting authorities and residents to impending danger and contact during adverse events. They can also be used in the operation of the smart city for the day-to-day running of the city, e.g. technologies related to water purification and the provision of information on water suitability (Elvas, Mataloto, Martins, & Ferreira, 2021).

In these different areas of smart city operation, the degree of resilience may vary. Resilience will depend on the resources and the operating mechanisms used. Each city may respond to threats in an individual way, so a city may be resilient to different threats to a different degree. The degree of resilience will therefore be an individual feature of each city.

Smartness has a significant positive effect on urban resilience, particularly in its infrastructural, economic and institutional dimensions. Cities with a higher level of smart development tend to demonstrate greater capacity to withstand, adapt to and recover from external disturbances (Zhu, Li, & Feng, 2019) Therefore, the concept of resilience is one of the important factors in smart city planning (Arafah, Winarso, & Suroso, 2018).

In summary, the concept of a resilient city and the concept of a smart city do not compete with each other, but complement each other. Smart city action includes both the identification of strengths and their use for the development of the city, as well as the identification of weaknesses, based on which the city can develop solutions to

counteract and minimize threats in the event of their appearance. A smart city should be resilient. Without resilience, the city will be more vulnerable to losses, which will negatively affect its functioning and development. By combining technological innovation with urban management, public participation and long-term planning, favourable conditions are created for building urban resilience. Resilience should therefore be seen as a natural extension of the smart city paradigm.

5. Practical perspective: examples of European cities

To illustrate the link between the concepts of the smart city and the resilient city, selected examples of European cities that have implemented policies integrating both approaches were analysed. Cities such as Barcelona, Amsterdam and Copenhagen are cited in the literature as examples of combining smart solutions that also contribute to strengthening urban resilience (Angelidou, 2016, Shao & Min, 2025, Smart cities – Ranking of European medium-sized cities, 2007).

Barcelona is one of the best-known examples of a smart city in Europe. The city uses digital technologies, data management systems and Internet of Things (IoT) solutions to manage transport, energy and waste management. Smart traffic management and urban infrastructure monitoring systems improve the city's operational efficiency whilst helping to increase its resilience to various types of disruption. These solutions enable a rapid response to emergencies and better management of urban resources (Bakici, Almirall & Wareham, 2012, Bibri & Krogstie, 2020).

Amsterdam is implementing its smart city strategy by developing sustainable mobility, smart energy systems and actively involving residents in decision-making processes. The Amsterdam Smart City programme supports innovative projects related to energy management, water management and urban space management. The solutions being implemented enhance the city's ability to adapt to climate change and other environmental threats (Addas, 2023, Angelidou, 2016).

Copenhagen is focusing on building the city's resilience in the face of climate change. The city's development strategy includes the development of green infrastructure, smart energy management systems and solutions to enhance the city's resilience to flooding. Integrating smart city technologies with climate policy enables the city to achieve its sustainable development and improve the safety of its residents (Oyadeyi & Oyadeyi).

Although these cities implement different strategies, they share common features such as the use of smart technologies, participatory governance and long-term urban planning. These elements strengthen urban resilience and contribute to sustainable urban development.

At the same time, the examples demonstrate that the specific forms of resilience-building differ depending on local conditions and priorities. While Barcelona focuses strongly on digital infrastructure and urban data systems, Amsterdam emphasises collaborative governance and sustainable energy solutions, and Copenhagen prioritises climate adaptation and environmental resilience. These differences confirm that resilience-building strategies must be adapted to the unique socio-economic, environmental and institutional contexts of each city.

6. Discussion

A resilience-oriented understanding of the smart city concept defines it as a city that uses information and communication technologies to strengthen awareness, intelligence, well-being and citizen participation in the face of pressures, shocks and hazards. Such city is able to survive, adapt, withstand disruption and transform its structures and functions, thereby contributing to an improved quality of life and a more sustainable urban environment under conditions of future uncertainty (Arafah & Winarso, 2017). According to this definition, the premise of the smart city concept is not only to deal with current affairs, meeting the needs of stakeholders, but also to act in a future-oriented way. Therefore, the city needs to develop a characteristic of resilience, manifested in the introduction of various protective mechanisms that could become active in a situation of disruption to its functioning.

Urban resilience is also closely related to the concept of sustainable development (Zhang & Li, 2018). Cities that are able to withstand and adapt to shocks such as climate change, economic crises or infrastructure failures are better prepared to maintain long-term sustainable development trajectories. Without resilience, sustainable development strategies may be disrupted by unexpected crises or environmental hazards (Kapucu, Ge, Martín & Williamson, 2021). The transformation of cities requires the integration of public administration, technology and environmental protection into a coherent system (Łażniewska, Janicka & Górecki).

Smart cities and urban resilience are commonly regarded as complementary approaches aimed at improving urban performance and providing effective responses to contemporary urban challenges, thereby enhancing the quality of human life (Shahrabani & Apanavičienė, 2022). The integration of smart technologies with the physical, environmental and social systems of a city may increase urban efficiency, sustainability, equity and, ultimately, resilience. Such integration can also strengthen the capacity of cities to respond to residents' needs, monitor infrastructure and environmental conditions during crises, and address related safety risks. Moreover, smart and resilient

systems may contribute to maintaining the continuity of critical services or enabling their rapid restoration after disruption (DesRoches & Taylor, 2018).

Resilience is more and more frequently included among the Smart Cities' objectives and that smart initiatives are often addressed to allow cities to *become more livable and resilient and, hence, able to respond quicker to new challenges* (Kunzmann, 2014). Resilience is vital because it helps people cope with uncertainty and leads to urban design that can effectively manage the negative impacts of disasters (Meduri, Singh, & Manoharan, 2024). Resilience should therefore be understood as not only strengthening the city against sudden, unforeseen events such as natural disasters or pandemics, but also as the ability to adapt to gradually changing external conditions, stretched over time, which may hinder the functioning of the city and its inhabitants. Building a city's resilience is a process that takes place both in times of stability and in times of threats or tensions.

Resilience should be regarded as an integral component of the complex structure of a city. Accordingly, urban development should be based on the capacity of the city to withstand disruption, adapt to changing conditions and maintain essential functions. This capacity is multidimensional and results from various processes and interactions that extend beyond the city's purely physical boundaries. For this reason, resilience constitutes an important attribute of any city that aspires to be considered smart (Desouza & Flanery, 2013). Consequently, resilience should be treated as one of the key factors in smart city planning (Arafah, Winarso, & Suroso, 2018). Resilient cities respond more quickly to economic, social and environmental changes (Tarasevych, Akhromkin, Volkova, Zablodska & Akhromkin, 2023).

Each smart city should develop its own strategies and measures aimed at enhancing both resilience and smartness, taking into account its specific context, resources and distinctive characteristics. Cities with a higher level of smart development generally demonstrate stronger capacities to withstand external disturbances (Zhu, Li, & Feng, 2019). Urban planning may substantially increase community preparedness and recovery capacity, particularly through the use of sensors embedded in physical and environmental systems to support diagnosis, prediction and adaptation. Moreover, smart growth strategies, including flexible land-use policies, targeted public investment and community participation in decision-making processes, may facilitate faster post-disaster recovery, support reconstruction in accordance with a shared community vision and improve preparedness for future events (DesRoches & Taylor, 2018, Mao & Li, 2024).

Resilience has become an essential element in the development of smart cities, as it contributes to improving quality of life, supporting sustainable urban development and strengthening environmental conditions (Arafah, Winarso, & Suroso, 2018).

The gradual integration of resilience into the smart city approach may therefore be regarded as an important direction for its further development (Lopez & Castro, 2020). Resilience should be at the core of smart cities, and smart cities at the core of resilience (Salam, 2023).

The analysis confirms that smart city initiatives and strategies for building urban resilience are mutually reinforcing. Smart governance, digital technologies and participatory decision-making processes create favourable conditions for strengthening cities' adaptive capacity. Resilience should therefore be regarded as one of the key features of a smart city.

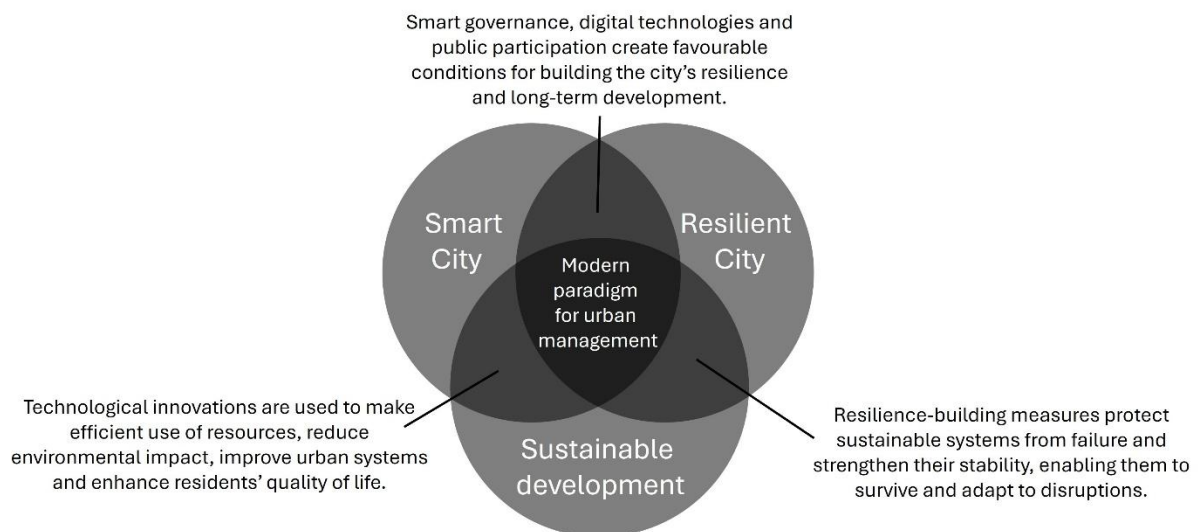


Figure 1. Smart City and Resilient City as two mutually reinforcing pillars of sustainable urban development. Source: own elaboration.

7. Conclusions

Pressure has been placed on modern cities to continuously develop economically, to secure the needs of their inhabitants to an ever higher level, to provide inclusive infrastructure. However, the increasing complexity of the threats and problems facing cities has resulted in a search for solutions that guarantee not only their development, but also their security. To face today's challenges, cities need to be resilient.

The concepts of smart city and urban resilience are complementary. Implementing their principles allows a city to develop harmoniously and in compliance with sustainability concept, especially through realization of SDG 11. The smart city concept is a dynamic and evolving concept, which is why, due to the intense changes in civilisation, it is a starting point for further research, the formulation of new statements. Cities implementing this concept should adapt it to their needs, thus taking steps in different areas taking into account their specific conditions, potentials, needs, collected data and also the voice of their inhabitants. As cities operate in different social, economic, political or geographical realities, the vulnerability of cities varies, building resilience for each city may be different in scope and scale. To identify areas that should be strengthened, a smart city should ask itself what it should be resilient to and to what extent. For building resilience, the context in which the city operates will therefore be crucial.

Building resilience does not end with the implementation of specific solutions. It is a continuous process that is supposed to adapt the city to changes on an ongoing basis. It is a process that has no end because it depends on unforeseen events that may occur in the future. Only after they have occurred can it be determined whether the mechanisms put in place to ensure resilience have worked, to what extent they have worked and whether the city has suffered damage and the extent of the damage.

Therefore, taking into account the above findings, in addition to efficiency, flexibility, effectiveness, innovation, participation, and having a vision of city development, another feature should be added to the list of indicated features of a smart city – resilience. The city should use its intelligence to build resilience to threats. This combination gives a greater chance of effectively countering various disruptions. It can therefore be stated that a smart city is a city that not only deals with current management, but also a city that anticipates and prepares for various dangerous scenarios and is also effective in responding to emerging disruptions.

The integration of smart city policies with resilience strategies supports the implementation of sustainable urban development and increases the ability of cities to respond to future challenges.

Combining smart city initiatives with projects aimed at enhancing resilience creates favourable conditions for achieving sustainable urban development. Cities that integrate technological innovation, participatory governance and resilience-focused planning are better equipped to ensure the long-term sustainability and safety of their residents. The combination of the concepts of the Smart City, the Resilient City and sustainable development forms a modern paradigm for urban management.

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