SILESIAN UNIVERSITY OF TECHNOLOGY PUBLISHING HOUSE

SCIENTIFIC PAPERS OF SILESIAN UNIVERSITY OF TECHNOLOGY 2024
ORGANIZATION AND MANAGEMENT SERIES NO. 213

SMART CITY ELEMENTS IN URBAN RESILIENCE

Aleksandra CZUPRYNA-NOWAK

Silesian University of Technology, Faculty of Organization and Management, Department of Economics and Computer Science; aleksandra.nowak@polsl.pl, ORCID: 0000-0001-8565-1029

Purpose: To investigate how integrating Smart City technologies enhances urban resilience, enabling cities to adapt, be resilient, and recover in the face of economic, environmental, and social challenges. The study aims to develop a framework that combines technological innovation with urban planning strategies to address key issues such as disaster preparedness, climate change adaptation, and economic stability. Ultimately, the study aims to guide policymakers, urban planners, and stakeholders on leveraging Smart City infrastructure to build resilient, sustainable, and resilient urban environments.
Design/methodology/approach: The paper conducts a literature review and case studies to investigate the impact of innovative city technologies on urban resilience. A literature review on urban resilience and smart city solutions is used to identify key concepts and challenges. Detailed case studies of cities implementing smart technologies to increase their resilience are conducted, including case studies from cities such as Katowice and Rotterdam.
Findings: The study showed that integrating innovative city technologies with urban resilience elements significantly increases the ability of cities to adapt, resist, and recover in the face of economic, environmental, and social challenges. Key factors supporting resilience were identified, such as diversity, efficiency, redundancy, and adaptability, reinforced using technology-based solutions such as intelligent infrastructure management systems, real-time data analysis, and advanced communication systems. The analysis of case studies confirmed that cities using smart city technologies cope better with crises, reducing their adverse effects and the time needed for recovery. The results also indicate that the integration of technologies requires a holistic approach, including the cooperation of different stakeholders, an appropriate regulatory framework, and systematic monitoring of the effects.
Originality /value: The study brings a new perspective to the literature by combining Smart City technologies with the concept of urban resilience. It offers a comprehensive approach to designing and implementing solutions that strengthen cities' resilience to various challenges.
Keywords: smart cities, urban resilience, smart city index.
Category of the paper: Research paper.

1. Introduction

In the face of dynamic climate change, rapidly developing urbanization, and increasing digitalization, cities worldwide face new challenges related to their resilience to crises. Natural disasters such as floods or hurricanes, power outages, cyberattacks, or sudden economic changes are just some of the threats that modern metropolisesIn this context, the concept of city resilience plays a key role, understood as the ability to adapt, respond, and return to balance after unforeseen disruptions. Modern cities are also witnessing the dynamic development of the Smart City concept. Smart City is not only the implementation of modern technologies such as the Internet of Things (IoT), Big Data, and artificial intelligence (AI) but also a comprehensive change in the way cities function. This concept aims to optimize urban resources, improve residents' quality of life, and increase operational efficiency. Smart City is not only about smart street lighting or traffic management applications - it is a complex network of systems and processes enabling a quick response to environmental, social, and technological changes. City resilience and Smart City are concepts that can complement each other. Integrating both approaches can improve cities' ability to anticipate, prevent, and respond to sudden disruptions. Rather than treating these concepts separately, cities are increasingly implementing strategies that combine resilience elements with Smart City technologies, allowing them to more effectively protect critical infrastructure, manage traffic, monitor air pollution, or respond to sudden weather changes. This article explores the interconnections between urban resilience and the Smart City concept. The article will discuss key definitions, theoretical foundations, implementation examples, and the main challenges and benefits of integrating these two concepts. It will also provide recommendations on how cities can increase their resilience by using Smart City tools to create more resilient, safe, and sustainable urban spaces.

2. Resilience and Smart City

The urbanization process in the 21st century brings increasing challenges for cities related to dynamic technological development, the growing intensity of climate change, extreme phenomena, and demographic pressure. In response to these challenges, two key concepts supporting the development and management of cities have been created—urban resilience and the idea of smart cities (Wardekker, 2020; Jiang, 2021; Shamsuddin, 2020). Both approaches combine modern tools and strategies to meet the challenges of modernity while differing in the scope of applications and the perspective of action.

2.1. Main assumptions of urban resillience

Resilience plays an increasingly important role in urban management, especially in global challenges such as climate change, natural disasters, and social and economic crises. Modern cities, as complex systems, must survive disruptions and quickly regenerate, adapt to new conditions, and implement lasting changes to increase their resilience for the future. Urban resilience is an interdisciplinary concept that integrates social, economic, environmental, and technological aspects to support cities in building lasting security and stability (Albino, 2015). The basic assumption of urban resilience is the ability of cities to absorb disruptions, quickly return to normal functioning, and transform their systems into more sustainable and resilient ones. Unlike traditional crisis management, which focuses on reacting to threats, urban resilience emphasizes anticipating, reducing risk, and implementing long-term strategies. The key pillars of this concept are resilience, regeneration, adaptation, and transformation (Ribeiro, 2019; Meerow, 2016; Büyüközkan, 2022). Resilience means minimizing disruptions' effects through strong infrastructure, efficient management, and effective support systems (Büyüközkan, 2022). Regeneration is the rapid restoration of full functionality after a crisis, which is possible thanks to effective response and recovery mechanisms. Adaptation refers to the ability to adapt to new conditions to avoid similar threats in the future. At the same time, transformation involves reorganizing urban systems towards more sustainable functioning. Urban resilience is multidimensional, covering various aspects of the functioning of cities. The physical dimension concerns urban infrastructure, including buildings, transport, energy, and water networks. It is crucial to design spaces that are resistant to floods, earthquakes, or other natural disasters. The economic dimension focuses on the stability of the local economy and the ability to maintain business in crises. The social aspect includes social cohesion, cooperation of residents, and the ability to cope with challenges together. The institutional dimension concerns the ability of public and private organizations to respond effectively to crises, as well as their ability to introduce structural changes. Contemporary approaches to urban resilience emphasize the concept's evolutionary nature, which goes beyond the traditional equilibrium model. Instead of restoring the city to its pre-crisis state, it aims to transform it to increase its capacity to cope with future disruptions. Assessing the resilience of cities is a key element of implementing this concept. It is often based on diagnostic tools and indicators such as the City Resilience Framework (CRF) developed by the Rockefeller Foundation. These indicators allow for the analysis of aspects such as critical infrastructure, the ability of communities to respond, and the flexibility of institutions. Modern tools such as GIS models enable detailed mapping of key areas vulnerable to hazards and spatial planning that considers resilience to different types of risks. However, the lack of uniform definitions of urban resilience and limited data availability make it difficult to accurately model and forecast resilience. In addition, each city has a unique set of challenges resulting from local conditions, which requires tailored solutions and strategies. Practical application of resilience Urban

resilience encompasses a wide range of activities in urban management. In spatial planning, it is crucial to design infrastructure that can withstand floods, earthquakes, or extreme weather events. Risk management focuses on creating effective crisis response strategies, such as evacuation plans or early warning systems. Adaptation to climate change requires investing in technologies that support sustainable development and reduce carbon dioxide emissions. Innovative approaches, such as developing smart cities, which use modern technologies to monitor and manage urban systems, are integral to resilience strategies. Examples of effective implementation of urban resilience can be found in cities such as Rotterdam, where innovative water management and flood protection solutions are developed, and in Singapore, where intelligent transport systems and energy management are invested. Other cities, such as Barcelona, combine resilience with improving the quality of life, creating spaces conducive to social cooperation and sustainable development. Such an approach not only allows for the protection of resources but also strengthens social cohesion and supports the development of local economies. Urban resilience is a dynamic concept that integrates diverse fields of knowledge and practice. It is the foundation for future-oriented urban management strategies, enabling cities to survive and thrive in the face of growing global challenges. In the context of intensifying climate change, increasing urbanization, and socio-economic tensions, urban resilience is becoming a necessity and an opportunity to introduce innovative solutions that will improve the quality of life of their inhabitants and ensure long-term environmental stability. Although the challenges related to implementing urban resilience are significant, they also offer enormous potential to transform cities into more resilient, sustainable, and welcoming spaces.

2.2. Smart city assumptions

The city concept is based on using modern information and communication technologies and innovative solutions to improve residents' quality of life, improve the management of urban resources, increase operational efficiency, and promote sustainable development. The essence of a smart city is integrating intelligent city management systems, such as IoT, big data, or advanced digital platforms, which enable monitoring of urban infrastructure and making better strategic decisions. A key aspect of this approach is supporting sustainable development by promoting ecological solutions, such as energy efficiency, renewable energy sources, or circular economy, which contributes to reducing CO_2 emissions and protecting natural resources (Ji, 2024; Tomadon, 2024).

The smart city also includes the development of smart infrastructure and urban mobility, which reduces traffic jams, improves public transport, and increases the availability of urban services. An essential element is the involvement of residents through the creation of participatory platforms that allow them to participate actively in decision-making processes, strengthening their influence on the development of cities. These activities lead to an improvement in the quality of life, both through better access to services and socio-economic integration (Shao, 2024).

The city concept is played by cooperation between the public, private, and civic sectors, which enables the effective implementation of projects and the achievement of strategic goals. Urban management in this model is based on indicators and standards that allow monitoring and evaluation of progress in implementing smart city initiatives. That makes adapting activities to local needs and avoiding implementation errors possible. The smart city also emphasizes building resilience in the towns to various types of crises, both environmental and social. By developing flexible adaptation strategies, cities can better respond to sudden events like natural disasters or economic crises. The effect of implementing the smart city concept is the improvement of the functioning of cities, reduction of operating costs, reduction of negative impact on the environment, and increase of the involvement of local communities in city management, leading to greater sustainability and inclusiveness.

3. Smart city elements in urban resilience

Resilience and the smart city concept are closely linked, as smart management technologies are a key tool supporting the development of urban resilience. Smart cities, thanks to the use of data, the Internet of Things (IoT), and artificial intelligence (AI), allow cities not only to function better daily but also to prepare for crises more effectively and respond to them faster and more efficiently (Allam, 2019). One of the most important areas in which the concept of urban resilience and smart cities should be considered is monitoring threats and responding in real time (Chen, 2020). Resilience is based on the city's ability to predict and react quickly to threats such as floods, earthquakes, air pollution, or power outages. The smart city concept uses sensor networks and data analysis systems that constantly monitor key aspects of the urban environment. For example, intelligent water management systems can detect a rise in water levels during heavy rainfall and automatically start pumps, preventing floods (Dai, 2024).

Crisis infrastructure management is another common ground between urban resilience and smart cities. Critical infrastructure, such as bridges, roads, water, and power networks, is crucial for the city's functioning. Smart cities enable ongoing monitoring of infrastructure conditions thanks to IoT sensors that collect data on their condition. In the context of resilience, potential problems, such as structural cracks or power grid overloads, are detected early, which helps prevent disasters and minimize losses. Smart cities implement intelligent power grids that optimize energy supply depending on demand. In a crisis, such as a power outage, these systems can redirect energy from alternative sources, such as solar panels or local generators. Thanks to this, the city maintains continuity of operation, a key element of resilience.

A resilient city must be able to maintain the efficiency of its transport system under challenging conditions. Smart cities implement intelligent transport systems that monitor traffic flow in real-time, report accidents, and redirect vehicles to alternative routes. Examples are

cities like Singapore, where dynamic traffic management prevents traffic paralysis in crises, such as during heavy rainfall (Omotayo, 2023).

Smart city elements are also used in water management and adaptation to climate change. Smart City allows for precise management of water resources, which is crucial in the face of growing climate threats. Thanks to IoT systems, cities can monitor river water levels, drinking water quality, or leaks in water supply networks. For example, Rotterdam has implemented water retention systems that collect excess water during heavy rains and use it during drought, increasing the city's resilience to climate change (Chen, 2020; Drodniak, 2018).

The relationship between resilience and smart cities is very closely visible in the communities and education. Community and education play a key role in integrating the concepts of urban resilience and smart cities. Including the community in city planning and management processes strengthens local resilience. This includes initiatives such as building support networks, holding joint workshops, and conducting public consultations (Wardekker, 2020). Communities with strong social ties are better prepared to deal with crises because they can more easily mobilize resources and share information. Thanks to mobile applications, residents can stay updated on threats such as approaching storms or air pollution. These technologies also enable residents to manage the city, e.g., by reporting infrastructure problems or co-creating local initiatives (Drobniak, 2018). Cooperation between schools, universities, and non-governmental organizations can create innovative projects supporting resilience (Amirzadeh, 2022). Integrating community and education within urban resilience and smart cities not only increases the resilience of cities to crises but also supports their sustainable development and improves the quality of life of their inhabitants.

Resilience and smart cities concepts in sustainable development and environmental protection are based on the synergy between technology, adaptability, and urban planning to increase cities' resilience to hazards and support long-term sustainability. The concept of smart cities combines information and communication technologies (ICT) with improving residents' quality of life and operational efficiency while considering future generations' environmental, social, and economic needs (Huovila, 2019). Urban resilience refers to the ability of cities to respond to hazards, absorb them, and adapt to changes such as climate change, urbanization, or economic shocks (Wardekker, 2020; Drobniak, 2018). Actions to build urban resilience cover different dimensions, such as environmental, economic, social, infrastructural, and institutional, which allows for better integration of sustainable development (Chen, 2020; Ribeiro, 2019).

Data analysis and prediction are the last level that can be considered for smart city and urban resilience. Smart city elements in urban resilience at the level of data analysis and prediction offer advanced tools for monitoring, managing, and planning the development of cities, taking into account their ability to respond to disruptions and changes. Urban resilience includes the ability of the town to absorb, adapt, and transform in the face of disruptions such as natural disasters, climate change, or social and economic crises. Contemporary models suggest that the integration of Smart City with resilience includes four pillars:

- adaptability - the city's ability to adapt to new conditions,
- resilience - the ability to minimize the impact of disruptions,
- recovery - the ability to quickly return to pre-disruption functions,
- transformation - the ability to change into a more resistant form (Chen, 2020; Vesalitskaya, 2019).

Smart Cities use advanced technologies such as IoT, Big Data, and AI to support resilience by:

- Real-time monitoring – e.g., GIS systems allow for the identification of areas susceptible to natural disasters (Sajjad, 2021).
- Modeling and simulations – e.g., predictive models forecast the effects of climate change and help develop adaptation plans (Chen, 2020).
- City indicators—Standard indicators for smart cities support the assessment of progress towards sustainable development (Huovila, 2019).

Resilience is increasingly essential in urban management, especially in global challenges such as climate change, natural disasters, and social and economic crises. Modern cities, as complex systems, must survive disruptions and quickly regenerate, adapt to new conditions, and implement lasting changes to increase their resilience for the future. Urban resilience is an interdisciplinary concept that integrates social, economic, environmental, and technological aspects to support cities in building lasting security and stability (Albino 2015). The basic assumption of urban resilience is the ability of cities to absorb disruptions, quickly return to normal functioning, and transform their systems into more sustainable and resilient ones.

4. Examples of smart city solutions in city resilience

Resilient cities using smart city technologies use advanced technological solutions to improve adaptability, crisis resilience, and the quality of life of their inhabitants.

One of the most advanced cities in the world in terms of using smart city technologies and building urban resilience is Rotterdam in the Netherlands. The city has created innovative solutions such as "Water Squares", which function as public spaces and water retention during floods. Rotterdam is implementing intelligent water level monitoring and risk forecasting systems to support flood protection. Integrated urban planning includes green areas and climate-resilient infrastructure, making Rotterdam a model for adaptation and sustainable urban development (Amirzadeh, 2022; Wardekker, 2020).

Another resilient city is Hong Kong. Hong Kong is a resilient Smart City that effectively copes with natural hazards thanks to advanced GIS technologies and intelligent resource management systems. The high density of development requires precise spatial planning, so the city has implemented digital solutions to monitor and analyze risks such as floods

and typhoons. Hong Kong also integrates transport and infrastructure systems to ensure greater resilience to crises, making it a model for other densely populated cities.

On the other hand, Vienna in Austria focuses on energy savings and emission reductions through programs such as the " Electric Mobility Program" and "Urban Heating and Cooling Program." The city has introduced green standards in public procurement and is becoming a global leader. Vienna integrates advanced technologies with climate policy, investing in modern infrastructure and green urban spaces. Thanks to these actions, the city strengthens its resilience to climate change. It improves the quality of life of its inhabitants, setting new standards in urban management and adaptation to future challenges.

A Polish city that is an example of urban resilience is Katowice. Katowice, especially the Załęże district, is an example of urban resilience in Poland, developed within the URBACT project "Resilient Europe". The city has implemented a local action program, combining Smart City technologies with adaptation to socio-economic challenges. Załęże integrates green spaces and an innovative approach to spatial planning, improving residents' quality of life. Katowice invests in crisis-resistant infrastructure and sustainable development, becoming a model for other European post-industrial cities. Thanks to strategic analysis and cooperation of the local community, the city builds resilience to changes and economic shocks, creating a sustainable future.

5. Conclusions

Integrating the Smart City concept with urban resilience is a key element of modern city management. It enables them to be better prepared for crises, respond faster to disruptions, and build long-term stability. Using advanced technologies such as the Internet of Things (IoT), real-time data analysis, or artificial intelligence, Smart City allows for more effective monitoring, management, and planning of urban spaces. Introducing such solutions helps improve the functioning of cities, increasing their ability to adapt and regenerate after crises and enabling transformation into more sustainable and resilient systems. A key aspect of urban resilience is its multidimensional nature, encompassing social, economic, environmental, and technological factors. Pillars such as resilience, regeneration, adaptation, and transformation are reinforced by innovative Smart City technologies, which enable ongoing monitoring of the condition of infrastructure, optimization of the management of urban resources, and faster response to unforeseen situations. By integrating solutions such as intelligent transport systems, energy networks, or water management systems, cities can more effectively minimize the effects of crises and reduce the time and costs of reconstruction. Examples of cities such as Rotterdam, Katowice and Singapore illustrate the potential of this integration in practice. Rotterdam has implemented intelligent water management systems

and solutions such as "Water Squares", which support water retention and protect the city from floods. As part of the URBACT project, Katowice combines Smart City technologies with local initiatives, improving residents' quality of life and strengthening social cohesion. In turn, thanks to advanced transport systems and innovative energy solutions, Singapore has become a model for other cities, effectively combining resilience and operational efficiency. Smart City and urban resilience are not free from challenges, such as the lack of uniform standards, limited data availability, or the diversity of local conditions. Nevertheless, their integration offers enormous potential for transforming cities into more resilient, sustainable, and friendly environments. In the era of climate change, urbanization, and growing socio-economic pressure, the development of these concepts is a necessity and an opportunity to improve residents' quality of life. In the future, further research and innovative implementations in Smart City and urban resilience can become the foundation for sustainable city management. The synergy between technology, urban planning, and social engagement will enable the creation of cities that not only effectively cope with current challenges but also build a safe and stable future for future generations.

References

1. Albino, V., Berardi, U., Dangelico, R.M. (2015). Smart cities: Definitions, dimensions, performance, and initiatives. *Journal of Urban Technology*, *22(1)*. Retrieved from: https://www.mendeley.com/catalogue/ce4d9c1a-be6e-3217-830c-c2aa0d894e0f/, 21.08.2024.
2. Almulhim, A.I., Cobbinah, P.B. (2024). Framing resilience in Saudi Arabian cities: On climate change and urban policy. *Sustainable Cities and Society*, *101,* doi:10.1016/j.scs.2024.105172.
3. Amegavi, G.B., Nursey-Bray, M., Suh, J. (2024). Exploring the realities of urban resilience: Practitioners' perspectives. *International Journal of Disaster Risk Reduction*, *103*, doi:10.1016/j.ijdrr.2024.104313.
4. Amirzadeh, M., Barakpour, N. (2021). Strategies for building community resilience against slow-onset hazards. *International Journal of Disaster Risk Reduction*, *66*, *102599*, doi:10.1016/j.ijdrr.2021.102599.
5. Amirzadeh, M., Sobhaninia, S., Sharifi, A. (2022). Urban resilience: A vague or an evolutionary concept? *Sustainable Cities and Society*, *81*, doi:10.1016/j.scs.2022. 103853.
6. Barata-Salgueiro, T., Erkip, F. (2014). Retail planning and urban resilience – An introduction to the special issue. *Cities*, *36*, pp. 107-111, doi:10.1016/j.cities.2013.01.007.

7. Büyüközkan, G., Ilıcak, Ö., Feyzioğlu, O. (2022). A review of urban resilience literature. *Sustainable Cities and Society*, *77*, *103579*, doi:10.1016/j.scs.2021.103579.
8. Chen, C., Xu, L., Zhao, D., Xu, T., Lei, P. (2020). A new model for describing the urban resilience considering adaptability, resistance and recovery. *Safety Science*, *128*, *104756*, doi :10.1016/j.ssci.2020.104756.
9. Coaffee, J. (2008). Risk, resilience, and environmentally sustainable cities. *Energy Policy*, *36(12)*, pp. 4633-4638, doi:10.1016/j.enpol.2008.09.048.
10. da Silva Tomadon, L., do Couto, E.V., de Vries, W.T., Moretto, Y. (2024). Smart city and sustainability indicators: A bibliometric literature review. *Discover Sustainability*, *5(1)*, pp. 1-21. Retrieved from: https://link-1springer-1com-1bnnegvla036f.han.polsl.pl/article/10.1007/s43621-024-00328-w, 5.08.2024.
11. Drobnik, A. (2018). Urban resilience programming – the example of the Załęże district in Katowice. *Scientific Works of the Wrocław University of Economics, No. 502,* doi:10.15611/pn.2018.502.02.
12. From fail-safe to safe-to-fail: Sustainability and resilience in the new urban world— *ScienceDirect*. Retrieved from: https://www.sciencedirect.com/science/article/abs/pii/S016920461100079, 7.09.2024.
13. Huang, G., Li, D., Zhu, X., Zhu, J. (2021). Influencing factors and their influencing mechanisms on urban resilience in China. *Sustainable Cities and Society, 74*, *103210*, doi: 10.1016/j.scs.2021.103210.
14. Huovila, A., Bosch, P., Airaksinen, M. (2019). Comparative analysis of standardized indicators for Smart sustainable cities: What indicators and standards to use and when? *Cities, 89,* pp. 141-153, doi:10.1016/j.cities.2019.01.029.
15. Jania, A. (2021). Diagnosing Urban Resilience in an Evolutionary Approach. *Acta Universitatis Lodziensis. Folia Oeconomica, 4(355)*, pp. 4-27, https://doi.org/10.18778/0208-6018.355.01.
16. Ji, X., Chen, J., Zhang, H. (2024). Smart city construction empowers tourism: Mechanism analysis and spatial spillover effects. *Humanities and Social Sciences Communications, 11(1)*, pp. 1-14. Palgrave, Downloaded January 3, 2025. Retrieved from: https://link-1springer-1com-1bnnegvla036f.han.polsl.pl/article/10.1057/s41599-024-03626-w
17. Jiang, H., Jiang, P., Wang, D., Wu, J. (2021). Can smart city construction facilitate green total factor productivity? A quasi-natural experiment based on China's smart city pilot. *Sustainable Cities and Society, 69, 102809*, doi:10.1016/j.scs.2021.102809.
18. Meerow, S., Newell, J.P., Stults, M. (2016). Defining urban resilience: A review. *Landscape and Urban Planning, 147,* pp. 38-49, doi :10.1016/j.landurbplan.2015.11.011.
19. Palakhamarn, T., Kamolvej, T. (2024). Revitalizing Urban Resilience in Thailand: Exploring Conceptual Frameworks and Terminology. *Journal of Architectural/Planning Research and Studies, 21(2),* pp. 263-282, doi:10.56261/jars.v21.262070.
20. Ribeiro, P.J.G., Gonçalves, L.A.P.J. (2019). Urban resilience: A conceptual framework.

Sustainable Cities and Society, *50*, doi:10.1016/j.scs.2019.101625.

21. Sajjad, M., Chan, J.C.L., Chopra, S.S. (2021). Rethinking disaster resilience in high-density cities: Towards an urban resilience knowledge system. *Sustainable Cities and Society, 69, 102850*. doi:10.1016/j.scs.2021.102850.
22. Shafiei Dastjerdi, M., Lak, A., Ghaffari, A., Sharifi, A. (2021). A conceptual framework for resilient place assessment based on spatial resilience approach: An integrative review. *Urban Climate, 36*, *100794*, doi:10.1016/j.uclim.2021.100794.
23. Shamsuddin, S. (2020). Resilience resistance: The challenges and implications of urban resilience implementation. *Cities, 103*, doi:10.1016/j.cities.2020.102763.
24. Shao, H., Tang, X., Xiao, X., Ma, Y., Lin, Z. (2024). Can Smart city policies enhance corporate environmental performance? Evidence from China. *Environment, Development and Sustainability*, pp. 1-32. https://link-1springer-1com-1bnnegvla036f.han.polsl.pl/article/10.1007 /s10668-024-05427-2, 5.08.2024.
25. Sharifi, A., Yamagata, Y. (2014). Resilient Urban Planning: Major Principles and Criteria. *Energy Procedia, 61*, pp. 1491-1495, doi:10.1016/j.egypro.2014.12.154.
26. Wang, W., Wei, H., Hassan, H., He, X. (2024). Research progress and prospects of urban resilience in the perspective of climate change. *Frontiers in Earth Science, 12*, doi:10.3389/feart.2024.1247360.
27. Zeng, X., Yu, Y., Yang, S., Lv , Y., Sarker, M.N.I. (2022). Urban Resilience for Urban Sustainability: Concepts, Dimensions, and Perspectives. *Sustainability*, *14(5)*, doi:10.3390/su14052481.