Współczesna Gospodarka

Contemporary Economy
Electronic Scientific Journal
Współczesna Gospodarka (ug.edu.pl)

Vol. 20 Issue 1 (2026) 85-98
*ISSN*2082-677X
DOI 10.26881/wg.2026.1.07

URBAN RESILIENCE TO BLACK SWANS AND THEIR IMPACT ON RESIDENTS' MOBILITY

Sandra Żukowska, Beata Chmiel

Abstract

Purpose. Contemporary cities face a growing number of sudden events that can affect the functioning of urban mobility systems. Their varied origins and course make them difficult to predict and respond to. The analysis aimed to define the concept of urban resilience and to specify which events can be classified as black swans and how they affect the mobility of city residents, in particular the passenger transport system.
Methodology. Due to the purpose of the study, it was necessary to use the Systematic Literature Review method, whose main assumption is to systematize knowledge in a specific area. The EBSCO, Scopus, and Web of Science databases were searched using two queries. A total of 147 publications were included in the full-text analysis. The PRISMA methodology was used for the review to ensure the study's transparency. Subsequently, a bibliometric analysis of 125 publications was performed using VOSviewer software.
Findings. The analysis showed that most publications on defining resilience and resilience strategies date from 2010 to 2025. This indicates a growing interest among researchers in the topic of resilience, which may be a response to increasingly frequent crises and sudden events. Furthermore, most analyses concern Asia and Europe. The COVID-19 pandemic has significantly contributed to the development of studies on urban resilience.

Keywords: urban mobility, resilience, black swans, urban authorities.

JEL classification: R41, Q54, O18

Introduction

Cities of all sizes face many environmental, socio-economic, and spatial challenges. It is now recognised that the functioning of cities is increasingly affected by factors such as population migration, climate change, economic crises, and other sudden events that are difficult to predict and prepare for (Aven, 2013). A special type of disruption is the so-called "black swan", i.e., events that are relatively rare, difficult to predict, but which can have a major impact on the functioning of systems. "Black swans" were first described in the book by N.N. Taleb (Taleb, 2008). One of the areas most vulnerable to various types of disruption is mobility, particularly passenger transport. Sudden events such as natural disasters or breakdowns affect infrastructure,

leading to reduced functionality or destruction (Hong et al., 2021). As a result, escape routes are compromised and crisis management becomes less effective. During emergencies, residents' mobility patterns are disrupted. People's behaviour is generally difficult to predict, which can exacerbate the crisis and slow down the process of rebuilding communities.

The literature offers many approaches to defining resilience, depending on the field of science or type of disruption. This research gap was the starting point for formulating the main objective of the study, which was to define the concept of urban resilience and to clarify what events can be classified as black swans and how they affect the mobility of city residents, in particular the passenger transport system. Two specific objectives were also identified: (1) to analyse whether and how the concept of "black swan" is used in scientific literature in the context of research on urban resilience and mobility, and (2) to identify what strategies for responding to disruptions are used in crisis situations.

The article uses the Systematic Literature Review method and bibliometric analysis, which are described in detail in the "Methodology" section. The results are then described based on the literature review matrix. Finally, conclusions are drawn.

1. Methodology

Resilience is an interesting area of research, and there are many studies in the scientific literature that refer to various aspects of resilience. The research objective was achieved through the use of qualitative methods: a systematic literature review, bibliometric analysis, and qualitative content analysis. The research procedure is presented in Figure 1.

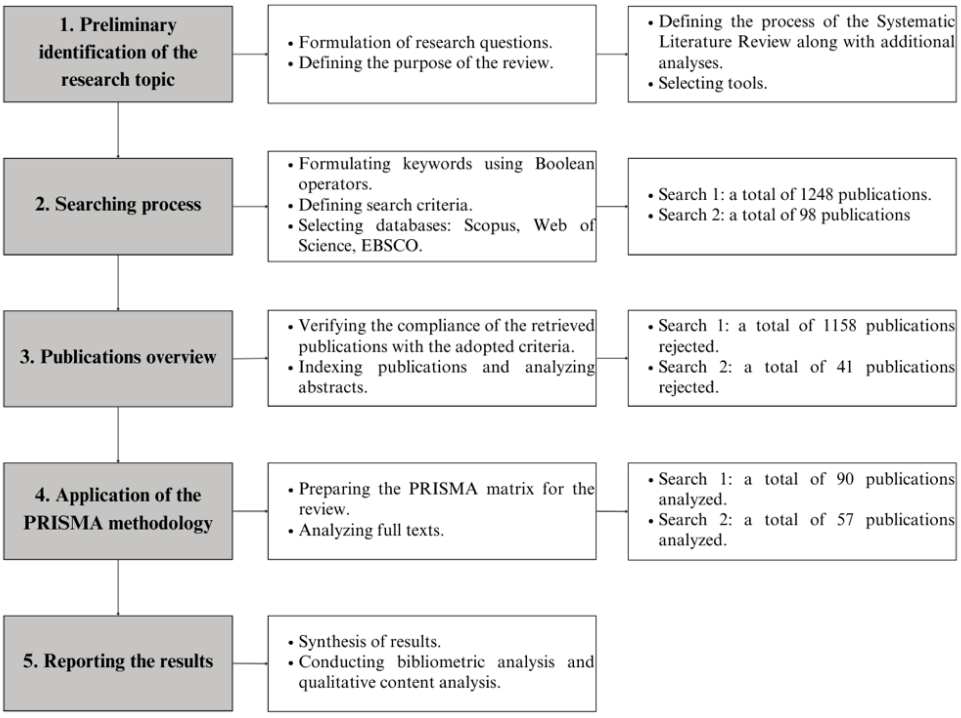

Figure 1. Research procedure

Source: own elaboration.

The article uses the Systematic Literature Review method, which allows for systematic, repeatable, and transparent analysis of scientific publications (Lame, 2019). This makes it possible to systematise knowledge and draw detailed conclusions. Two queries were formulated using Boolean logical operators. Search 1: "urban transport" OR "public transport" OR "urban

mobility") AND ("black swan*" OR "extreme event*" OR "resilience". Search 2: "transport system resilience" OR "resilient infrastructure") AND ("risk management" OR "crisis response" OR "emergency preparedness") AND ("urban" OR "cit*" OR "agglomeration*") AND ("case stud*" OR "comparative stud*").

Three publicly available databases were searched: EBSCO, Web of Science, and Scopus. Restrictive conditions were also defined. Only publications in English, peer-reviewed, and available in open access were searched. The time frame was limited to the period 2005-2025, which was conditioned by a marked increase in researchers' interest in this topic a decade ago. Table 1 presents the results of the database search in detail.

Table 1. Systematic Literature Review summary

Search	Databases	N searches	N rejected	N after analysis of abstract	N full-text analysis
("urban transport" OR "public transport" OR "urban mobility") AND ("black swan*" OR "extreme event*" OR "resilience")	EBSCO	587	533	5	90
	Scopus	403	240	15	
	Web of Science	258	103	70	
("transport system resilience" OR "resilient infrastructure") AND ("risk management" OR "crisis response" OR "emergency preparedness") AND ("urban" OR "cit*" OR "agglomeration*") AND ("case stud*" OR "comparative stud*")	EBSCO	4	1	3	57
	Scopus	98	56	42	
	Web of Science	19	7	12	

Source: own elaboration.

The publications were catalogued using Mendeley reference management software. Then, after rejecting publications that did not meet the criteria, 90 publications in search 1 and 57 publications in query 2 were included in the full-text analysis. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) methodology was used for the full-text analysis, which allows for the structured analysis of texts using qualitative content analysis (Sarkis-Onofre et al., 2021). The manuscripts were analysed using a matrix that indicated the basic metadata of the publication (year, authors, country, purpose), the methods used, and the main conclusions, depending on the specific query.

Next, a bibliometric analysis was conducted. Ultimately, 69 publications from query 1 and 56 publications from query 2 were included, and articles that did not contain the sought-after information were eliminated. The publicly available VOSviewer programme was used for the bibliometric analysis. A map of keywords was created based on the metadata included in the analysis of the publications. Next, mind maps were used to identify various resilience strategies described in scientific publications. A map of the affiliations of researchers working on the subject of resilience was also created using specialised QGIS software. A detailed analysis of the content and metadata of a total of 125 scientific publications allowed for in-depth conclusions to be drawn.

2. Findings

The geographical distribution of authors addressing the issue of resilience is shown in Figure 2. The greatest research interest in issues related to defining resilience in the context of mobility and transport, as well as models and strategies aimed at strengthening it, was noted primarily in European and Asian countries. The largest group of publications comes from the United Kingdom, followed by China, Portugal, France, Italy, Brazil, Australia, and Chile.

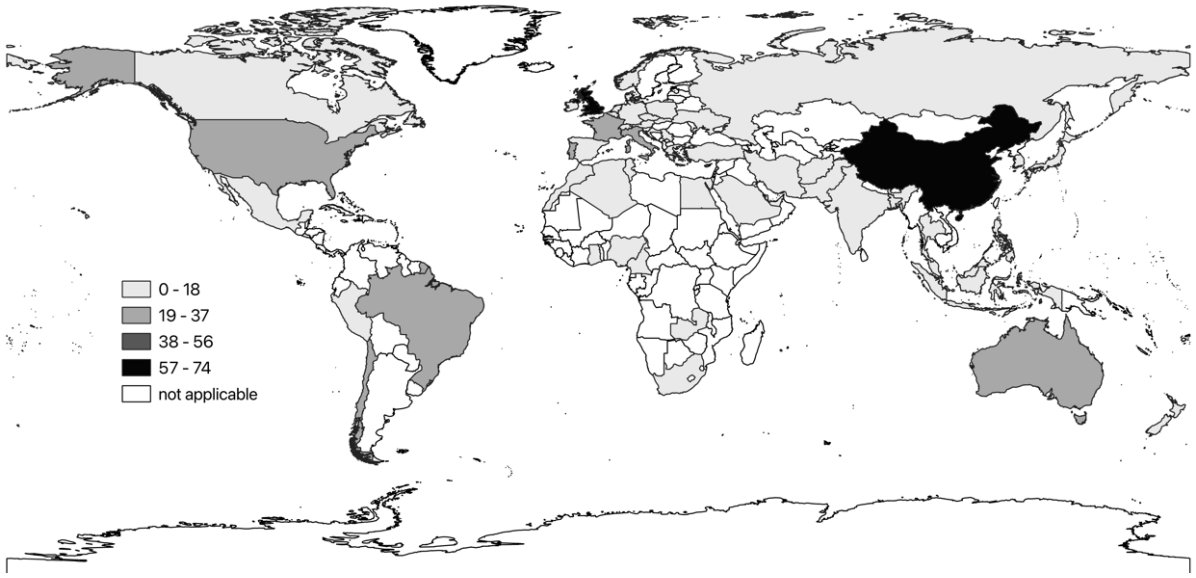

Figure 2. Research interest in urban resilience in the context of mobility and transport
Source: own elaboration.

The analysis indicates that most research focuses on theoretical rather than practical issues. There is also a noticeable difference in the structure of research teams, with more researchers working in the field of theoretical and definitional analysis than in the field of practical applications. The highest level of research activity in the field of transport resilience and mobility can be observed in countries with a well-established scientific tradition and developed transport infrastructure. The dominant position of the United Kingdom and China compared to other countries may be related to long-standing research policies focused on resilience issues in the context of, among other things, climate change and systemic threats.

In the area of models and strategies aimed at strengthening resilience, relatively lower research activity was noted, which may suggest that issues related to practical solutions in this area remain at the development stage. Here too, highly developed countries such as the United Kingdom, the United States, and China play a dominant role. This can also be linked to both greater opportunities for funding applied research and growing adaptation needs resulting from climate threats and social challenges.

It should also be emphasised that the United Kingdom has the highest level of involvement in theoretical and practical research in the field of resilience. China and the United States are ranked next, reflecting the established and growing importance of these countries in the global scientific discourse. In the case of other countries, such as Portugal, significant research activity has also been noted, with greater intensity of research in the area of definitions than in applications, which may indicate the stage of development of national research trends. A similar trend has been observed in Italy, France, and Brazil.

Figure 3 presents the results of bibliometric modelling in the form of keyword maps relating to the issue of resilience.

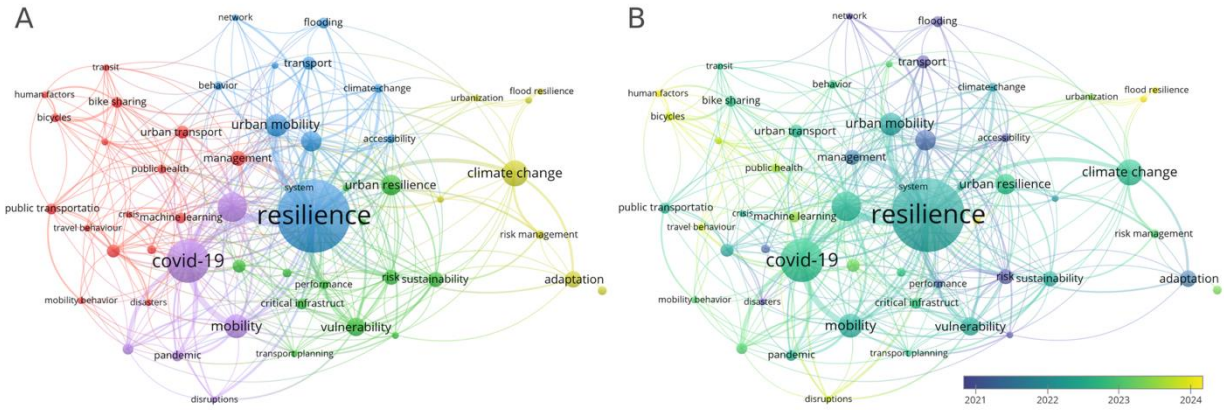

Figure 3. Co-occurrence map of keywords related to "resilience" (A) and requency of occurrence over time (B)

Source: own elaboration.

For transparency of results and to narrow down the analysis to the most representative concepts, only keywords appearing at least three times in the analysed corpus of publications were included in the further stages of the study. For example, setting a lower threshold ($x < 3$) would result in excessive consideration of keywords with limited analytical value, while using a higher threshold ($x > 3$) could lead to the exclusion of relevant but less frequently occurring terms. Of the 711 terms identified, 53 met this criterion, which made it possible to extract a network of connections centred around the most frequently used concepts.

An analysis of the frequency of occurrence and the total strength of connections, reflecting the intensity of co-occurrence of individual terms with other concepts, clearly indicates that the central concept in the studied corpus of publications is the term "resilience". It was recorded 42 times and achieved the highest link strength value (117), confirming its overriding role in the scientific discourse on transport and mobility resilience. The term "COVID-19" ranks second (23 occurrences, 79 links), which confirms the significant impact of the pandemic on the intensification of research on the resilience of transport systems. The concept of "public transport" (15 occurrences, 63 links) also occupies a significant position, indicating the high importance of public transport as a key area of resilience analysis. Other keywords, such as "mobility" (12 occurrences; 46 links), "urban mobility" (11; 40), "vulnerability" (9; 40), and "climate change" (13; 29), despite their lower frequency of occurrence, form significant links. This indicates an intensifying interest in the issue of resilience in the context of urban mobility and climate challenges, and, on the other hand, the need for an in-depth analysis of phenomena related to the vulnerability of transport systems to disruptions.

The analysis of keyword co-occurrence enabled the identification of five thematic clusters (see Figure 3A), which reflect the dominant research trends in the area of transport resilience and mobility. The identified clusters provide a synthetic overview of the main directions of analysis, showing the diversity of theoretical and applied approaches:

- Cluster I (blue) covers issues related to mobility and transport, including concepts such as "urban mobility", "transport", "network", and "flooding". It focuses on the functioning of transport systems in conditions of disruption and on the analysis of infrastructural determinants of resilience.
- Cluster II (red) covers issues related to public transport and user behaviour. It includes concepts such as "public transport", "urban transport", "bike sharing", "human factors", and "travel behaviour". This cluster emphasises the importance of research on urban mobility, public transport, and new forms of mobility, as well as on the social conditions

that shape the resilience of transport systems. It also points to the need to take social factors into account as an element of increasing adaptation and resilience.

- Cluster III (purple) focuses on issues related to the pandemic and other crisis situations. It includes the following keywords: "COVID-19", "pandemic", "disasters", "crisis", and "machine learning". This cluster takes into account the significant role of the COVID-19 pandemic as a catalyst for intensifying research on the resilience of transport systems and mobility. At the same time, it points to the growing importance of using advanced analytical methods, including machine learning, in identifying, modelling, and assessing the effects of crisis events, and in formulating adaptation strategies.
- Cluster IV (green) covers issues related to the vulnerability of systems to disruption and the functioning of critical infrastructure. It includes keywords such as "vulnerability", "risk", "sustainability", "critical infrastructure", "urban resilience", and "transport planning". This cluster emphasises the key role of risk analysis and transport planning in strengthening the resilience of mobility systems.
- Cluster V (yellow) refers to issues related to climate change and adaptation. It includes concepts such as "climate change", "adaptation", "risk management", "flood resilience", and "urbanization". This highlights the growing importance of research on the impact of climate change on transport systems and adaptation strategies. The term "resilience", assigned to the blue cluster, occupies a central position in the entire network, serving as a hub integrating various research trends.

An analysis of the temporal dimension of keyword co-occurrence networks (see Figure 3B) indicates a clear evolution in research topics. In the earlier period (2021; blue-purple colours), concepts related to the classical approach to infrastructure resilience, such as "vulnerability", "critical infrastructure", "risk sustainability", and "flooding", dominated. In 2022–2023 (green), the focus of scientific discourse shifted towards research on "resilience", "urban mobility", "mobility", and "climate change", reflecting the impact of the COVID-19 pandemic and the growing importance of climate challenges for transport systems. The latest stage (2024; yellow) is characterised by an increase in interest in practical and social issues such as bike sharing, human factors, and urbanisation, indicating an intensification of research into adaptive strategies in the field of sustainable urban mobility.

Although the analysed collection also includes publications from earlier years (the oldest one from 2012), the time scale of the keyword co-occurrence map covers the period 2021–2024, which results from the fact that it was mainly in this time interval that the highest frequency of occurrence of key terms was recorded, which caused the average dates of their appearance to shift towards recent years.

Based on the literature review, it can be concluded that previous studies have focused mainly on analysing the impact of the COVID-19 pandemic on the functioning of transport systems in cities (Bubicz et al., 2023; Downey et al., 2022; D. Li & Lasenby, 2023a, 2023b; X. Li et al., 2022; Simic et al., 2022; Teixeira et al., 2021; Tori et al., 2023a, 2023b; Wang et al., 2022). Special focus was placed on shared systems, such as public bicycles and electric scooters, as well as adaptation processes in transport planning and issues related to changes in users' transport behaviour (Q. An et al., 2025; Y. An, 2022; Bergantino & Gardelli, 2024; Borowska-Stefanska et al., 2024; Dadashzadeh et al., 2025; Dias et al., 2021a, 2021b; Q. M. Li & Xu, 2022; Nikiforiadis et al., 2020; Talpur et al., 2025; Teixeira, Silva, & Moura e Sá, 2021; Teixeira, Silva, & Sá, 2021; Teixeira & Lopes, 2020; Tori et al., 2023a; Yang et al., 2022). The studies also emphasised the importance of transport system resilience, defined as the ability to maintain continuity of mobility in crisis situations and to respond effectively to external shocks.

The publications analysed differ in their definition of resilience, but several approaches can be identified. In some studies, the resilience of the transport system is understood in functional terms, as the ability to maintain basic transport functions despite disruptions. In this context, the

need to ensure the continuity of residents' mobility even in crisis conditions is emphasised. The second approach defines resilience as the system's ability to respond to shocks and disruptions. In this context, urban transport is seen as a structure exposed to sudden and unpredictable events, from health crises to infrastructure disasters, which must demonstrate the ability to both "absorb" disruptions and return to equilibrium once the event has ceased.

Some studies refer to the broader concept of resilience, in which transport is an integral part of the functioning of the entire urban system (Ge et al., 2022; Martins et al., 2019; Teixeira & Lopes, 2020; Thombre & Agarwal, 2021). In this approach, resilience means not only "surviving" a crisis period, but also the ability to adapt and transform, enabling the implementation of new solutions and long-term increases in the flexibility of the system.

In literature, particularly that devoted to urban transport, the concepts of resilience and "black swans" appear in different but interrelated contexts. Some of the analyses do not contain a direct definition of the term "resilience", but use it in a descriptive sense (Hasselwander et al., 2021; Nikiforiadis et al., 2020; Simic et al., 2022; Teixeira, Silva, & Sá, 2021). This indicates that the concept is still insufficiently conceptualised in the field of transport research. A review of the literature shows that the concept of "black swans" appears sporadically and is usually not clearly defined. In most studies, authors focus on the consequences of the COVID-19 pandemic as a sudden and unpredictable phenomenon, without directly referring to the concept proposed by NN. Taleb (Taleb, 2008).

Only a few studies have addressed this issue directly. In the study, Ge et al. (2022) "black swans" were defined as extreme events that are difficult to predict and have a significant impact on transport systems. The authors emphasise that these are rare but highly influential phenomena that reveal the weaknesses of existing systems. Instead, Zou et al. (2025) they refer to potential future crises, referred to as "Disease X", i.e., unpredictable events that could act as "black swans" in public transport. Future, as yet unknown infectious diseases with pandemic potential, which could suddenly and radically disrupt the functioning of transport systems, were cited as an example.

The COVID-19 pandemic serves as a typical example of a "black swan" in research, i.e., a phenomenon characterised by a low probability of occurrence, a high degree of unpredictability, and serious consequences for socio-economic systems, including urban transport systems. No other examples of events classified as "black swans" have been reported in the research to date. This limitation may be due to the concentration of the literature on a single, globally felt crisis that dominated scientific discourse in 2019–2022. This points to a research gap in considering other potential events of this type that may affect transport systems in the future, such as sudden climate disasters, cyberattacks on critical infrastructure, or unexpected energy crises. The vast majority of studies use terms such as 'disruptions' rather than "black swans".

Terms closely related in meaning and subject matter to the concept of "black swans" are also commonly used in research, such as: disruptions, shocks, catastrophes, disruptive events, extraordinary situations, unpredictable events, disruptive events or extreme events. The most frequently cited example of this type of phenomenon was the COVID-19 pandemic, followed by social events (public transport strikes, terrorist attacks), technical events (infrastructure failures, targeted attacks – cyber and physical) and natural events (extreme weather phenomena, including storms, floods, snowstorms and fires, as well as natural disasters, catastrophes and other pandemics).

When comparing both concepts, it can be concluded that in research, resilience refers to the properties of a system, i.e., its strength, flexibility, and adaptability, while "black swans" refer to a category of events with a difficult-to-predict course that test this resilience. In research and planning practice, this implies the need to design transport resilience taking into account the inevitability of "black swans", even though their nature and timing remain unknown.

The occurrence of disruptions and "black swans" disrupts the functioning of systems, necessitating rapid response and adaptation measures. The scientific literature contains many

references to the practical use of various resilience strategies. 42% of these come from Asia, mainly China and India. Twenty-eight per cent are examples from Europe, dominated by Italy, the Netherlands, and the United Kingdom. Nine per cent of studies on the use of a specific resilience strategy are examples from South America and the same number from Australia, while examples from Africa and North America account for 7% and 5% respectively. This indicates greater interest in the area of resilience in Asia and Europe, which may be due to more frequent disruptions and a more developed area of crisis management.

Figure 4. Map of applied resilience strategies

Source: own elaboration.

The choice of strategy depends primarily on the type of disruption, the infrastructure at risk, and institutional, demographic, and geographical conditions. The resilience strategies identified in the literature are divided into: (1) green solutions, (2) technical strategies, (3) social and institutional strategies, (4) solutions based on the choice of a specific urban development concept, (5) planning and adaptation strategies, and (6) data-driven strategies. Within each group, several specific strategies were identified that require varying amounts of financial resources, human capital, labour, or materials. Each group of strategies has strengths and weaknesses that can determine the effectiveness of the reconstruction or adaptation process.

Green solutions, which include Nature-based Solutions and Green Infrastructures, are based on building sustainable infrastructure and supporting biodiversity (Almheiri et al., 2024). An example of such solutions is the construction of retention basins near important transport hubs or green public transport stops. These solutions are relatively inexpensive and bring long-term benefits. However, they require coherent spatial planning, and selective implementation is ineffective (Kapucu et al., 2024). Technical strategies primarily involve engineering solutions, such as the construction of new infrastructure or the creation of models using geoinformation data (Pakati et al., 2025). Technical strategies enable a rapid response to disruptions at critical points (e.g., bridges, tunnels), protecting particularly sensitive areas. They require significant financial investment and large amounts of high-quality data (Garshasbi et al., 2025).

Social and institutional strategies, such as knowledge management and transmission of memory about the disaster, are mainly aimed at increasing the level of acceptance of crisis management measures by local communities and accelerating the reconstruction/adaptation process. (Fontanella Pisa, 2024). However, it should be emphasised that social and institutional strategies can have a negative impact on communities by perpetuating trauma and exacerbating social inequalities (Silchenko & Murray, 2023).

Urban development strategies, such as resilient cities, smart cities, and green cities, can also be effective in building resilience. These strategies incorporate elements of resilience through a long-term focus on improving the quality of life and the efficiency of city functioning (Monstadt & Coutard, 2019). Implementing the objectives of a specific development concept requires long-term development planning, the involvement of many stakeholder groups, and effective management (Monstadt & Coutard, 2019). In practice, building resilience based solely on the concept of development may encounter social resistance. Another group consists of planning and adaptation strategies, which include Disaster Risk Management and the 5-step process of incorporating climate into development plans. Their strengths include a long-term planning perspective, high effectiveness, and stakeholder involvement (Afrin et al., 2021). The lack of integration between different systems, the lack of data standardization, and the reluctance of stakeholders to get involved remain a challenge (das Dores de Jesus Da Silva et al., 2024). The last group consists of data-driven strategies that utilise modern artificial intelligence and machine learning technologies. These strategies require many complex calculations and highly qualified staff (Aldahlawi et al., 2024). Strengths include increased crisis management efficiency and the accuracy of forecasts (Xing et al., 2025).

Based on the analysis of the identified resilience strategies, it is not possible to unequivocally identify the better one. The identified strengths and weaknesses of the strategies rather indicate that they complement each other. Therefore, municipal authorities should skilfully plan crisis management, taking into account various elements of resilience strategies.

Conclusion

An analysis of scientific literature has identified significant trends in research on the resilience of transport systems and mobility. The highest level of research activity has been observed in developed countries, primarily in the United Kingdom, China, and the United States. It should be emphasised that theoretical research plays a dominant role. The COVID-19 pandemic has been a catalyst for the development of this research area, leading to an intensification of research on public transport, shared systems, and user transport behaviour.

In terms of time, the evolution of the subject matter is evident: from research on infrastructure vulnerability (2021), through the growing importance of mobility and resilience (2022–2023), to interest in adaptation strategies and social aspects of sustainable urban mobility (2024). The concept of transport resilience is defined in various ways: (1) as the ability of a system to maintain continuity of operation despite disruptions, (2) as its flexibility and adaptability to shocks, and (3) as part of a broader urban system in need of transformation. It has also been observed that the concept of "black swans" appears rarely and most often by default, with the COVID-19 pandemic being an example of a "black swan" for many authors.

The scientific literature contains many resilience strategies that address various disruptions, including floods, human error, and failures. The analysed studies are dominated by case studies and analyses of scientific and grey literature, conducted mainly in Asian and European countries. The identified strategies were grouped into six categories: (1) green solutions, (2) technical strategies, (3) social and institutional strategies, (4) solutions based on the choice of a specific urban development concept, (5) planning and adaptation strategies, and (6) data-based strategies. Each of these groups is based on different elements.

The selection of a specific strategy should be preceded by an analysis of demographic and geographical conditions, and a process of urban development planning. Only a resilience strategy tailored to local conditions can be effective. Many researchers have pointed to the key role of city authorities, who are responsible for urban development planning and crisis management, which is particularly important in the implementation of urban development concepts. In addition, the growing role of public participation should be emphasised. On the one hand, stakeholder

involvement can facilitate communication, but on the other, it can generate conflicts. However, there is no doubt that the importance of modern technologies and engineering will grow. Their implementation can contribute to more precise and effective planning and distribution of resources.

Despite the growing number of publications, there is still a need for in-depth conceptualisation of the concept of resilience and the development of research focused on specific, application-oriented solutions that increase the resilience of transport systems in the context of future, unpredictable challenges. Although the Systematic Literature Review allowed for an in-depth analysis of the concept of "resilience" and the identification of resilience strategies, its limitations should be pointed out. The analysis included a limited number of scientific publications, which could be expanded in the future to include an analysis of grey literature and municipal documents. Furthermore, the analysis showed that current resilience research focuses on the theoretical dimension, so further research is needed on the practical side of resilience.

This publication was prepared within the framework of the research project PRELUDIUM 23, financed by the National Science Centre, Poland, under the agreement no. UMO-2024/53/N/HS4/01417.

Bibliography

Afrin, S., Chowdhury, F. J., & Rahman, M. M. (2021). COVID-19 Pandemic: Rethinking Strategies for Resilient Urban Design, Perceptions, and Planning. In *Frontiers in Sustainable Cities* (Vol. 3). Frontiers Media S.A. https://doi.org/10.3389/frsc.2021.668263

Aldahlawi, R. Y., Akbari, V., & Lawson, G. (2024). A systematic review of methodologies for human behavior modelling and routing optimization in large-scale evacuation planning. In *International Journal of Disaster Risk Reduction* (Vol. 110). Elsevier Ltd. https://doi.org/10.1016/j.ijdrr.2024.104638

Almheiri, A., Montenegro, J. F., Ewane, E. B., & Mohan, M. (2024). Climate change hazards and the resilience of coastal cities in the Gulf Cooperation Council countries: A systematic review. In *City and Environment Interactions* (Vol. 24). Elsevier B.V. https://doi.org/10.1016/j.cacint.2024.100177

An, Q., Qin, Z., Cheng, L., & Li, W. (2025). Assessing the temporal and spatial resilience of bike-sharing demand: A spatiotemporal dynamic analysis. *KSCE Journal of Civil Engineering*, *29*(4). https://doi.org/10.1016/j.kscej.2024.100045

An, Y. (2022). IMPACT OF COVID-19 ON ASSOCIATIONS BETWEEN LAND USE AND BIKE-SHARING USAGE. In J. van Ameijde, N. Gardner, K. H. Hyun, D. Luo, & U. Sheth (Eds.), *Proceedings of the International Conference on Computer-Aided Architectural Design Research in Asia* (pp. 605–614). The Association for Computer-Aided Architectural Design Research in Asia. https://doi.org/10.52842/conf.caadria.2022.1.605

Aven, T. (2013). On the meaning of a black swan in a risk context. *Safety Science*, *57*, 44–51. https://doi.org/10.1016/j.ssci.2013.01.016

Bergantino, A. S., & Gardelli, A. (2024). The contribution of e-scooters services to urban transport resilience. *Journal of Transport Geography*, *118*. https://doi.org/10.1016/j.jtrangeo.2024.103869

Borowska-Stefanska, M., Dulebenets, M. A., Koneczny, P., Kowalski, M., Masierek, E., Turobos, F., & Wisniewski, S. (2024). Changes to the Transport Behaviour of Inhabitants of a Large City Due the Pandemic. *SUSTAINABILITY*, *16*(6). https://doi.org/10.3390/su16062568

Bubicz, M., Arsenio, E., Barateiro, J., & Henriques, R. (2023). Planning for more resilient urban transport systems: Lessons learned from the Covid-19 pandemic. In L. de Picado Santos, J. Pinho de Sousa, & E. Arsenio (Eds.), *Transportation Research Procedia* (Vol. 72, pp. 3435–3442). Elsevier B.V. https://doi.org/10.1016/j.trpro.2023.11.774

Dadashzadeh, N., Volkova, N., Ekmekci, M., Horpenko, D., Woods, L., & Nikitas, A. (2025). What psychological and socio-demographic factors can influence people's intention to use ridesharing during the war? A case study in Ukraine. *TRANSPORTATION RESEARCH PART F-TRAFFIC PSYCHOLOGY AND BEHAVIOUR*, *109*, 211–230. https://doi.org/10.1016/j.trf.2024.12.014

das Dores de Jesus Da Silva, L., Kubisch, S., Aguayo, M., Castro, F., Rojas, O., Lagos, O., & Figueroa, R. (2024). Chilean Disaster Response and Alternative Measures for Improvement. *Social Sciences*, *13*(2). https://doi.org/10.3390/socsci13020088

Dias, G., Arsenio, E., & Ribeiro, P. (2021a). The Role of Shared E-Scooter Systems in Urban Sustainability and Resilience during the Covid-19 Mobility Restrictions. *SUSTAINABILITY*, *13*(13). https://doi.org/10.3390/su13137084

Dias, G., Arsenio, E., & Ribeiro, P. (2021b). The role of shared e-scooter systems in urban sustainability and resilience during the covid-19 mobility restrictions. *Sustainability (Switzerland)*, *13*(13). https://doi.org/10.3390/su13137084

Downey, L., Fonzone, A., Fountas, G., & Semple, T. (2022). The impact of COVID-19 on future public transport use in Scotland. *TRANSPORTATION RESEARCH PART A-POLICY AND PRACTICE*, *163*, 338–352. https://doi.org/10.1016/j.tra.2022.06.005

Fontanella Pisa, P. (2024). Understanding memory transmission in disaster risk reduction practices: A case study from Japan. *International Journal of Disaster Risk Reduction*, *100*. https://doi.org/10.1016/j.ijdrr.2023.104112

Garshasbi, D., Kitiphaisannon, J., Wongbumru, T., & Thanvisitthpon, N. T. (2025). Assessment of future urban flood risk of Thailand's bangkok metropolis using geoprocessing and machine learning algorithm. *Environmental and Sustainability Indicators*, *25*. https://doi.org/10.1016/j.indic.2024.100559

Ge, L. P., Voss, S., & Xie, L. (2022). Robustness and disturbances in public transport. *PUBLIC TRANSPORT*, *14*(1), 191–261. https://doi.org/10.1007/s12469-022-00301-8

Hasselwander, M., Tamagusko, T., Bigotte, J. F., Ferreira, A., Mejia, A., & Ferranti, E. J. S. (2021). Building back better: The COVID-19 pandemic and transport policy implications for a developing megacity. *SUSTAINABLE CITIES AND SOCIETY*, *69*. https://doi.org/10.1016/j.scs.2021.102864

Hong, B., Bonczak, B. J., Gupta, A., & Kontokosta, C. E. (2021). Measuring inequality in community resilience to natural disasters using large-scale mobility data. *Nature Communications*, *12*(1870), 1–9. https://doi.org/10.1038/s41467-021-22160-w

Kapucu, N., Ge, Y., Rott, E., & Isgandar, H. (2024). Urban resilience: Multidimensional perspectives, challenges and prospects for future research. *Urban Governance*, *4*(3), 162–179. https://doi.org/10.1016/j.ugj.2024.09.003

Li, D., & Lasenby, J. (2023a). Investigating impacts of COVID-19 on urban mobility and emissions. *CITIES*, *135*. https://doi.org/10.1016/j.cities.2023.104246

Li, D., & Lasenby, J. (2023b). Investigating impacts of COVID-19 on urban mobility and emissions. *Cities*, *135*. https://doi.org/10.1016/j.cities.2023.104246

Li, Q. M., & Xu, W. P. (2022). The impact of COVID-19 on bike-sharing travel pattern and flow structure: evidence from Wuhan. *CAMBRIDGE JOURNAL OF REGIONS ECONOMY AND SOCIETY*, *15*(3), 477–494. https://doi.org/10.1093/cjres/rsac005

Li, X., Ha, J., & Lee, S. (2022). MOBILITY RESILIENCE OF COMMUTE TRIPS DURING THE COVID-19 PANDEMIC IN SEOUL, KOREA. In C. C. Wang & S. Shirowzhan (Eds.), *ISPRS Annals of the Photogrammetry, Remote Sensing and Spatial Information*

Sciences (Vol. 10, Issues 4/W3-2022, pp. 135–142). Copernicus Publications. https://doi.org/10.5194/isprs-annals-X-4-W3-2022-135-2022

Martins, M. C. D., da Silva, A. N. R., & Pinto, N. (2019). An indicator-based methodology for assessing resilience in urban mobility. *TRANSPORTATION RESEARCH PART D-TRANSPORT AND ENVIRONMENT*, *77*, 352–363. https://doi.org/10.1016/j.trd.2019.01.004

Monstadt, J., & Coutard, O. (2019). Cities in an era of interfacing infrastructures: Politics and spatialities of the urban nexus. *Urban Studies*, *56*(11), 2191–2206. https://doi.org/10.1177/0042098019833907

Nikiforiadis, A., Ayfantopoulou, G., & Stamelou, A. (2020). Assessing the Impact of COVID-19 on Bike-Sharing Usage: The Case of Thessaloniki, Greece. *SUSTAINABILITY*, *12*(19). https://doi.org/10.3390/su12198215

Pakati, S. S., Shoko, C., & Dube, T. (2025). Integrated flood modelling and risk assessment in urban areas: A review on applications, strengths, limitations and future research directions. *Journal of Hydrology: Regional Studies*, *61*. https://doi.org/10.1016/j.ejrh.2025.102583

Sarkis-Onofre, R., Catalá-López, F., Aromataris, E., & Lockwood, C. (2021). How to properly use the PRISMA Statement. *Systematic Reviews*, *10*(1), 13–15. https://doi.org/10.1186/s13643-021-01671-z

Silchenko, D., & Murray, U. (2023). Migration and climate change – The role of social protection. In *Climate Risk Management* (Vol. 39). Elsevier B.V. https://doi.org/10.1016/j.crm.2022.100472

Simic, V., Ivanovic, I., Doric, V., & Torkayesh, A. E. (2022). Adapting Urban Transport Planning to the COVID-19 Pandemic: An Integrated Fermatean Fuzzy Model. *SUSTAINABLE CITIES AND SOCIETY*, *79*. https://doi.org/10.1016/j.scs.2022.103669

Taleb, N. N. (2008). *The Black Swan: The Impact of the Highly Improbable*. Penguin Books Ltd.

Talpur, A., Baig, F., Pervez, A., & Lee, J. J. (2025). Analysis of travel decision behaviour during extreme floods in Pakistan. *TRANSPORTATION SAFETY AND ENVIRONMENT*, *7*(1). https://doi.org/10.1093/tse/tdaf007

Teixeira, J. F., & Lopes, M. (2020). The link between bike sharing and subway use during the COVID-19 pandemic: The case-study of New York's Citi Bike. *TRANSPORTATION RESEARCH INTERDISCIPLINARY PERSPECTIVES*, *6*. https://doi.org/10.1016/j.trip.2020.100166

Teixeira, J. F., Silva, C., & Moura e Sá, F. (2021). The motivations for using bike sharing during the COVID-19 pandemic: Insights from Lisbon. *Transportation Research Part F: Traffic Psychology and Behaviour*, *82*, 378–399. https://doi.org/10.1016/j.trf.2021.09.016

Teixeira, J. F., Silva, C., & Sá, F. M. E. (2021). The motivations for using bike sharing during the COVID-19 pandemic: Insights from Lisbon. *TRANSPORTATION RESEARCH PART F-TRAFFIC PSYCHOLOGY AND BEHAVIOUR*, *82*, 378–399. https://doi.org/10.1016/j.trf.2021.09.016

Thombre, A., & Agarwal, A. (2021). A paradigm shift in urban mobility: Policy insights from travel before and after COVID-19 to seize the opportunity. *TRANSPORT POLICY*, *110*, 335–353. https://doi.org/10.1016/j.tranpol.2021.06.010

Tori, S., de Séjournet, A., & Macharis, C. (2023a). Reactions of the public transport sector to the COVID-19 pandemic. Insights from Belgium. *TRAVEL BEHAVIOUR AND SOCIETY*, *31*, 244–253. https://doi.org/10.1016/j.tbs.2023.01.001

Tori, S., de Séjournet, A., & Macharis, C. (2023b). Reactions of the public transport sector to the COVID-19 pandemic. Insights from Belgium. *TRAVEL BEHAVIOUR AND SOCIETY*, *31*, 244–253. https://doi.org/10.1016/j.tbs.2023.01.001

Wang, J., Huang, J., Yang, H., & Levinson, D. (2022). Resilience and recovery of public transport use during COVID-19. *Npj Urban Sustainability*, *2*(1). https://doi.org/10.1038/s42949-022-00061-1

Xing, Y., Shao, D., Yang, Y., Lin, Q., & Xu, Z. (2025). Evaluation of drainage efficiency via street inlets under the influence of terrain slope in the course of pluvial urban flood event. *Journal of Hydrology: Regional Studies*, *58*. https://doi.org/10.1016/j.ejrh.2025.102243

Yang, Y., Beecham, R., Heppenstall, A., Turner, A., & Comber, A. (2022). Understanding the impacts of public transit disruptions on bikeshare schemes and cycling behaviours using spatiotemporal and graph-based analysis: A case study of four London Tube strikes. *Journal of Transport Geography*, *98*. https://doi.org/10.1016/j.jtrangeo.2021.103255

Zou, L. M., Chen, Y. H., Guo, R., Wang, P. C., He, Y. R., Chen, S. Y., Wang, Z. J., & Zhu, J. M. (2025). Unraveling the impact of COVID-19 on Beijing's subway system using a causal machine learning analysis. *SUSTAINABLE CITIES AND SOCIETY*, *131*. https://doi.org/10.1016/j.scs.2025.106709

ODPORNOŚĆ MIEJSKA NA CZARNE ŁABĘDZIE I ICH WPŁYW NA MOBILNOŚĆ MIESZKAŃCÓW

Abstrakt

Cel. Współczesne miasta mierzą się z rosnącą liczbą nagłych zdarzeń, które mogą oddziaływać na funkcjonowanie systemu mobilności miejskiej. Ich różna geneza i przebieg sprawiają, iż są trudne do przewidzenia, a reagowanie na nie jest utrudnione. Celem analizy było zdefiniowanie pojęcia odporności miejskiej oraz doprecyzowanie, jakie zdarzenia można zakwalifikować jako czarne łabędzie i w jaki sposób oddziałują one na mobilność mieszkańców miast, w szczególności na system transportu pasażerskiego.
Metoda. Z uwagi na cel badania konieczne było zastosowanie metody Systematycznego Przeglądu Literatury, której głównym założeniem jest usystematyzowanie wiedzy w określonym obszarze. Przeszukano bazy publikacji naukowych EBSCO, Scopus i Web of Science, wykorzystując dwa zapytania. Do analizy pełnotekstowej włączono łącznie 147 publikacji. Do przeglądu użyto metodyki PRISMA, dzięki czemu zapewniono transparentność badania. Następnie przeprowadzono analizę bibliometryczną, do której włączono 125 publikacji, z wykorzystaniem oprogramowania VOSviewer.
Wyniki. Analiza wykazała, że najwięcej publikacji dotyczących defininiowania odporności i strategii odporności pochodzą z lat 2010-2025. Wskazuje to na wzrost zainteresowania badaczy tematyką odpornosci, co może być odpowiedzią na coraz częściej pojawiające się kryzysy i nagłe zdarzenia. Ponadto większość analiz dotyczy Azji i Europy. Pandemia COVID-19 istotnie przyczyniła się do rozwoju studiów nad odpornością miejską.

Słowa kluczowe: urban mobility, resilience, black swans, urban authorities.

Klasyfikacja JEL: R41, Q54, O18

dr Sandra Żukowska
Zakład Rozwoju Regionalengo, Instytut Geografii Społeczno-Ekonomicznej i Gospodarki Przestrzennej, Wydział Nauk Społecznych, Uniwersytet Gdański
ul. Prof. Marii Janion 3, 80-309 Gdańsk
sandra.zukowska@ug.edu.pl

dr Beata Chmiel
Katedra Logistyki, Wydział Ekonomiczny, Uniwersytet Gdański
ul. Armii Krajowej 119/121, 81-824 Sopot
beata.chmiel@ug.edu.pl