Research Paper

Spatial Challenges in Severely-Cold Region Cities through the Perspective of Complexity Science

A Review and Future Pathways

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Abstract

With rapid urbanization around the world, cities are facing growing challenges in sustainable development. Cities in severely cold regions deal not only with common urban problems such as population growth, resource pressure, and environmental pollution, but also with serious risks caused by extreme cold, heavy snow, and permafrost. These conditions affect urban form, infrastructure, and daily life in many ways. Complexity science helps explain how different factors interact and how urban systems change over time. It also offers useful ideas for understanding and dealing with uncertainty and change in urban planning. This study examines how complexity science can be used in cities in severely cold regions. It points out current research gaps and suggests ways to support more sustainable and resilient urban development in these areas. In terms of methods, this study uses a systematic literature review. By looking at how complex systems thinking has been used in major urban studies, it summarizes the main trends in methods, data needs, and practical use in urban research. The study finds that complexity science offers a useful way to understand the multi-scale and nonlinear relationships found in cold-region cities. However, its use still faces several problems, such as limited data integration, weak interdisciplinary collaboration, and the difficulty of turning theory into planning practice. Based on this, the paper suggests four directions for future research: developing more accurate coupled models that combine physical processes with social and economic change; building detailed simulation frameworks for cold-region cities; using multi-source monitoring data and artificial intelligence to improve the simulation, prediction, and management of extreme weather and snow-related disasters; building cross-disciplinary cooperation between complexity science, urban planning, and disaster risk management; and developing adaptive strategies for infrastructure and planning that can better respond to cold conditions, snow disasters, and freeze–thaw cycles.

Keywords

Severely-cold region, Urban space, Complexity science, Adaptive planning

1. Introduction

In the context of increasingly severe global climate change in the 21st century, urban systems are facing more and more sustainability challenges. These include frequent extreme weather events, energy shortages, and environmental pollution, which put pressure on urban planning, infrastructure, and the stability of social operations (Lee & Romero, 2023). Among them, cities in cold regions located in high-latitude or high-altitude climate zones must deal with more severe natural environmental limits, such as long-term low temperatures, heavy snowfall, freeze–thaw cycles, permafrost degradation, and increasing heating demands (González-Herrero et al., 2024; Kurylyk et al., 2014). These climate conditions affect not only the spatial form and daily operation of cities, but also increase the links and risks among energy, transport, buildings, and ecological systems (Sun & Han, 2013; Tisgrioi & Tsikaloudaki, 2018).

In this situation, cities are affected by climate change. There is a close interaction between urban development and climate adaptation. On one hand, cities need to respond to the risks brought by climate change. Urban planning and construction can also reduce climate pressure to some extent (Zhao, 2018). These interactions and changes together create new patterns and emerging behaviors that are hard to explain with traditional methods (Shi et al., 2024). Therefore, cities are often seen as typical complex adaptive systems. Complex systems science provides a useful way to understand such issues. It highlights diversity, multi-scale features, and constant change in urban systems, and helps explain how cities work as complex adaptive systems (Baynes, 2009).

In recent years, more researchers have begun to use complexity science to study cold-region cities. Because these cities have different energy systems, economic conditions, and social structures, they develop differently from cities in temperate and tropical regions (Makhutov et al., 2015). Many studies use complex network methods to study the weakness of heating systems, or combine remote sensing and deep learning to detect infrastructure risks caused by permafrost degradation (Mao et al., 2024; Chen et al., 2024). At the same time, more studies have also looked at urban thermal conditions, building energy use, and climate-responsive design (Xu et al., 2024; Leng et al., 2020). Still, this field is new, and the overall research framework is not complete.

This study looks at the basic ideas and main methods of complexity science in urban research. It points out current problems and research gaps, and discusses possible future directions. The goal is to offer a clearer basis for studying and planning cold-region cities from a systems science view.

2. Methodology

2.1. Three-phase Systematic Review

This study uses a systematic review to examine how complexity science has been used in cold-region city research, especially across different fields and scales. It follows a clear and repeatable process to collect and review past studies and bring together existing evidence in a more organized way (Moher et al., 2009). Because cold-region cities have clear features in spatial form, infrastructure, and human–environment relations, this method is useful for finding key topics, changes in methods, and research progress in this field. It also helps build a basic framework for later discussion. This process has three steps:

- Literature search and screening: Search databases and find the main studies in this field.
- Literature metrics analysis: Use bibliometric tools to examine the structure and development of the field.

- Qualitative synthesis: Review key results from highly cited studies and keyword changes to summarize methods, practical use, and current gaps.

2.2. Literature search and screening

The data in this study came from the Web of Science (WOS) Core Collection. The search covered 2004 to 2024 and looked at the main research trends over the past twenty years. Only peer-reviewed journal articles and conference papers were included. Book reviews, news reports, and other non-research materials were removed. The screening process is shown in Figure 1. The search included three parts: complex science methods, urban studies, and cold-region topics. These parts were linked with Boolean operators (AND/OR) to expand the search while keeping the results relevant. After initial screening and manual checking, 42 studies were kept for later quantitative analysis (Table 1)。

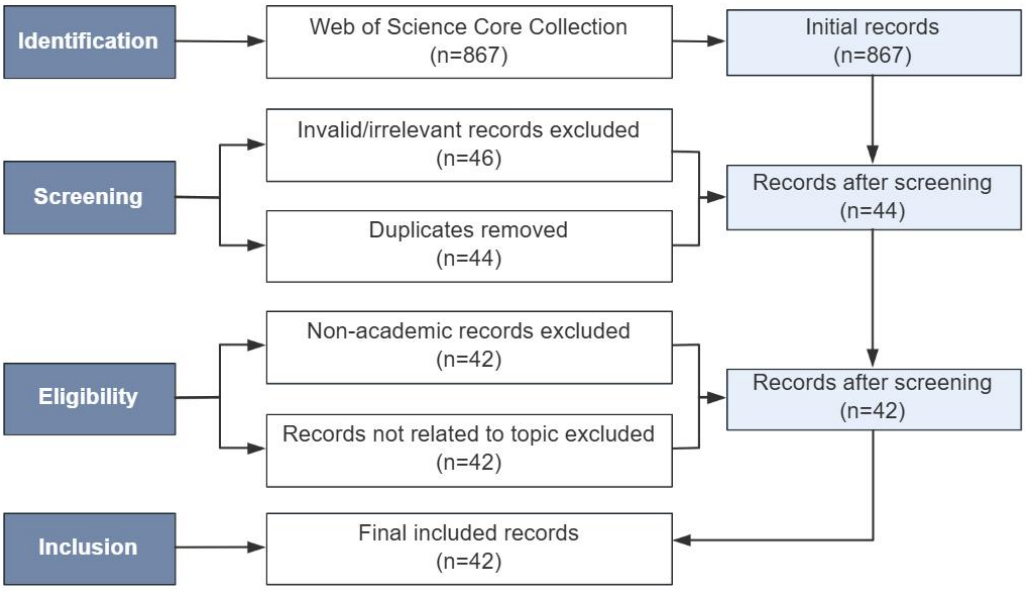

Figure 1. The selection process of systematic review literature. Source: Self-drawn by the authors.

Thematic group	Keyword combinations
Complexity science	"complexity science" OR "complex systems" OR "complex adaptive system*" OR "complex network*" OR "complexity theory" OR "systems theory" OR "system dynamics" OR "nonlinear system*" OR "self-organizing system*" OR "agent-based modeling" OR "network science" OR "dynamic modeling" OR "emergent behavior" OR "complexity analysis" OR "system thinking"
Urban research	"urban" OR "city" OR "cities" OR "settlement*" OR "town*" OR "metropolitan" OR "municipality" OR "community*" OR "urban system*" OR "urban spatial structure" OR "urban morphology" OR "urban fabric" OR "urban infrastructure" OR "urban transportation" OR "urban energy system" OR "urban planning" OR "urban development" OR "urban resilience"
Severely-Cold region	"cold" OR "cold climate" OR "severe winter" OR "frigid" OR "high-latitude" OR "arctic" OR "subarctic" OR "permafrost" OR "boreal" OR "tundra" OR "polar" OR "subarctic city*" OR "extreme cold" OR "severely-cold region*" OR "freezing climate" OR "high-latitude region*" OR "arctic urban*" OR "subarctic settlement*" OR "boreal urban*" OR "frigid zone*"

Table 1. Combinations of keywords used for study screening. Source: Self-drawn by the authors.

2.3. Quantitative Analysis Phase

In the quantitative stage, this study used bibliometric analysis to examine the knowledge structure of this field. Metadata from the selected studies were collected. CiteSpace was used to map co-occurrence and collaboration networks in order to identify major research topics and links among research groups. High-frequency keywords and highly cited papers were also examined. In addition, this study looked at how complexity science has been used to study issues.

3. Discussion

3.1. Number of Papers Analysis

The annual and cumulative numbers of publications show how academic attention has changed over time. They also reflect changes in research focus under climate change. This study examines publications from 2004 to 2024 (Figure 2) and identifies the main stages in this field. These results help show research trends and gaps for future work.

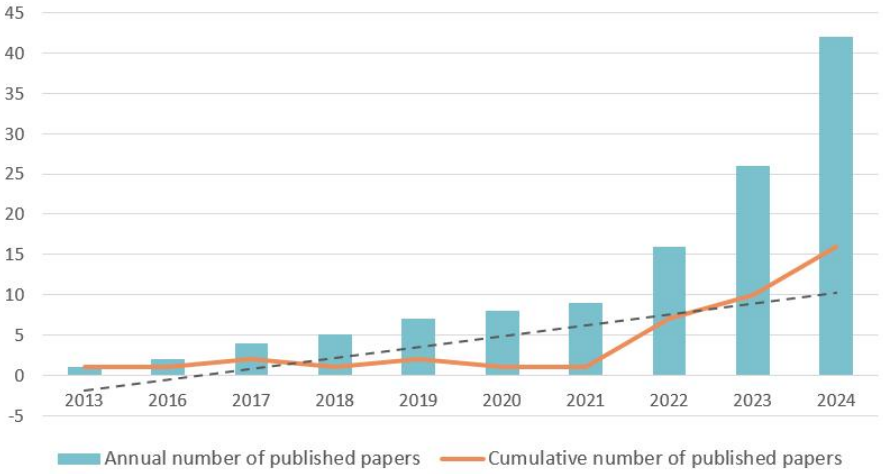

Figure 2. Annual number of published articles and cumulative number of published articles. Source: Self-drawn by the authors.

Research on the use of complexity science in cold-region cities began in 2013, when the first related study appeared. From 2016 to 2018, only a few studies were published, with fewer than five in total. Early work in this field was limited and scattered, but it gradually increased and has grown more quickly in recent years. This suggests that the field has moved from an early exploratory stage to a more organized stage. Research interest has also shifted from theoretical discussion to practical issues.

Around 2021 to 2022, this field reached an important turning point. In 2022, seven studies were published, the highest annual number up to that time, and the cumulative total reached 16. This growth reflects the value of complexity science in cold-region urban research, and rising practical demand. Growing interest in this topic is linked to global warming, increasing infrastructure risks, and greater attention to urban issues. The field is also becoming more interdisciplinary and more practice-oriented.

In recent years, the number of publications has continued to rise, although with some fluctuation. In 2023, 10 studies were published, and in 2024, the number rose to 16. The total number of studies reached 42. These trends suggest that complexity science is gaining wider recognition as a useful

approach for addressing urban problems in cold regions. Research in this area has expanded from mainly theoretical discussion to broader practical use. Overall, this field remains active and continues to provide support for future research on improving and adapting urban development in cold regions.

3.2. Key Authors Analysis

The author collaboration network shows a clear core–periphery structure. It includes 106 nodes (N) and 166 edges (E), with a network density of 0.0298 (Figure 3). This indicates that extensive collaboration among scholars has not yet formed. Overall, the network connections are relatively sparse. However, some small research groups show close internal cooperation. This suggests that the field is transitioning from individual exploration to team research. The research directions of these core teams clearly demonstrate the application path of complexity science in solving urban problems in cold regions.

For example: The Leng team from China uses machine learning and optimization algorithms to conduct intelligent simulation and optimization of energy systems at both building and urban scales (Leng & Li, 2016; Song et al., 2022). His team focuses on environmental Sergeev is a representative scholar in Arctic and subarctic research. System modeling and prediction, developing hybrid methods combining machine learning and geostatistics to improve accuracy . Huettmann, Baltensperger and others focus (Tarasov et al., 2017; Sergeev et al., 2019) on ecosystem risk assessment, paying attention to urban ecological resilience in severely-cold regions under global warming . Overall, although a widespread (Huettmann et al., 2023; Baltensperger et al., 2013) collaborative network is not yet mature, the field has formed several research hubs centered on scholars from East Asia, Russia, and parts of Europe and North America. These teams have promoted methodological innovations in three core directions energy, environment, and ecology through complex system simulation, prediction, and risk assessment respectively. They have laid a key academic foundation for understanding cities in severely-cold regions as complex giant systems.

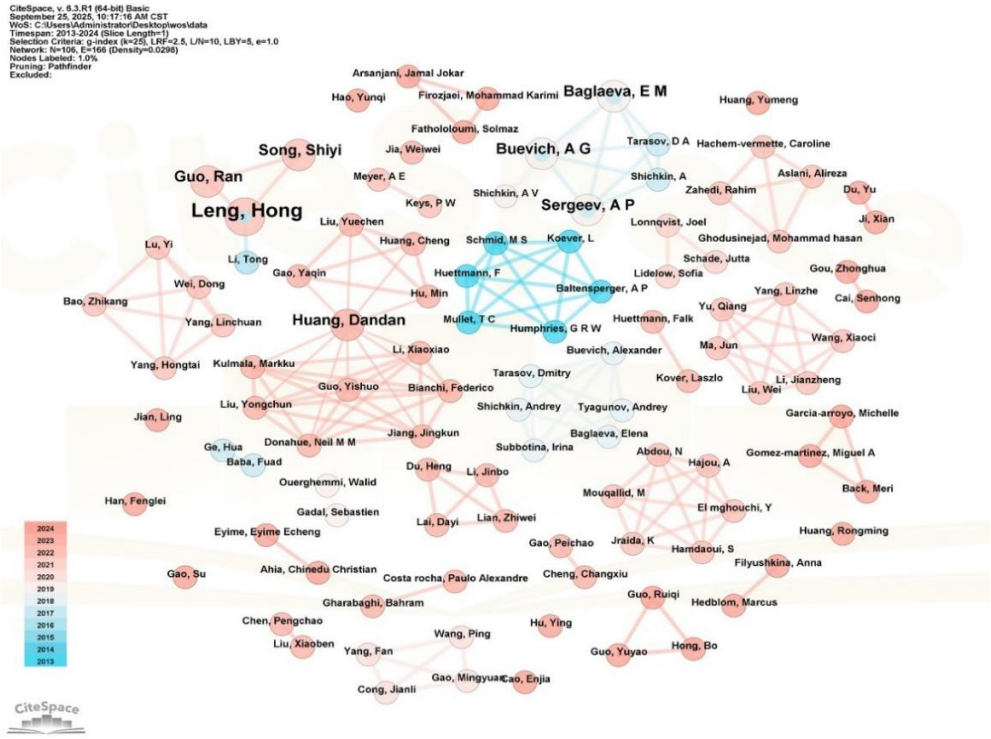

Figure 3. Author Co-occurrence Network. Source: Self-drawn by the authors.

3.3. Research Hotspots and Emerging Trends

3.3.1. Keyword Co-occurrence Analysis

The keyword co-occurrence network analysis of the literatures shows 137 keyword nodes (N), 352 connections (E), and a network density of 0.0378 (Figure 4). This indicates that the field has formed a knowledge structure with closely linked themes. From the perspective of high-frequency and high-centrality keywords, the core status of machine learning highlights data-driven approaches as the mainstream paradigm for analyzing urban complexity in severely-cold regions. The prominence of "temperature" and "design" reflects the research's core concern for system adaptability under climate constraints. Meanwhile, methodological keywords such as genetic algorithms coexist with thematic keywords like "climate change" and "outdoor thermal comfort". This reveals that international research has dual characteristics: frontier exploration of methodologies and practical concern for the built environment.

These keywords can be categorized into three dimensions:

- Methodological dimension: Represented by machine learning and genetic algorithms, it marks the shift of research paradigm from traditional description to simulation, prediction and optimization based on intelligent algorithms.
- Object dimension: Focuses on complex systemic challenges such as climate change and energy consumption, emphasizing the interaction between energy and the environment from building to regional scales.
- Intervention dimension: Seeks planning and design solutions to enhance built environment resilience in extreme climates through urban design, architectural morphology and other approaches.

In summary, the compact network structure indicates that complexity science is no longer the application of scattered tools, but forms a coherent research chain from computational identification and mechanism simulation to strategy formulation.

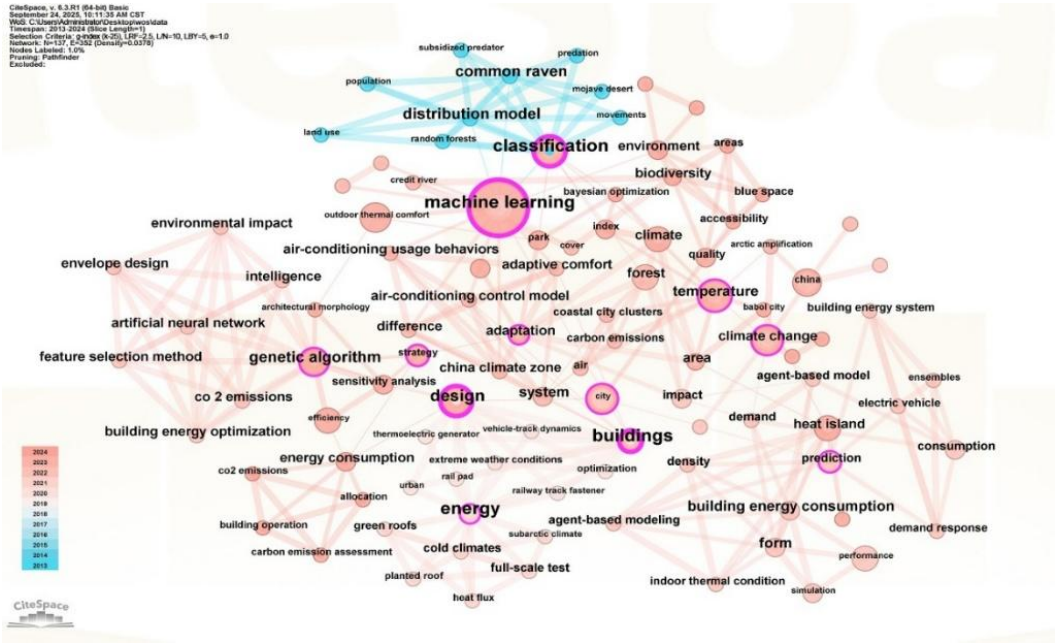

Figure 4. Keyword Co-occurrence Network. Source: Self-drawn by the authors.

3.3.2. Important Literature Analysis

By sorting out the top 10 most cited literatures, it can be found that current research mainly focuses on areas such as climate adaptation, building energy consumption optimization, thermal comfort prediction,and renewable energy application. This reflects the wide applicability of complexity science methods in addressing urban development issues under severely-cold climatic conditions (Table 2).

Title	First Author	Year	Citation volume
Variations in outdoor thermal comfort in an urban park in the hot-summer and cold-winter region of China	Wei, D.	2022	120
Combining spatial autocorrelation with machine learning increases prediction accuracy of soil heavy metals	Sergeev, A.P.	2019	81
Modelling and evaluating the economy-resource-ecological environment system of a third-polar city using system dynamics and ranked weights-based coupling coordination degree model	Wang, Y.H.	2023	50
Machine learning-based prediction of outdoor thermal comfort: Combining Bayesian optimization and the SHAP model	Guo, R.Q.	2024	47
Does urban climate follow urban form? Analysing intraurban LST trajectories versus urban form trends in 3 cities with different background climates	Lemoine-Rodriguez, R.	2022	44
Prediction and optimization of heating and cooling loads for low energy buildings in Morocco: An application of hybrid machine learning methods	Abdou, N.	2022	43
A support vector machine model to forecast ground-level PM2.5in a highly populated city with a complex terrain	Mogollon-Sotelo, C.	2021	39
Modelling community-scale renewable energy and electric vehicle management for cold-climate regions using machine learning	Zahedi, R.	2022	39
Assessment of operational carbon emissions for residential buildings comparing different machine learning approaches	Huang, R.M.	2024	37
Effect of dynamic modeling of thermal bridges on the energy performance of residential buildings with high thermal mass for cold climates	Ge, H.	2017	36

Table 2. The Top Ten Cited Literatures. Source: Self-drawn by the authors.

In research on thermal comfort and urban microclimate, Wei et al. studied thermal comfort in urban parks in China's hot-summer and cold-winter regions. They used machine learning to show how weather factors and landscape space affect human thermal perception in different seasons, and the results can help urban green space design (Wei et al., 2022). Guo et al. also studied thermal comfort. They built prediction models for thermal comfort under different shading conditions. Using microclimate monitoring data and questionnaires, they combined Bayesian optimization and SHAP models to build a more understandable machine learning method (Guo et al., 2024). These studies show that data-based methods can better support environmental control in cold or extreme climates.

In research on urban form and climate, Lemoine-Rodríguez et al. studied long-term changes in land surface temperature (LST) and urban form in Beijing, Cairo, and Santiago. They found that compact and greener urban form can help reduce urban warming. By combining 2D and 3D urban form indicators, the study showed that climate differences strongly affect local thermal environments, and it offers a useful example for comparing cities under different climate conditions (Lemoine-Rodríguez et al., 2022).

In research on building energy use and optimization, Abdou et al. used hybrid machine learning methods to predict heating and cooling loads in low-energy buildings under different climate conditions in

Morocco. The results showed that hybrid optimization models can reduce energy use and carbon emissions (Abdou et al., 2022). Ge and Baba studied thermal bridges in buildings. They found that ignoring thermal bridges can lead to clear underestimation of building energy use in cold regions. Their study showed that more accurate models are important for energy-saving building design (Ge & Baba, 2017).

In research on energy systems and transport, Wang et al. built a system dynamics model for the economy, resources, and ecological environment of Third Pole cities. They proposed an optimization framework based on coupling coordination degree and stressed the importance of giving priority to ecological development under resource limits (Wang et al., 2023). Zahedi et al. studied residential communities in cold regions of Canada. They combined renewable energy systems and electric vehicle load management, and used machine learning to improve prediction and control of energy supply and demand. This offers a new way to improve community energy systems in cold regions (Zahedi et al., 2022).

3.3.3. Research Themes Analysis

Cluster analysis shows the links and basic structure of research themes. The modularity Q value is 0.8032 (> 0.3), and the average silhouette value S is 0.9105 (> 0.7), which means the clusters are clear and the grouping is reliable (Figure 5). Based on the clustering results, the studies can be grouped into several main categories.

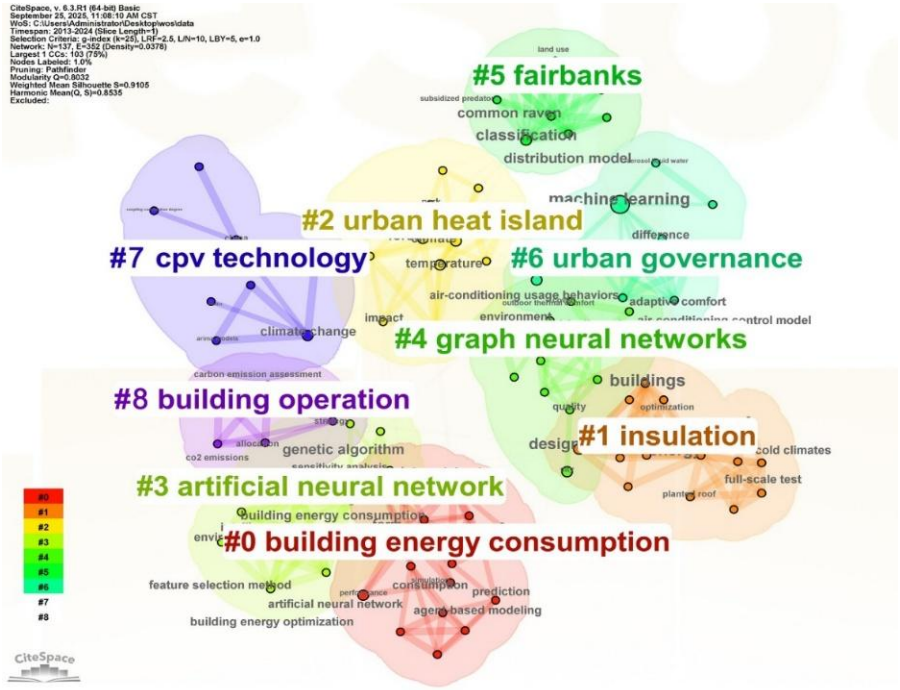

Figure 5. Keyword clustering. Source: Self-drawn by the authors.

One main cluster focuses on engineering problems and building energy efficiency, especially building energy use, life cycle management, and technical optimization.Keywords include building energy consumption,insulation, CPV technology, and building operation. International research on cities in cold regions mainly focuses on energy efficiency and building performance. This focus aims to address climate change and reduce carbon emissions. Studies highlight the use of advanced insulation materials, high-efficiency energy technologies, and intelligent operational strategies. These approaches help turn buildings in cold regions from high-energy-demand systems into sustainable, low-carbon solutions.

The urban climate and scale-coupling cluster focuses on the urban heat island (UHI) effect. Low temperatures are the main challenge for cities in cold regions. The UHI effect is also important in winter and summer. It affects microclimates and heating and cooling needs. This cluster shows that research should go beyond individual buildings to the urban scale. Studies examine how urban form and changes in surface cover interact with the climate system. These interactions create environmental feedback loops.The findings give urban planners guidance on ventilation, green space layout, and building density.

The frontier modeling and intelligent analysis cluster studies new research tools and methods. Keywords include artificial neural networks and graph neural networks. International research favors data-driven approaches and complex system simulations. Advanced AI and deep learning help handle nonlinear and high-dimensional data in cold-region cities. These techniques support energy consumption forecasting,disaster risk assessment, and optimization of complex systems. This cluster shows how complexity science can be applied in practice.

The regional case and governance cluster studies specific geographic cases and policy issues. Keywords include Fairbanks and urban governance. Fairbanks is a typical cold-region city in Alaska. Researchers often use it for cross-regional comparison and technology testing. The cluster also focuses on urban governance. Studies examine how management mechanisms, policy tools, and cross-department collaboration can support advanced building technologies. They also look at how climate adaptation strategies can be implemented and maintained over time in cold-region cities.

4. Conclusion

4.1. Research Development Trends

The research is shifting from traditional physical models and statistical methods to data-based analytical methods and intelligent algorithms. Technologies such as complex network analysis, machine learning, and multi-agent models are being applied. These methods help scholars study the nonlinear interactions and multi-scale changes of urban systems. This trend enhances the accuracy and predictive power of the research. It also increases the demand for high-resolution and heterogeneous data. Collecting and integrating these data remains a major challenge.

Complexity science is not only applied in the fields of energy and architecture. Current research covers the entire urban system. It encompasses changes in urban morphology, microclimate control, transportation networks, and the interaction between humans and the environment. This indicates that scholars are attempting to view cold-region cities as an integrated system for understanding. The interdisciplinary nature and expansion of scale bring new challenges. Limited interdisciplinary cooperation means there are problems in both theory and practice.

4.2. Future Research Development Directions

Firstly, it is necessary to strengthen the construction of data infrastructure. Collecting climate and environmental data in cold regions is quite challenging. Research efforts should integrate multiple data sources. This includes remote sensing technology, Internet of Things sensors, and socio-economic surveys, among others. Integrating these sources helps make complex models run more accurately.

Secondly, promote interdisciplinary collaboration. Establish a closer network of scientific research and a platform for knowledge sharing. Promote deep integration in fields such as urban planning, climate

science, engineering, and computer science, and enhance the comprehensiveness and applicability of complexity research.

Thirdly, strengthen the transformation from theory to practice. Explore the combination of complex models with policy simulations and urban planning decision-making tools. Develop an actionable adaptive governance resilience planning strategy to narrow the scope of governance.

Finally, develop a complex framework suitable for the unique environment of cold regions, with a focus on building a comprehensive model that can simultaneously simulate multiple physical processes and social dynamics. These models should be able to support rapid response and long-term planning in extremely low temperatures, ice disasters, and permafrost environments.

5. References

Abdou, N., El Mghouchi, Y., Jraida, K., Hamdaoui, S., Hajou, A. and Mouqallid, M. (2022). 'Prediction and optimization of heating and cooling loads for low energy buildings in Morocco: An application of hybrid machine learning methods', *Journal of Building Engineering*, 61, pp. 105332.

Baltensperger, A.P., Mullet, T.C., Schmid, M.S., Humphries, G.R.W., Kövér, L. and Huettmann, F. (2013). 'Seasonal observations and machine-learning-based spatial model predictions for the common raven (Corvus corax) in the urban, sub-arctic environment of Fairbanks, Alaska', *Polar Biology*, 36(11), pp. 1587–1599.

Baynes, T.M. (2009). 'Complexity in Urban Development and Management', *Journal of Industrial Ecology*, 13(2), pp. 214–227.

Chen, Y., Li, S., Wang, L., Mittermeier, M., Bernier, M. and Ludwig, R. (2024). 'Retrieving freeze-thaw states using deep learning with remote sensing data in permafrost landscapes', *International Journal of Applied Earth Observation and Geoinformation*, 126, pp. 103616.

Ge, H. and Baba, F. (2017). 'Effect of dynamic modeling of thermal bridges on the energy performance of residential buildings with high thermal mass for cold climates', *Sustainable Cities and Society*, 34, pp. 250–263.

González-Herrero, S., Lemus-Canovas, M. and Pereira, P. (2024). 'Climate change in cold regions', *Science of The Total Environment*, 933, pp. 173127.

Guo, R., Yang, B., Guo, Y., Li, H., Li, Z., Zhou, B., Hong, B. and Wang, F. (2024). 'Machine learning-based prediction of outdoor thermal comfort: Combining Bayesian optimization and the SHAP model', *Building and Environment*, 254, pp. 111301.

Huettmann, F., Kövér, L., Robold, R., Spangler, M. and Steiner, M. (2023). 'Model-based prediction of a vacant summer niche in a subarctic urbanscape: A multi-year open access data analysis of a 'niche swap' by short-billed Gulls', *Ecological Informatics*, 78, pp. 102364.

Kurylyk, B.L., MacQuarrie, K.T.B. and McKenzie, J.M. (2014). 'Climate change impacts on groundwater and soil temperatures in cold and temperate regions: Implications, mathematical theory, and emerging simulation tools', *Earth-Science Reviews*, 138, pp. 313–334.

Lee, H. and Romero, J. (2023). *Climate change 2023: Synthesis report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Geneva, Switzerland: IPCC.

Lemoine-Rodríguez, R., Inostroza, L. and Zepp, H. (2022). 'Does urban climate follow urban form? Analysing intraurban LST trajectories versus urban form trends in 3 cities with different background climates', *Science of The Total Environment*, 830, pp. 154570.

Leng, H., Chen, X., Ma, Y., Wong, N. H. and Ming, T. (2020). 'Urban morphology and building heating energy consumption: Evidence from Harbin, a severe cold region city', *Energy and Buildings*, 224, pp. 110143.

Leng, H. and Li, T. (2016). 'Research on Public Open Space of Rural Areas in Severe Cold Regions Based on Survey of Residents on the Behavioral Activity', *Procedia Engineering*, 146, pp. 327–334.

Makhutov, N.A., Moskvichev, V.V. and Fomin, V.M. (2015). 'Designing machinery for the Arctic: A problem of socioeconomic development of Russia's eastern regions', *Herald of the Russian Academy of Sciences*, 85(1), pp. 79–86.

Mao, D., Wang, P., Fang, Y.P. and Ni, L. (2024). 'Understanding District Heating Networks Vulnerability: A Comprehensive Analytical Approach with Controllability Consideration', *Sustainable Cities and Society*, 101, pp. 105068.

Moher, D., Liberati, A., Tetzlaff, J. and Altman, D.G. (2009). 'Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement', *PLOS Med*, 6(7), pp. e1000097.

Sergeev, A.P., Buevich, A.G., Baglaeva, E.M. and Shichkin, A.V. (2019). 'Combining spatial autocorrelation with machine learning increases prediction accuracy of soil heavy metals', *CATENA*, 174, pp. 425–435.

Shi, Y., Zhai, G., Xu, L., Zhou, S., Lu, Y., Liu, H. and Huang, W. (2021). 'Assessment methods of urban system resilience: From the perspective of complex adaptive system theory', *Cities*, 112, pp. 103141.

Song, S., Leng, H. and Guo, R. (2022). 'Planning Strategy for Urban Building Energy Conservation Supported by Agent-Based Modeling', *Buildings*, 12(12), pp. 2171.

Sun, C. and Han, Y. (2013). 'The Research on the Performance-Driven Design System of the Low Energy Consumption Public Space in Cold Climate Area', *South Architecture*.

Tarasov, D.A., Buevich, A.G., Sergeev, A.P., Shichkin, A.V. and Baglaeva, E.M. (2017). 'Topsoil pollution forecasting using artificial neural networks on the example of the abnormally distributed heavy metal at Russian subarctic', *in AIP Conference Proceedings*, 1836, pp. 020024.

Tsirigoti, D. and Tsikaloudaki, K. (2018). 'The Effect of Climate Conditions on the Relation between Energy Efficiency and Urban Form', *Energies*, 11(3), pp. 582.

Wang, Y., Song, C., Cheng, C., Wang, H., Wang, X. and Gao, P. (2023). 'Modelling and evaluating the economy-resource-ecological environment system of a third-polar city using system dynamics and ranked weights-based coupling coordination degree model', *Cities*, 133, pp. 104151.

Wei, D., Yang, L., Bao, Z., Lu, Y. and Yang, H. (2022). 'Variations in outdoor thermal comfort in an urban park in the hot-summer and cold-winter region of China', *Sustainable Cities and Society*, 77, pp. 103535.

Xu, X., Dong, Q. and Zhen, M. (2024). 'Assessing effects of future climate change on outdoor thermal stress and building energy performance in severe cold region of China', *Building and Environment*, 251, pp. 111236.

Zahedi, R., Ghodusinejad, M. hasan, Aslani, A. and Hachem-Vermette, C. (2022). 'Modelling community-scale renewable energy and electric vehicle management for cold-climate regions using machine learning', *Energy Strategy Reviews*, 43, pp. 100930.

Zhao, L. (2018). 'Urban growth and climate adaptation', *Nature Climate Change*, 8(12), pp. 1034.