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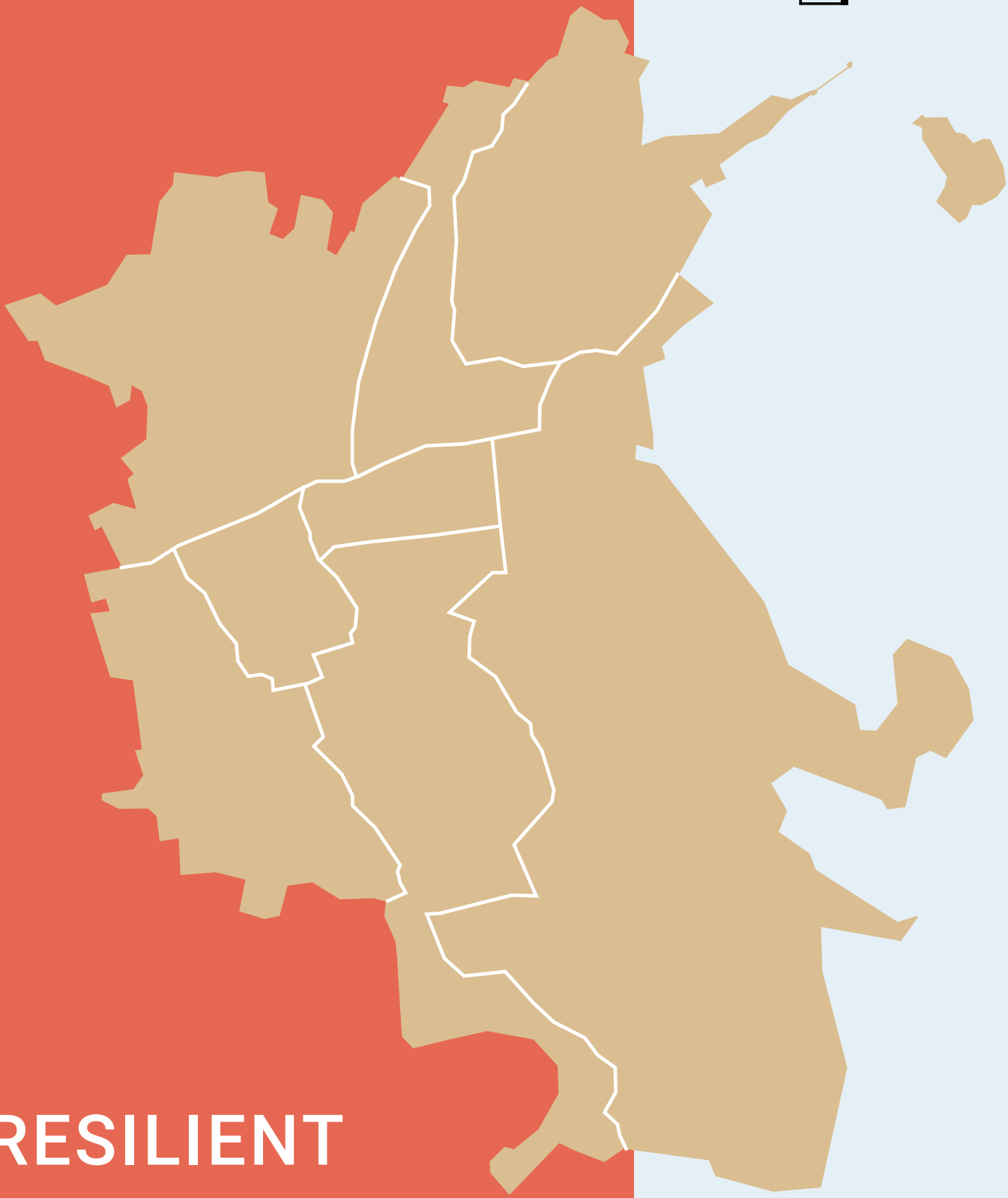

RESILIENT CITY INDEX:

Mapping the Journey from Vulnerability to Strength

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RESILIENT CITY INDEX:

Mapping the Journey from Vulnerability to Strength

The Resilient City Index by Qala AI is an innovative tool for assessing and improving urban resilience worldwide. The index applies geospatial analytics in data-driven decision-making to provide city leaders with valuable insights, fortify their infrastructure, and help them adapt to urban development risks, such as climate change and economic crises.

City leaders have a crucial role in protecting communities from the emerging threats associated with urbanization. This report emphasizes their responsibility to prioritize resilience as a fundamental aspect of urban development. It highlights the direct link between a city's adaptability and long-term prosperity.

Partner

Department of
Digitalization
of Almaty city

2024

Mission

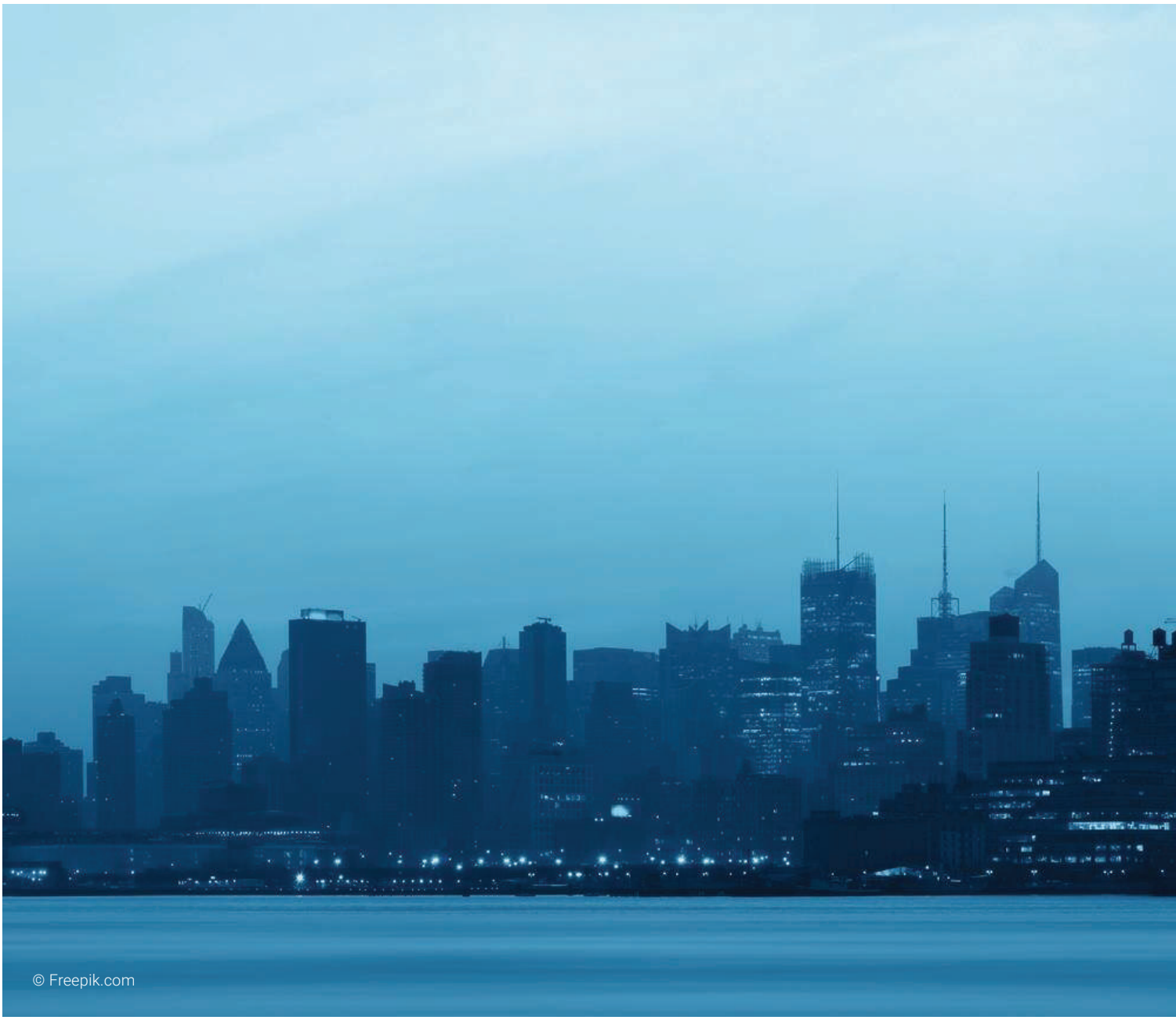
The mission of the Qala AI team is **to provide cities and businesses with innovative solutions** and insights for sustainable prosperity in the face of challenges.

Our commitment to bridging the gap between city leaders and communities is rooted in our belief that forward thinking and forward planning can redefine the dynamics of urban living.

Our Resilient City Index is the foundation of a powerful narrative, the story of a journey towards resilience. On this journey, we are more than observers. We aspire to be the architects of change, creating an interactive space that goes beyond the conventional understanding of urban challenges.

In a world flooded with data, we see the real value behind the abundance of information. That value lies in actionable insights. QALA AI aims to go beyond surface-level analytics and dry statistics, uncovering the nuances that traditional assessments can miss. Our platform serves as an ever-vigilant guardian, continuously processing city data to not only identify current challenges, but also anticipate potential pitfalls at the micro level. This proactive approach allows cities to plan, prepare, and prevent crises before they occur.

Driven by our commitment to innovation, **we position ourselves as translators, interpreting the language of cities.** Through the Resilient City Index, we analyze the nuances in the data, revealing hidden risks and bottlenecks that might otherwise go unnoticed. Our mission is not only to offer insight into the challenges cities face, but also provide practical, actionable solutions that lay the foundation for a resilient and adaptable urban future.



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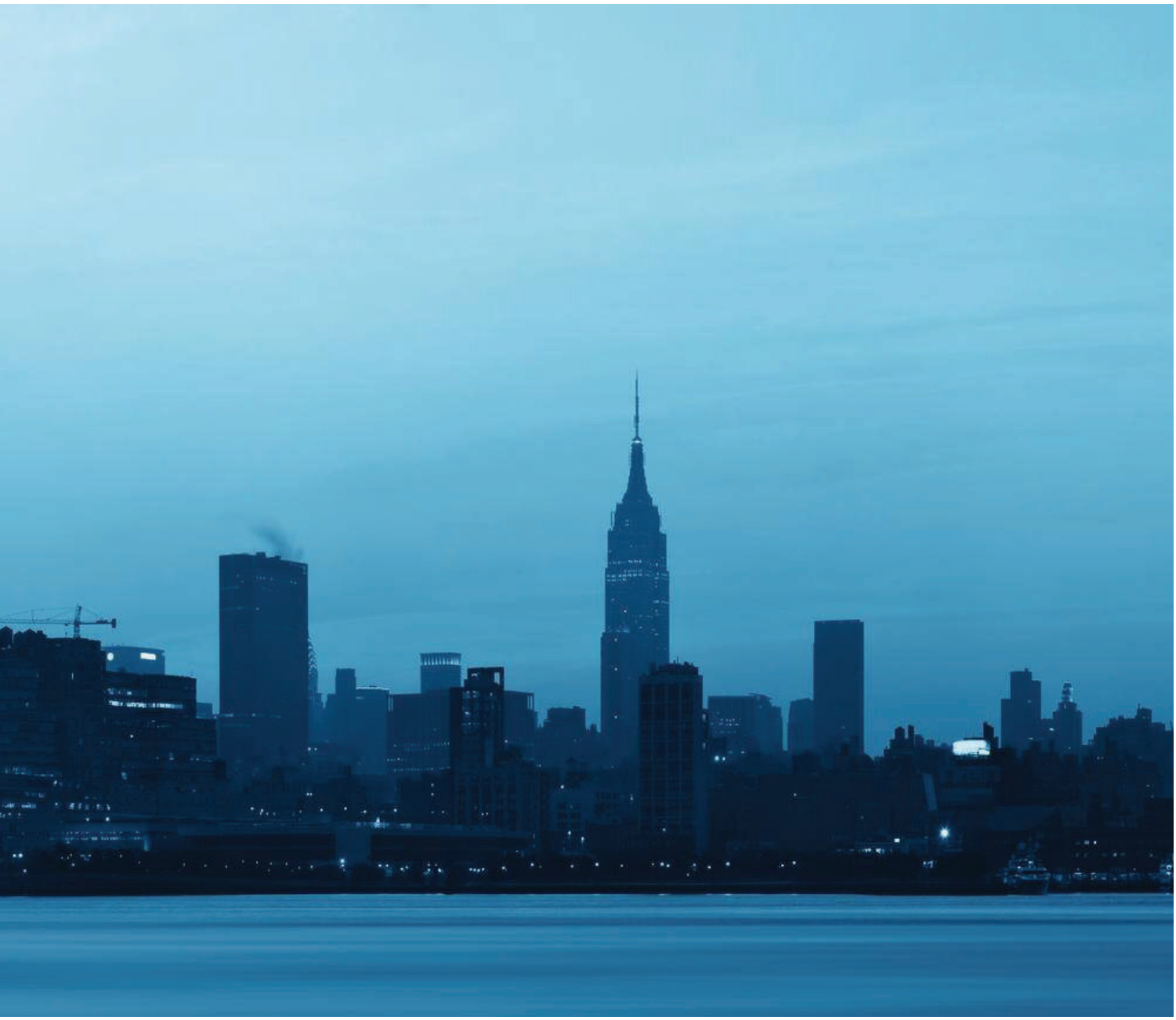

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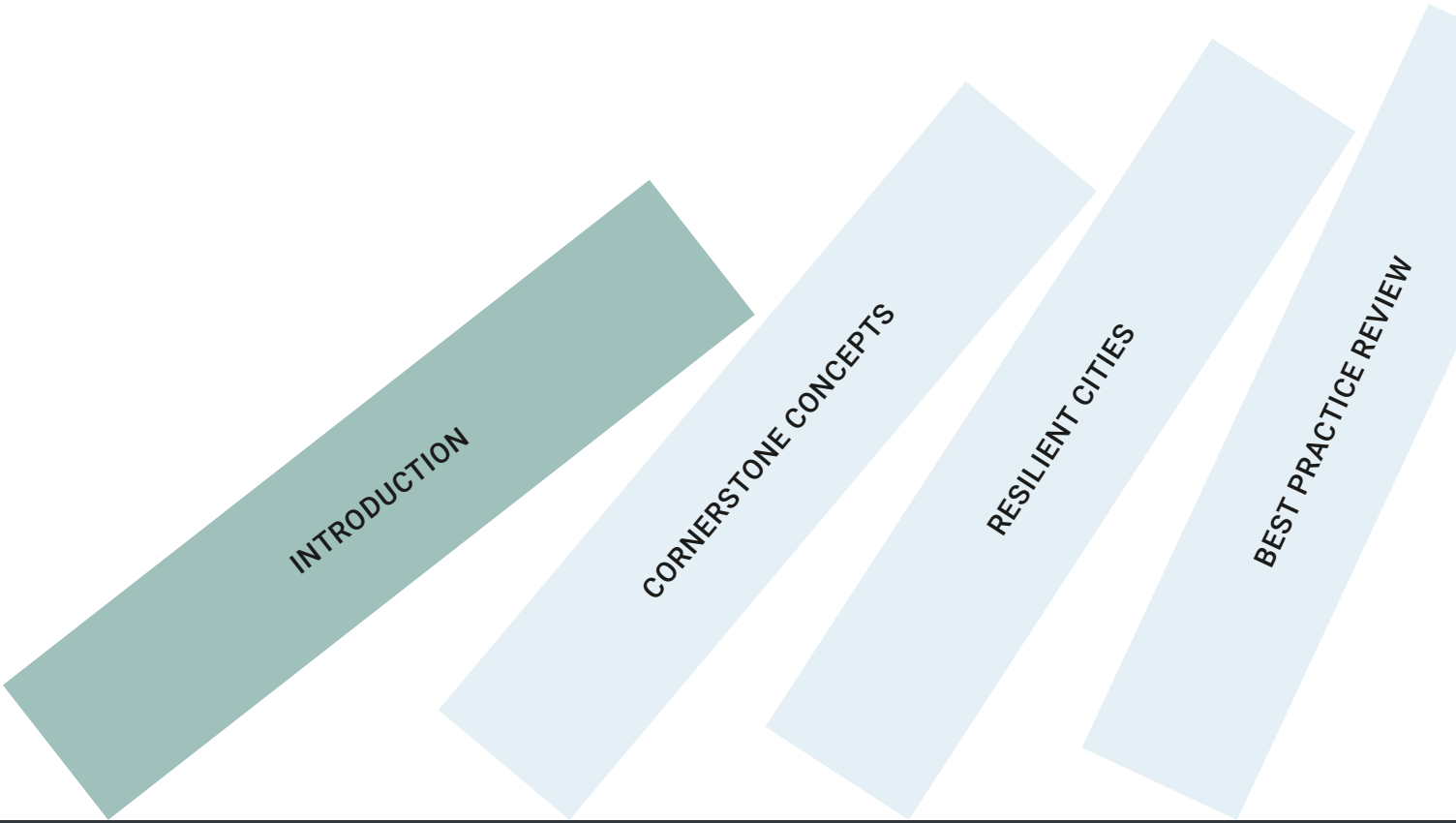


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Introduction

City governance in today's turbulent world requires a proactive, visionary leader to navigate a complex set of challenges. In fact, **the role of a city leader extends far beyond traditional governance,** encompassing responsibilities like urban development, public services and economic stability. As they manage ever more diverse and dynamic urban landscapes, modern leaders must develop efficient policies while catering to the diverse needs of a growing population. Faced with rapidly evolving global trends like climate change or economic downturn, the city leader emerges as the keystone, supporting her community through challenges with resilience, adaptability and a firm commitment to the wellbeing of citizens.

By the early 21st century, urbanization has emerged as a worldwide phenomenon, defining an unprecedented shift in the human landscape. Over half of the world's population now resides in urban areas, a number projected to rise significantly in the coming decades. This exponential growth in urban populations stands as a testament to the evolving dynamics of our societies and economies.

Behind the statistics lie pressing challenges that are shaping the agendas of city leaders around the globe. The rapid influx of people into urban centers is putting an immense strain on infrastructure, services and resources. The World Cities Report notes that almost 60% of the infrastructure required to support urban populations by 2030 remains unbuilt [1], highlighting a critical gap between supply and demand. Cities have always existed as economic and cultural hubs. However, this concentration of population comes at an environmental cost. According to UN-Habitat, cities consume 78% of the world's energy and produce more than 60% of greenhouse gas emissions [2]. These figures emphasize the **urgent need for sustainable, environmentally conscious strategies** for urban development.

The challenges of urbanization are complex and multifaceted. Richard Florida, a prominent urban studies theorist, writes: "Cities are at the very center of the many grand challenges we face - climate change, poverty, job creation, public health, sustainable energy, and inclusive development. [3] "These issues are of pressing concern for city leaders struggling with the complexities of modern urban landscapes.

Affordable housing is a key problem for many metropolitan areas. The rapid influx of people to urban areas often outpaces the construction of affordable housing, resulting in housing shortages and high prices. This strain on the housing market exacerbates social inequalities and forces many residents to move to the outskirts of cities, far from job opportunities and essential services. Urban growth also has a significant impact on transportation. Congested roads and inadequate public transport systems present challenges to mobility that affect both quality of life and economic productivity. Developing efficient and accessible transportation systems that serve diverse urban populations remains a top priority for city planners.

In response to these challenges, city leaders are advocating for **innovative approaches to urban development.** The discourse around urbanization trends highlights the significance of proactive policies and cooperative efforts. Cities worldwide, including Bristol, UK and Medellin, Colombia, are focusing their Resilience Strategies [4] [5] on developing inclusive, sustainable, and resilient urban environments. They prioritize social resilience by involving communities in decision-making. These urban development strategies include various initiatives to strengthen cities against challenges such as climate change, social inequality and economic volatility. The strategies aim to promote fair access to resources and services while reducing the environmental footprint of urban areas.

Moreover, the global conversation on urbanization requires us to acknowledge the diversity of urban landscapes. **Tailored approaches that consider each city's unique context are crucial,** as megacities face different challenges than smaller urban areas or those in emerging economies. Collaboration between public and private sectors, as well as active community engagement, is essential to address these urbanization challenges. Inclusive decision-making processes involving diverse stakeholders lead the way to more sustainable and community-centered urban development. As urbanization trends continue, city leaders are poised to confront these challenges head-on. By adopting comprehensive and forward-looking strategies, **cities can turn these challenges into opportunities for growth,** innovation, and a better quality of life for their residents.

The process of urbanization brings with it a complex combination of both challenges and opportunities. Figures and trends highlight the critical need for sustainable, inclusive, and resilient urban development. City leaders are at the forefront of navigating these challenges and shaping the future of cities. **Innovative solutions and collaborative efforts are essential** to build thriving urban environments for generations to come.

1 *World Cities Report, 2016*
2 *United Nations*
3 *Richard Florida, 2017*
4 *The Bristol Resilience Strategy, 2016*
5 *Resilient Medellin: A strategy for our future, 2016*

Cornerstone Concepts

Urban Resilience

The conceptual framework of the Resilient City Index (RCI) is based on its mission and guiding principles, which prioritize the interests and needs of people living in urban areas. This **human-centric principle** is at the core of the framework (see Fig. 1), focusing on the well-being, safety, and prosperity of the individuals living in urban environments. This framework puts people and their interests at the forefront to holistically evaluate a city's resilience. It takes into account how its policies, infrastructure, and services cater to the needs and aspirations of its inhabitants. Community welfare is the key factor shaping the criteria and parameters of RCI, ultimately aiming to create more livable, inclusive, and resilient cities.

There are many concepts that could be considered human-centric. We have identified six of these as our cornerstone concepts: sustainable development, liveability, quality of life, quality of urban environment, human capital, and urban resilience.

In recent decades, **sustainable development** has been the main conceptual framework for studying the development processes of cities and countries. This approach has been given special status by the United Nations, which has developed 17 Sustainable Development Goals (SDGs). Despite some methodological contradictions within the framework and its active use in various contexts, most researchers and stakeholders share a general vision of sustainable development. It "meets the needs of the present without compromising the ability of future generations to meet their own needs" [6].

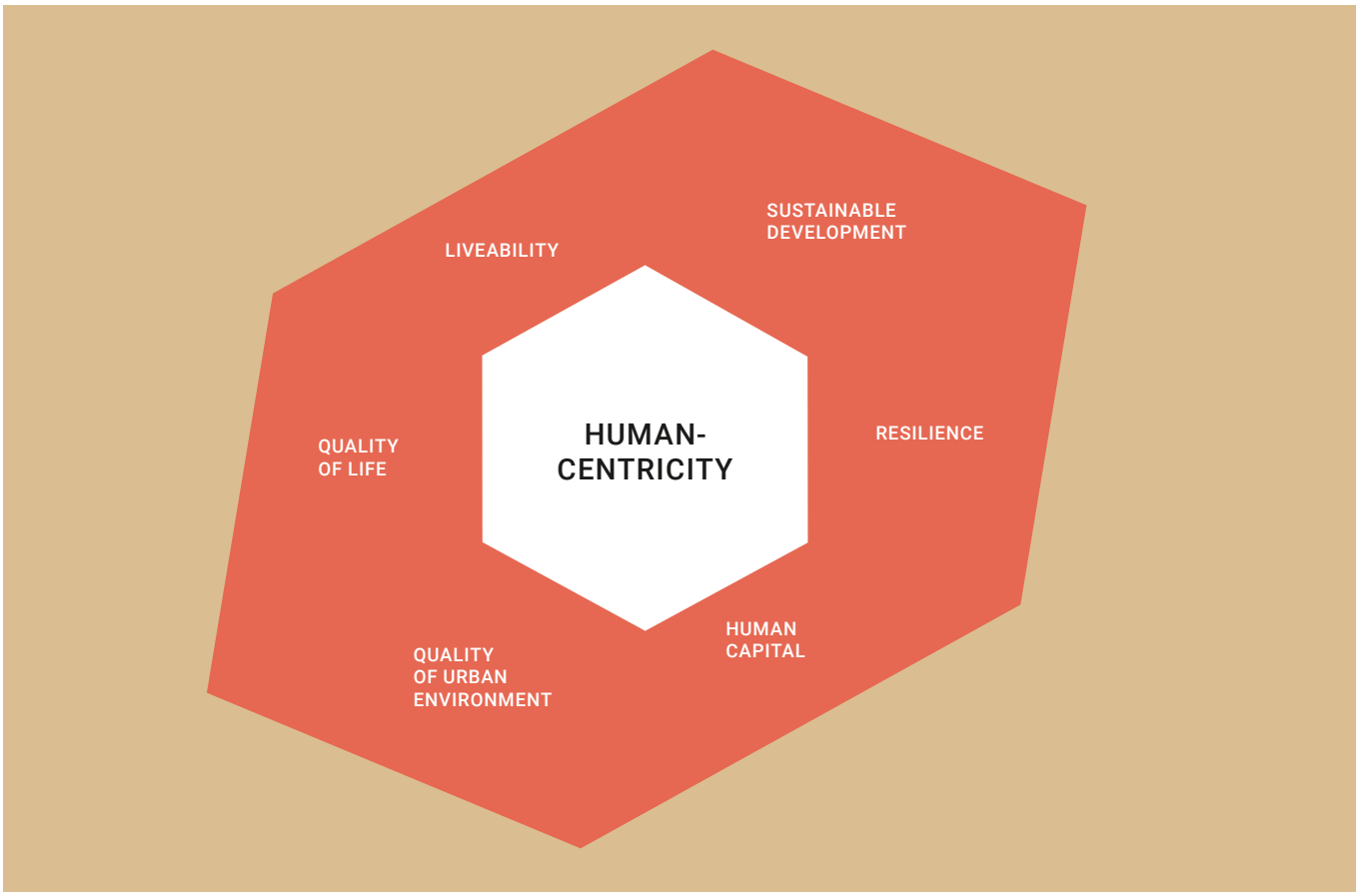

Fig. 1 — Human-centricity is the key principle of the Resilient City Index

6 *World Commission on Environment and Development*

For the purposes of this report, however, we have chosen to use an alternative approach instead of focusing on the concept of sustainable development. The early 2020s have brought about qualitatively new challenges, such as the COVID-19 pandemic and its consequences, as well as geopolitical turbulence. Almaty, as a major economic hub of Eurasia and one of Central Asia's main points of attraction, has not been immune from these global crises. Given the current circumstances, it is therefore crucial to **assess risks and the city's ability to respond to them,** rather than focus on long-term planning for sustainable development.

The primary responsibility of the city is to monitor risk factors and develop adaptive capacity. These objectives do not contradict the widely accepted concept of sustainable development, but rather complement it by prioritizing short- and medium-term issues. In a broader context, we can assume that cities (as the main drivers of any national economy) are able to respond more quickly to everyday risks, while sustainable development issues can continue to be prioritized at the state level. The set of Sustainable Development Goals supports these ideas. Out of the 17 SDGs, only one is directly related to urban development issues, namely Goal 11, which aims to "ensure open, safe, resilient and sustainable cities and human settlements").

For the concept of **liveability,** the opposite is true. The term is often used in the development of various methods for assessing urban processes, but it lacks a common definition. Several reasonable definitions exist, including:

- "the ability of urban spaces to fulfill the expectations of its inhabitants for wellbeing and quality of life"; [7]
- "safe, attractive, socially cohesive and inclusive, and environmentally sustainable communities; with affordable and diverse housing linked by convenient public transport, walking and cycling infrastructure to employment, education, public open space, local shops, health and community services, and leisure and cultural opportunities" [8].

One may note that the two definitions appear to contradict each other. The first refers to spaces, whereas the second focuses on communities. Furthermore, the concept itself is vague, with a clear emphasis on satisfying needs and improving **quality of life.** This approach is difficult to quantify, as it involves studying subjective perceptions of individuals or groups. Traditionally, the study of quality of life has relied on the perception of residents' satisfaction with the services and opportunities provided by the city [9]. However, in times of macroeconomic instability, this approach may not be flexible enough.

Another common use of the term "quality" is to assess the **quality of the urban environment.** This assessment should also be based on the idea of the city meeting the needs of its population, taking into account the standards of quality of life [10]. This approach is more objective, but it may be too distant from the real needs of the population and does not align with our view of human-centricity.

In contrast, the concept of **human capital** should be recognized as the most human-centered. Unlike the practice-oriented approaches discussed earlier, this direction originates from the theoretical works of French sociologist and anthropologist P. Bourdieu. In the most general sense, human capital is "the knowledge, skills and health that people invest in and accumulate during their lives, which allows them to realize their potential as useful members of society" [11]. This definition does not address urban problems and can be applied in any geographic context. Human capital is typically assessed at the national level, as seen in World Bank reports. While it could be used as the primary approach in this report, it fails to account for the subjectivity of the city — not merely a passive space for human interaction, but an environment that strongly influences human behavior.

Although the conceptual approaches discussed above have certain shortcomings, each of them contributes in some way to shaping our vision of urban processes. However, the concept of **urban resilience** stands out as the most relevant framework to our goal-setting. This concept is increasingly used in various analytical reports, including those produced by the United Nations. The UN Development Program (UNDP) provides the most authoritative definition of resilience: "the ability of city dwellers to withstand economic, social, health, environmental, disaster and climate related risks" [12].

This definition implies the subjectivity of city residents, which is in line with our vision. UNDP also emphasizes that in the post-coronavirus world, assessing risks in cities, where they are most densely concentrated, is crucial. Finally, the framework identifies resilience as a key attribute of cities striving for sustainable development.

7 *Martino, N. et al., 2021*
8 *Higgs, C. et al., 2019*
9 *Din, H. S. E. et al., 2013*
10 *Sarchenko, V., & Khirevich, S., 2020*
11 *World Bank, 2023*
12 *UNDP*

Urban Health and Inequality

Urban resilience is a broad framework that does not specify the origin of risks or how their impact is distributed. To address this, we propose complementing it with two conceptual blocks: the antecedent and the consequent. The antecedent block establishes the initial conditions that determine a city's ability to strengthen or weaken resilience. The subsequent block analyzes the impact of risks on city residents. Fig. 2 illustrates the final conceptual framework of our study.

The selection of **urban health** as a risk factor is based on two factors: the context of Almaty (refer to the "Almaty As Is" section) and the complexity of this concept. Our concept of urban health is in line with a model by David Vlahov (see Fig. 3).

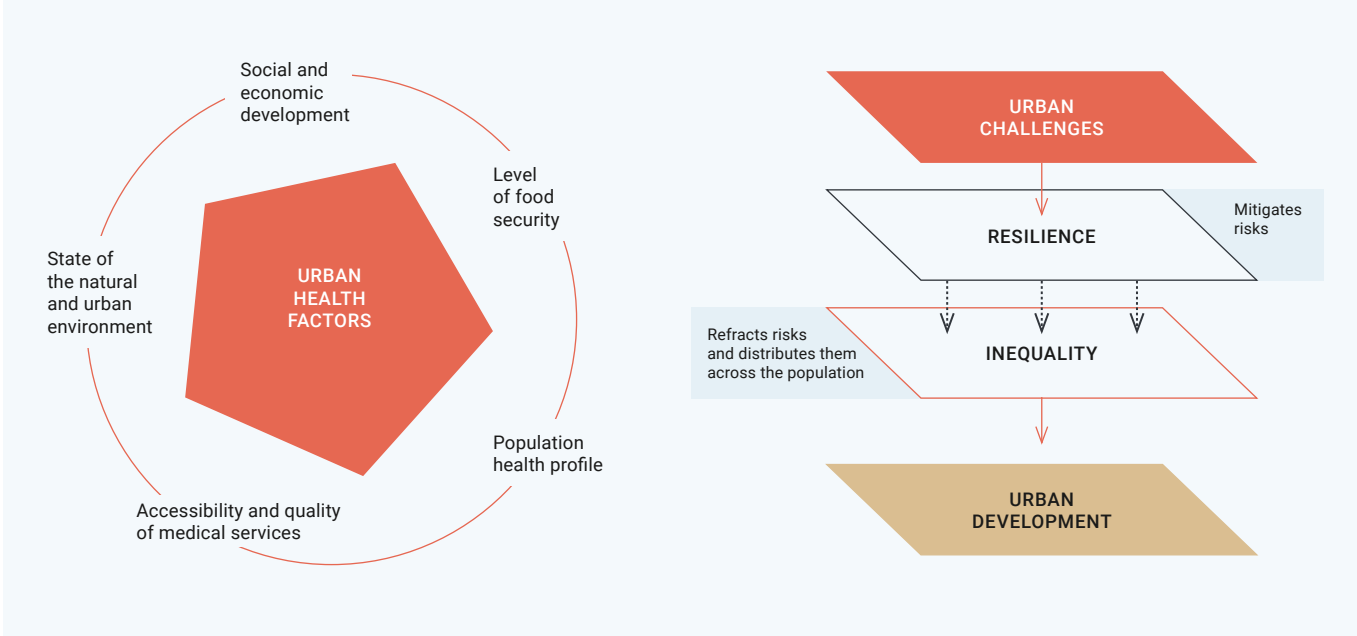

Fig. 2 — D. Vlahov's model of urban health [13]

Fig. 3 — A concept diagram of the Resilient City Index

David Vlahov is an epidemiologist at the University of California, San Francisco. According to his model, a city's resilience to sudden and severe shocks is influenced by urban health. **A healthier population allows the city to respond to challenges more effectively,** reduces the danger of risks, and accelerates recovery from their negative consequences. In this context, and in line with the WHO definition, urban health refers to a city's ability to respond to health challenges and promote the complete physical, mental and social well-being of its residents, rather than simply the absence of disease or infirmity. This concept can also be defined by a set of properties that affect adaptability to changing socio-economic, climatic, environmental and technological conditions. A healthy city possesses greater resilience and can therefore better mitigate risks.

Any effects, positive or negative, are unevenly distributed across space and society. Certain territories and communities are more vulnerable to risks than others. Therefore, it is important to consider risks that are "processed" by resilience while taking inequality into account. Unlike resilience, inequality does not mitigate risks but acts as a prism, redistributing them among people and territories.

Although risks may exist at a citywide level, it is possible to identify the areas with maximum and minimum impact. Therefore, **a spatially differentiated approach is the most effective way to study the issues** that impede the city's development. In addition, inequality itself poses a risk: if allowed to grow excessively, it will have a negative impact on many aspects of city life.

Almaty's inherent risk cannot be managed at the citywide level alone. It is necessary to consider the internal unevenness of processes, which takes various forms, such as physical-geographical, environmental, social, economic, attraction (in terms of business or tourism), transportation, and architecture.

To apply the study's results in practice (such as implementing them in city management processes or forming recommendations), **it is essential to first assess the extent of inequality in any form.** This will enable more efficient resource management in strengthening resilience, as many risks are localized but can have a negative impact on the entire city if left unaddressed.

[13] *Galea, S., & Vlahov, D., 2006*

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Resilient Cities

The concept of urban resilience has been gaining relevance every year since the 2010s, surpassing the importance of sustainability due to the critical nature of urban risks. More and more institutions and international organizations are now prioritizing research and policy documents on urban resilience.

Leading international agencies and institutions have initiated several key programs on urban resilience:

UNDRR
UN Office for Disaster Risk Reduction

The United Nations Office for Disaster Risk Reduction (UNDRR) launched its Making Cities Resilient 2030 (MCR2030) campaign in 2010. MCR2030 is a unique multi-stakeholder initiative that aims to improve local resilience through advocacy, sharing of knowledge and experiences, establishing city-to-city learning networks, providing technical expertise, and connecting multiple levels of government with building partnerships [14]. To date, 1,652 cities have joined the MCR2030 cities (694 Stage A cities, 420 Stage B cities, and 538 Stage C cities).

The Rockefeller Foundation

The Rockefeller Foundation pioneered the **100 Resilient Cities** Network in 2013 to help more cities build resilience to the physical, social, and economic challenges that are increasingly prevalent in the 21st century [15]. **Over 1,000 cities applied** to join the Network, and 100 have been selected, representing more than one-fifth of the world's urban population. So far, more than **50 Resilience Strategies** have been developed, outlining over 1,800 specific actions and initiatives. This has led to more than 150 collaborations between partners and cities to address urban challenges. Platform partners have pledged **$230 million in support,** and **more than $655 million** has been leveraged from state, philanthropic, and private sources to implement resilience projects.

RESILIENT CITIES NETWORK

The legacy of the Resilient Cities Network is built on the 100 Resilient Cities (100RC) initiative. In 2019, as the initiative came to a close, member cities and CROs led it into the next phase, resulting in the transition to the Resilient Cities Network (R-Cities) [16]. For over a year, more than 30% of our member cities and CROs participated in an extensive collaborative design process to build the new phase of the urban resilience movement. The Resilient Cities Network consists of cities that are committed to building and investing in urban resilience across five geographic regions: Africa, Asia Pacific, Europe and the Middle East, Latin America and the Caribbean, and North America.

GFDRR
Global Facility for Disaster Reduction and Recovery

Launched in June 2017, the City Resilience Program (CRP) is a partnership between the World Bank and the Global Facility for Disaster Reduction and Recovery (GFDRR). It is a multi-donor initiative that aims to enable cities to plan for and mitigate the negative effects of disasters and climate change. This can help cities to save lives, reduce losses, and unlock their economic and social potential. The program is supported by the Swiss State Secretariat for Economic Affairs (SECO) and the Austrian Federal Ministry of Finance.

CRP supports cities across three main thematic areas: **Planning for Resilience** provides technical assistance to ensure that capital investment plans are risk informed. **Finance for Resilience** focuses on mobilizing capital for urban resilience. **Partnership for Resilience** concentrates on advocacy and convening global expertise. Together, these three thematic areas are key to helping cities face the resilience challenges of the future [17].

UN-HABITAT

The United Nations Human Settlements Programme (UN-Habitat) has launched the City Resilience Profiling Programme (CRPP), which focuses on making cities resilient. The program provides local governments with the tools and knowledge required to build their capacity to prepare for, respond to, and recover from shocks and stresses, leading them towards sustainability. It provides cities with the frameworks and approaches necessary to evaluate urban resilience and develop Actions for Resilience (A4R) tailored to their specific needs [18].

14 *UNDRR*
15 *The Rockefeller Foundation*
16 *The Resilience Cities Network*
17 *Global Facility for Disaster Reduction and Recovery (GFDRR)*
18 *UN-Habitat*

As the resilience agenda has grown in importance since the 2010s, the position of a **City Resilience Officer** has become increasingly common in city administrations in both developed and developing countries.

Chief Resilience Officers (CROs) are at the heart of many cities' efforts to become more resilient in the face of increasing shocks and stressors, from rising inequality to the impacts of climate change. CROs are typically **high-ranking city officials** who coordinate across government departments and city stakeholders to develop policies and take action to make the city more resilient.

For example, a CRO in the CRP network has a number of key responsibilities:

1

Collaborate across government departments to improve internal communication within a city and address its inherent complexities. The CRO facilitates communication that transcends internal divisions, fostering and promoting synergy among various projects and agency plans.

2

Engage a diverse range of stakeholders including government officials, representatives from the private sector, non-profits, and civil society, to understand the city's challenges and build support for specific initiatives and overall resilience building.

3

Lead the development of the resilience strategy by engaging a wide range of stakeholders to identify the city's resilience challenges, assess its capabilities, and plans to address them, and identify gaps between the two. Upon completion, the CRO will have a set of resilience-building initiatives to implement, with support from 100RC and platform partners.

4

Act as the focal point for resilience, ensuring that the city adopts a resilience-oriented approach that ensures the holistic use of resources and synergistic project planning, allowing the city to maximize the impact of its projects.

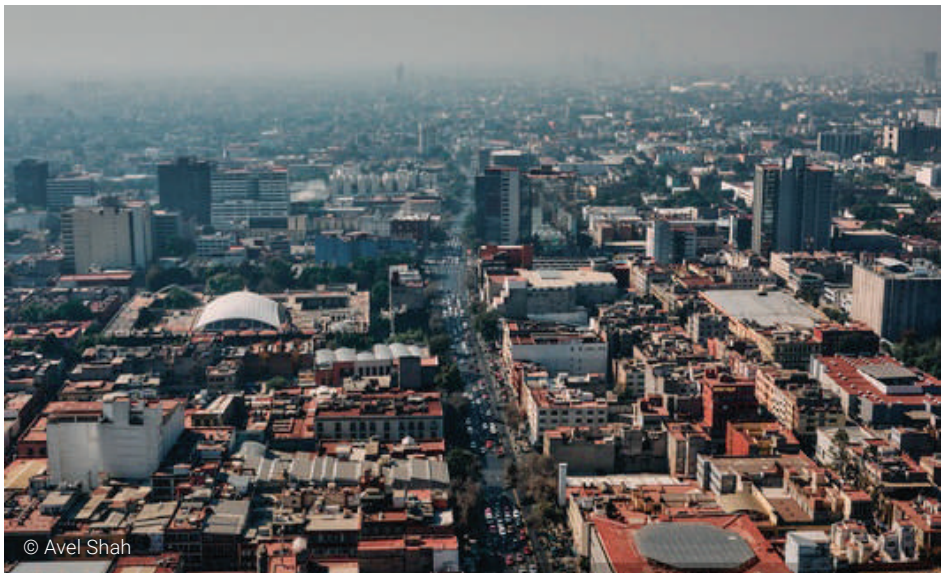
There are many great **examples of Chief Resilience Officers** building resilience in cities such as Manchester, Glasgow, Bristol, London (UK), Barcelona (Spain), Los Angeles, New York City, Washington DC (USA), Amman (Jordan), Cape Town (South Africa), Kyoto (Japan), Rio de Janeiro (Brazil), Seoul (South Korea), Sydney (Australia), Chennai, Surat, Pure (India), Tbilisi (Georgia) and many others.

Many cities around the world have developed urban resilience strategies. Here are a few examples:

Rotterdam (The Netherlands) is a prime example of an innovative approach to urban resilience. The city has implemented a multi-faceted strategy that includes water management solutions, climate adaptation measures, and sustainable infrastructure development. Rotterdam has transformed its vulnerability to flooding into an opportunity for economic growth and sustainable development.

London (United Kingdom) has launched the London City Resilience Strategy 2020. It focuses on longer-term shocks and stresses that may impact London's material prosperity by 2050. The strategy aims to identify gaps in London's resilience, and then to highlight projects and actions to address them.

Mexico (Mexico) has developed the CDMX Resilience Strategy under the 100RC initiative. This strategy is a response to a global commitment by CDMX to foster public policies that strengthen Mexico City's capacity to address various risks without compromising development.



Cities generate large amounts of data that can be used to gain a better understanding of urban dynamics and make more informed decisions about resilience planning and policies. **Digital systems can improve urban resilience** by managing component systems more efficiently, promoting integration between systems, and facilitating stress reduction and early warning in emergency scenarios. For example, Australian cities are taking urgent action to respond to the climate crisis following the country's exposure to severe bushfires, storms, floods and heat.

The Resilient Sydney Platform is an online data portal that visualizes city-scale environmental footprints for strategic planning of climate actions at the city council level. The Platform promotes transparency of risks and opportunities across the city and encourages accountability for tangible action on the ground. Launched in 2019, the Platform hosts geotagged data, visualizations, and tools to help city governments understand the key environmental impacts in their communities. The Platform has been used by 14 councils to actively pursue major net zero plans, and by 16 councils to develop local Resilience Plans.

Several initiatives support the development of digital solutions for building city resilience. For example, Visa and the Resilient Cities Network are inviting member cities to identify challenges and develop innovative solutions that position their city as a digital leader. The aim is to address the challenges that affect citizens, particularly those in vulnerable communities. In the first edition of this initiative, a team of experts have collaborated with three cities to select the best strategies to tackle their challenges. The initiative aims to support the growth of local economies, particularly their vulnerable groups, in order to help bridge the digital divide [19].

Data is instrumental in planning disaster response. For example, in the aftermath of the 2023 earthquake in Turkey and Syria, relief agencies used satellite data provided by NASA to identify critical areas for response. Although disaster risk management scenarios are typically static and assume fixed times and locations of people and activities, human behavior is nonlinear and chaotic, spanning across temporal and spatial scales. **By leveraging data, Disaster Risk Reduction planning can become more dynamic and better reflect reality.** Data analysis can enhance the accuracy of damage prediction and make emergency response more efficient. This, in turn, can improve existing disaster risk assessment and management strategies [20].

Building resilience is not about sacrificing efficiency. It is about ensuring the long-term sustainability of socio-economic systems in the face of future disruptions. **Emerging technologies enable more accurate and automated decision-making** for safer infrastructure, while also providing end-users with tools to communicate, visualize, and interact with the ecosystem [21].

> *Cities are currently facing unparalleled challenges such as climate change, rapid urbanization, and social and economic disparities. Digital systems have the potential to either improve the resilience of cities or disrupt their fragile equilibrium.*

Bayan Konirbayev

Chief Technology Officer of Digital Trade Corridor (member of Port Singapore Authority Group), worked as Chief Digital Officer of Almaty City for more than 4 years and was responsible for the development and implementation of Almaty City's digitalization strategy, Smart City projects and development of IT talent.

19 *Arup & Resilient Cities Network (R-Cities), 2023*
20 *Haraguchi, M. et al., 2022*
21 *Carluccio, S. & Ní Bhreasail, Á., 2019*

Boris Revich

Professor, Doctor of Medical Sciences, Head of the Laboratory of Environmental Quality and Public Health, Institute for Forecasting, RAS, Collective Nobel Peace Prize on IPCC, 2007

Air pollution is the primary problem for most cities, causing excess mortality rates of up to 5% and more for those aged 65 and older. It is also a risk factor for bronchial asthma in children. In the near future, abnormally high temperatures and expanding heat islands may become another major risk factor.

Resilient and sustainable cities intentionally create ***urban environments that promote the physical and mental health of their residents*** *while allowing maximum mobility for people of all ages. A barrier-free, low-risk environment is an important element. On these criteria, Toronto ranks among the best cities in the world.*

Several emerging trends and technologies have the potential to play a major role in promoting urban resilience programmes, especially in reducing health risks. These include the use of clean fuels (hydrogen or hydroelectric power), environmentally friendly vehicles, modernized transport and road systems, restrictions on high-rise construction, the development of blue-green infrastructure, the creation of large — rather than small — open green spaces, vertical landscaping of houses, and others. To ensure effective nature management, ***it is important to balance mitigation and adaptation measures with economic indicators.*** *Additionally, improving the energy efficiency of buildings is another important aspect to consider.*

To assess the health risks and economic losses associated with climate change, it is important to establish the temperature threshold above which population mortality increases. Additionally, a set of preventive measures should be developed to minimize the health risks associated with heat islands.

Mohamed Mezghani

Secretary General of the International Association of Public Transport (UITP) working with 1,900 authorities, operators and industries in more than 100 countries all around the world. Mohamed Mezghani has been working for more than 30 years in public transport and urban mobility related fields.

Public transport plays a critical role in developing resilient cities. In this context, ***resilience refers to a city's ability to withstand, adapt to, and recover from various shocks and stresses.***

Public transportation contributes to this resilience in several ways:

1. *Efficient public transport systems can alleviate traffic congestion. Cities can become less vulnerable to disruptions caused by accidents, road closures, or emergencies by reducing the number of personal vehicles on the road.*
2. *It provides affordable and accessible mobility options for a wide range of citizens, which is important for those who cannot afford personal vehicles, the elderly, and individuals with disabilities.*
3. *Public transport systems are typically more energy-efficient and environmentally friendly than individual car travel. Reducing the dependence on private vehicles can help mitigate the impact of climate change and improve the city's resilience.*
4. *A robust public transportation system can support economic resilience by providing access to employment centers, educational institutions, and other economic hubs even during disruptions. This contributes to the city's overall economic prosperity and ensures the continuity of its services.*
5. *Public transport promotes social inclusion by providing affordable and accessible transportation options for all residents, regardless of income levels. This strengthens social cohesion and ensures that everyone has the means to access essential services.*

In summary, ***public transport is a fundamental component of resilient cities*** *as it facilitates the movement of people, reduces environmental impact, enhances economic stability, and ensures that urban areas are better prepared to face and recover from various shocks and stresses.*

Best Practice Review

For our review of best practices, we examined 50 indices from all macro-regions of the world, including Europe, Africa, America, Asia, Australia, and Oceania. We also considered approaches by major international organizations such as the UN, World Bank, OECD, major federal agencies, leading consulting firms, corporations and universities. Additionally, we identified a separate group of indices that hold value for theoretical and methodological approaches.

To organize global experiences in the development of urban indices, we typed 28 best practices in this field based on two criteria:

1

How comprehensive an index or methodology is.

This means assessing the scope of thematic categories it covers. For example, an index that only focuses on a single theme, such as urban ecology, will have low comprehensiveness. In contrast, a methodology that assesses multiple topics — from ecology and climate change to human capital and governance efficiency — will have high comprehensiveness.

2

How detailed the obtained results are.

This is achieved through non-linear assessment. Practices that assess processes at the intra-city level are grouped into various types and further classified by sample size (100 or more cities is considered "large" and less than 100 cities is considered "medium"). Practices that assess processes at the national level and focus on individual cases — a single city in each case — are classified into separate types.

Based on these criteria, the reviewed practices have been classified into 12 types. The graph below (see Fig. 4) provides an overview of the indices and methodologies for each type.

The review of best practices has provided valuable insights into prevalent trends and methodological approaches within the realm of resilient and sustainable development indices. It is important to note that only a small portion of the indices outlined in the typology — approximately one-fifth — include intracity detail. However, spatial analytics are essential for tailored interventions within urban landscapes. Many practitioners tend to operate with a limited number of indicators. This approach enables comparative analytics and the creation of city rankings at regional and national levels. However, in pursuit of a human-centric approach, it is imperative to identify the most vulnerable areas of urban development and specific territories.

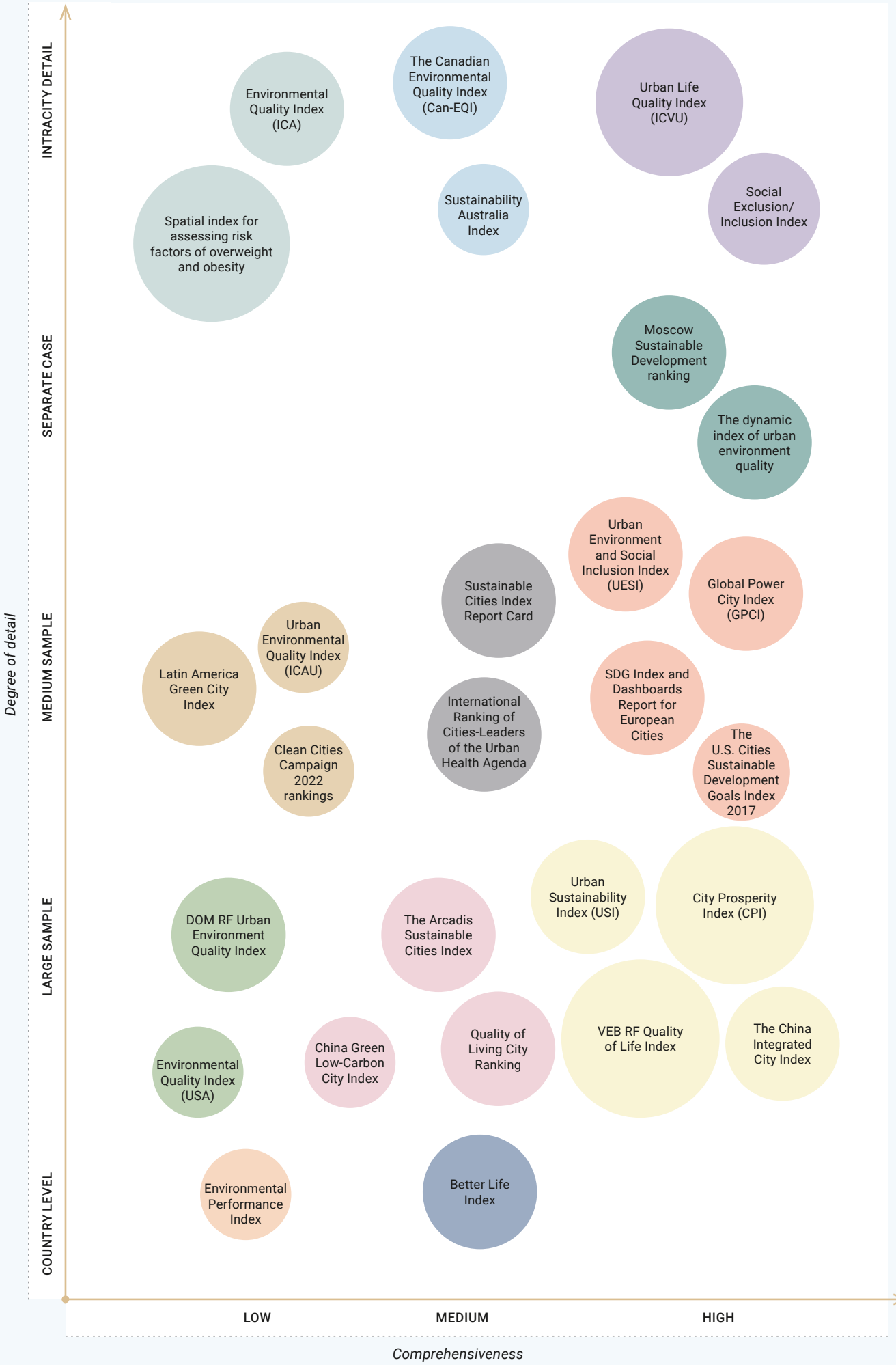
The vision for the Resilient City Index has emerged through synthesizing this accumulated knowledge and critically examining the strengths and limitations of each approach. The index aims to create a holistic tool for resilient urban development by combining the learnings from explored materials and leveraging the merits and drawbacks of different methodologies.

Comprehensiveness (X axis) reflects the range of an index, ranging from highly specialized to universally applicable.

Degree of detail (Y axis) reflects the level at which indicators are assessed, from national and regional to city and neighborhood levels.

Bubble size indicates the locality or universality of each best practice and its relevance to the Resilient City Index.

Fig. 4 — Best practices ranked by comprehensiveness and degree of detail



Resilient City Index

The city is a unique system due to the paradoxical differences in how its subsystems and their components are able to evolve, leading to emerging disparities and complexity in achieving balanced development. To understand and address these inequalities, a thorough examination of the dynamics within a city is necessary, considering all its moving parts and interactions.

A comprehensive analysis of a city requires the use of a wide range of methods and tools. **Geospatial analytics provides a high-resolution view of location-based data.** It fundamentally relies on processing, interpreting, and visualizing geographic information to draw meaningful insights and make informed decisions. This processing of information enables new possibilities and approaches in urban management and planning.

Geospatial analysis has a wide range of applications and profound impact, especially in urban environments. By examining the spatial relationships between various elements in a cityscape, **we can gain an in-depth understanding of how these components interconnect and influence one another.** Geospatial analytics is a cornerstone of urban management and planning, providing a detailed and nuanced perspective that facilitates sustainable and efficient city development.

The Resilient City Index (RCI) is a composite index that includes over 70 spatial indicators across five sub-indices: Social and Commercial Infrastructure, Inequality and Human Capital, Housing and the Built Environment, Mobility and Connectivity and Urban Health and Environment. The index combines data from mobile operators, fiscal records, satellite imagery, mapping services, and city statistics to create a rich repository that offers a comprehensive perspective on urban environments. Diverse datasets such as these can be leveraged to empower a variety of applications and insights across various domains in urban development and management. This multi-dimensional approach offers a comprehensive understanding of the strengths and weaknesses across various aspects of urban resilience. It allows city planners, policymakers, and stakeholders to identify areas for improvement and prioritize interventions effectively.

RCI is an essential tool for evaluating a city's ability to withstand and recover from various shocks and stresses. Its primary purpose is to assess the resilience of urban areas across different dimensions to understand their capacity to adapt, recover, and thrive in the face of challenges.

The key objectives of RCI are:

1

Evaluation of Resilience

The index should provide a structured framework for assessing a city's resilience across multiple factors, such as infrastructure, economic diversity, human capital, and environmental sustainability. This evaluation offers a comprehensive view of a city's strengths and weaknesses in handling various adversities.

2

Guiding Policy

The index should provide policymakers with valuable insights, helping them to prioritize areas for policy intervention and direct resources towards building resilience in sectors that need attention the most. This guidance is essential for strategic planning and resource allocation.

3

Public Awareness and Engagement

Public awareness of a city's resilience and its potential vulnerabilities is crucial. The index, communicated through reports or public releases, should raise awareness among residents, businesses, and local communities about the city's capacity to handle crises. This knowledge encourages active participation and engagement in resilience-building initiatives.

4

Long-Term Planning

Cities should be able to use the index to develop long-term strategies for resilience. The index should assist in setting goals and targets to enhance the city's ability to adapt to future challenges related to climate change, economic fluctuations, public health crises, or other contingencies.

5

Monitoring Progress

The index should enable cities to monitor progress and improvements over time, and evaluate the efficiency of implemented policies, interventions, and investments in bolstering resilience. Regular assessments can support adaptive planning, ensuring that cities remain agile in the face of evolving threats.

In essence, RCI should serve as a diagnostic tool, providing a comprehensive understanding of a city's resilience landscape. Its purpose extends beyond measurement to guide cities towards proactive measures that enhance their capacity to withstand, adapt, and thrive in an increasingly complex and unpredictable world.

Guiding Principles

The foundational principles of the Resilient City Index are based on three key pillars: human-centricity, multidimensionality, and upgradability.

1

Human-Centricity

At the heart of the index is a strong focus on the well-being, needs, and experiences of the individuals living in urban environments. By prioritizing human interests, the index ensures that policies, initiatives, and evaluations aim to enhance the quality of life, promote equality, and foster inclusivity for city residents.

2

Multidimensionality

The index assesses the complexity of urban systems by considering multiple dimensions and aspects that collectively contribute to a city's resilience. It incorporates a diverse range of social, economic, environmental, and infrastructural factors for a comprehensive evaluation of the city's capacity to withstand and adapt to various challenges.

3

Upgradability

The index is designed to evolve and adapt over time. It emphasizes the need for continual enhancement, innovation, and adaptability to changing urban landscapes and emerging challenges. This principle ensures that the index remains relevant, responsive, and effective in evaluating and guiding urban resilience initiatives as cities evolve.

RCI links the three fundamental levels of the city — governance, services, and urban space — to key challenges (see Fig. 5). It is a comprehensive tool that assesses a city's resilience by examining its performance across multiple interconnected dimensions.

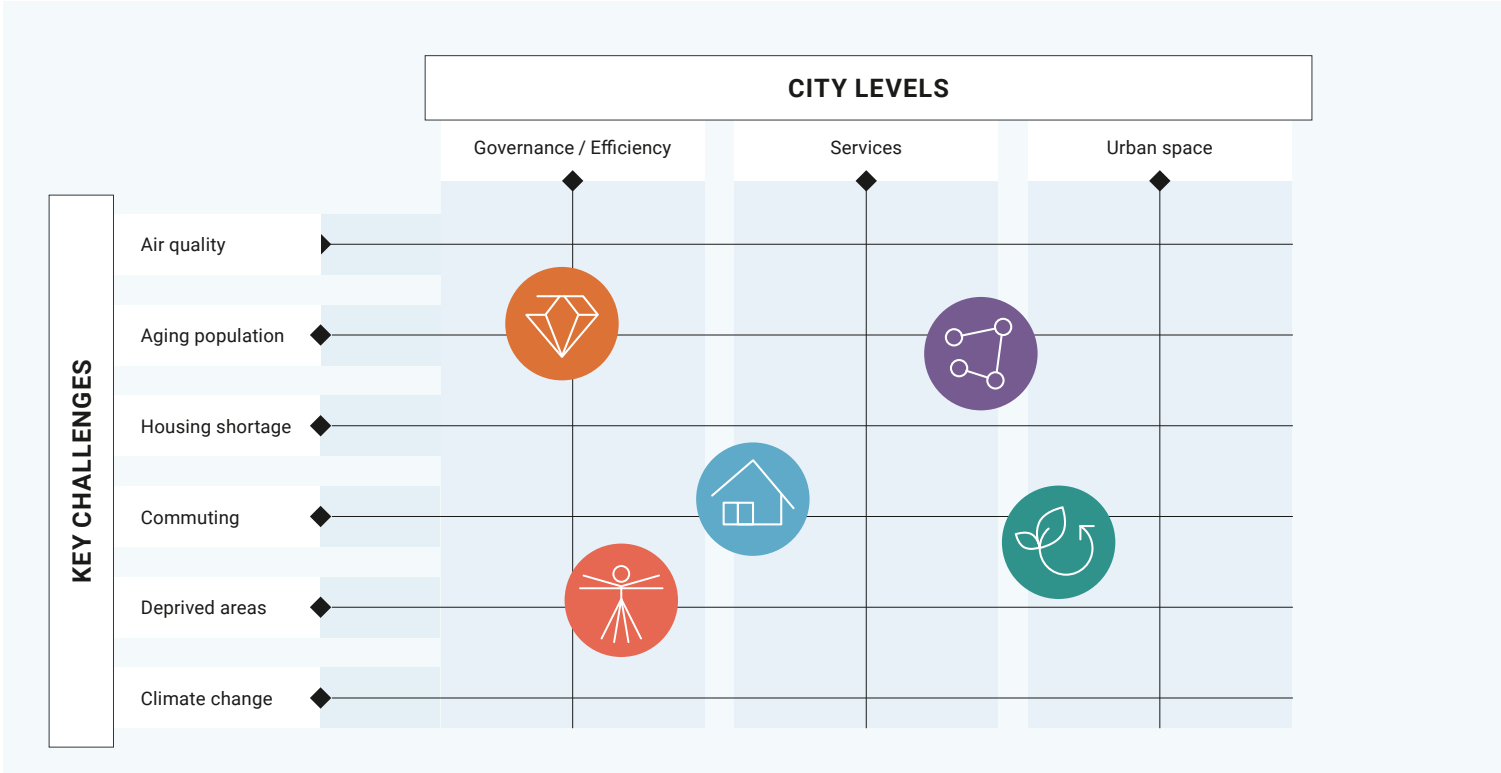


Fig. 5 — The allocation of sub-indices to their respective subjects

RCI comprises **five sub-indices,** each providing a detailed lens through which cities can evaluate and address specific aspects of their resilience. It offers insights into various areas that are essential for improving urban livability, sustainability, and adaptability to future challenges.

Social and Commercial Infrastructure

This sub-index examines the quality and accessibility of essential services such as healthcare, education, and public amenities, as well as the vitality of commercial sectors. It highlights their pivotal role in supporting the social fabric and economic vitality of a city.

Inequality and Human Capital

This sub-index examines socio-economic disparities, education, employment, and inclusivity by assessing the distribution of resources, opportunities, and social equity within a city. It acknowledges that fostering human potential is integral to a city's resilience.

Housing and the Built Environment

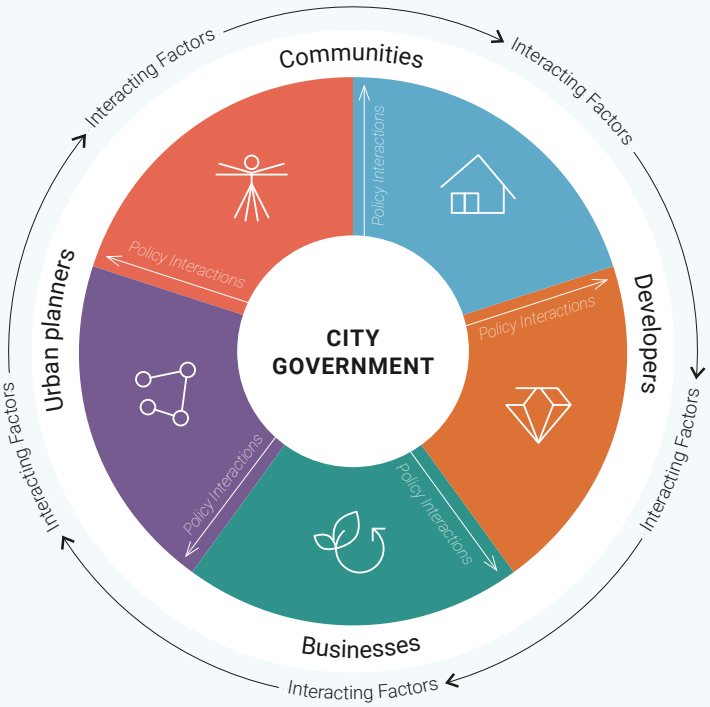
This sub-index explores the capacity of the built environment to withstand challenges while ensuring safe and adequate living conditions for residents. It focuses on the quality, affordability, and sustainability of housing options and urban structures.

Mobility and Connectivity

Evaluating the resilience of transportation systems, connectivity, accessibility, and infrastructure, this sub-index emphasizes the importance of efficient mobility for economic activity, social cohesion, and disaster response within urban areas.

Urban Health and Environment

This sub-index focuses on environmental sustainability, urban health factors, ecological resilience, and measures that address the impact of climate change. It acknowledges the vital relationship between a healthy environment and the well-being of city residents.



This scheme presents a framework in which pivotal decision-makers, such as the city mayor and the city administration, hold significant influence (see Fig. 6). Their actions and initiatives cater to diverse stakeholders, including communities, businesses, urban planners, and developers. In the scheme, the policy-making is guided by the five sub-indices: Social and Commercial Infrastructure, Inequality and Human Capital, Housing and the Built Environment, Mobility and Connectivity and Urban Health and Environment. These sub-indices are interconnected, representing interdependent aspects that shape policy directions and interactions within the city.

Fig. 6 — Administration and stakeholder interaction according to RCI

Methodology

The Resilient City Index methodology employs the H3 hexagonal hierarchical geospatial indexing system of zooms 8, 9 and 10, with the latter being the minimum. Moving between different zoom levels involves a transition process. When transitioning from a larger to a closer zoom level, a regular hexagon is subdivided into seven regular hexagons as shown in the Fig. 7.

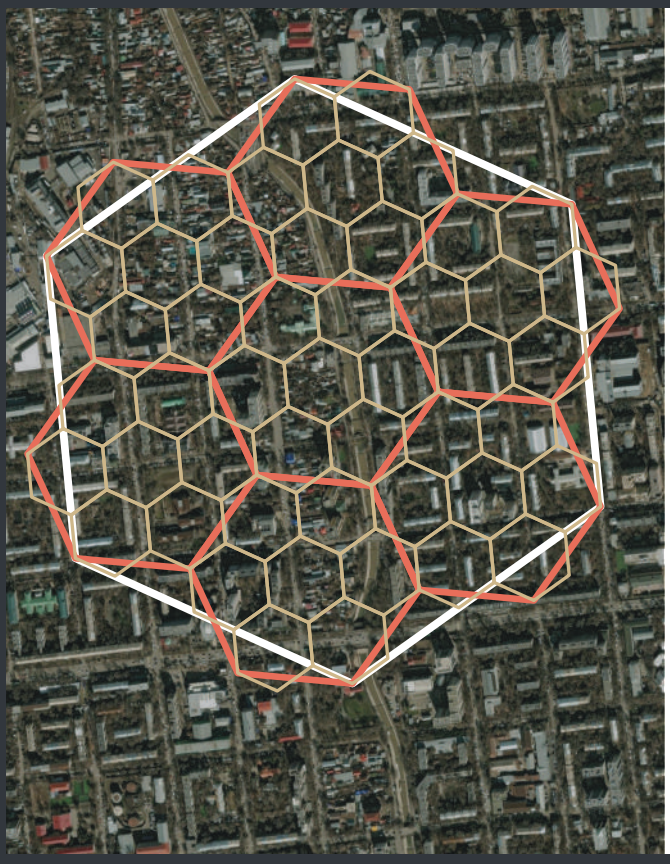


Fig. 7 — The H3 hexagonal grid

After calculating the index values for the hexes of the 10th zoom, we get:

1

A set of 7 values for the 10th zoom indicators in the hexagon of the 9th zoom;

2

A set of 49 values for indicators of the 10th zoom in the hexagon of the 8th zoom

To transfer the value of the indicators to the larger hexagons of the 8th and the 9th zooms, we use the **median value** from the corresponding datasets. For example:

a. $X^9 = \left\{ x_1^{10}, \ldots, x_7^{10} \right\}$.

is the sorted set of values for metric A from the 10th zoom in the 9th zoom hexagon, where the upper index represents the zoom and the lower index represents the ordinal number of the metric after sorting.

Thus, the value of index A for the 9th zoom will be x_4^{10} from the set X^9

b. $X^8 = \left\{ x_1^{10}, \ldots, x_{49}^{10} \right\}$.

is the sorted set of values for metric A from the 10th zoom in the 8th zoom hexagon, where the upper index represents the zoom and the lower index represents the ordinal number of the metric after sorting.

Thus, the value of index A for the 8th zoom will be x_{28}^{10} from the set X^8

Indicator values are normalized on a scale of 0 to 1, where a value closer to 0 suggests a higher risk probability, while a value closer to 1 suggests a lower risk probability.

The aggregation of the main index and sub-indices from indicators.

The main index contains 5 sub-indices, each consisting of N indicators. The sub-indices were calculated using the **arithmetic mean** formula:

$$\overline{x}_j = \frac{1}{N} \sum_{i=1}^{N} x_j ,$$

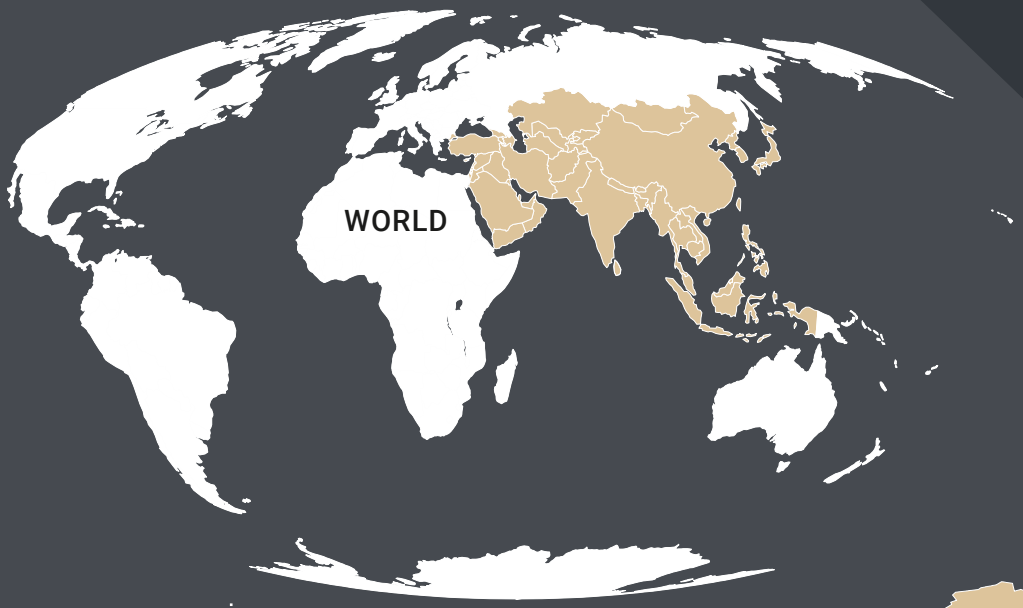
where $\overline{x}_j$ — is the subindex of the j-th number.

Accordingly, the formula for calculating the main index is:

$$x = \frac{1}{5} \sum_{j=1}^{5} \overline{x}_j .$$

These values are subsequently normalized to a scale of 0–100. A higher value indicates greater resilience and a lower chance of risk actualization.

ALMATY
CASE STUDY



149,939,063 km²

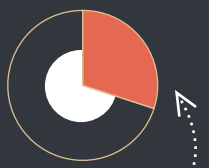
44,580,000 km²

ALMATY CASE STUDY

ALMATY BY THE NUMBERS [22]

13.4 %
share of the population over 60 years old in 2022

48 %
of SMEs owned by women as of early 2023



30 %
of residents with higher education in 2021

[22] *According to official statistics*
[23] *Across all cities in Kazakhstan*

2,222,782 people
population at the end of 2023

18.5% or $41.6 billion
share in Kazakhstan's GDP in 2022

1.85 mln
tourists in 2022

20.7 units per 100 people passenger car ownership in 2022

3.08 children per woman total fertility rate in 2021 [23]

77.32 years
life expectancy at birth in 2022

3,882,000 km²

2,725,000 km²

682 km²

Almaty: As Is

Almaty, the largest city in the Republic of Kazakhstan, has served as the country's capital for almost 70 years. It is situated in the foothills of the Ile Alatau (Trans-Ili Alatau) mountains, and the mountain peaks that surround the city to the south are visible from almost any point in the city on a clear day. For this reason, local residents commonly use **the terms "up" and "down" as reference points.**

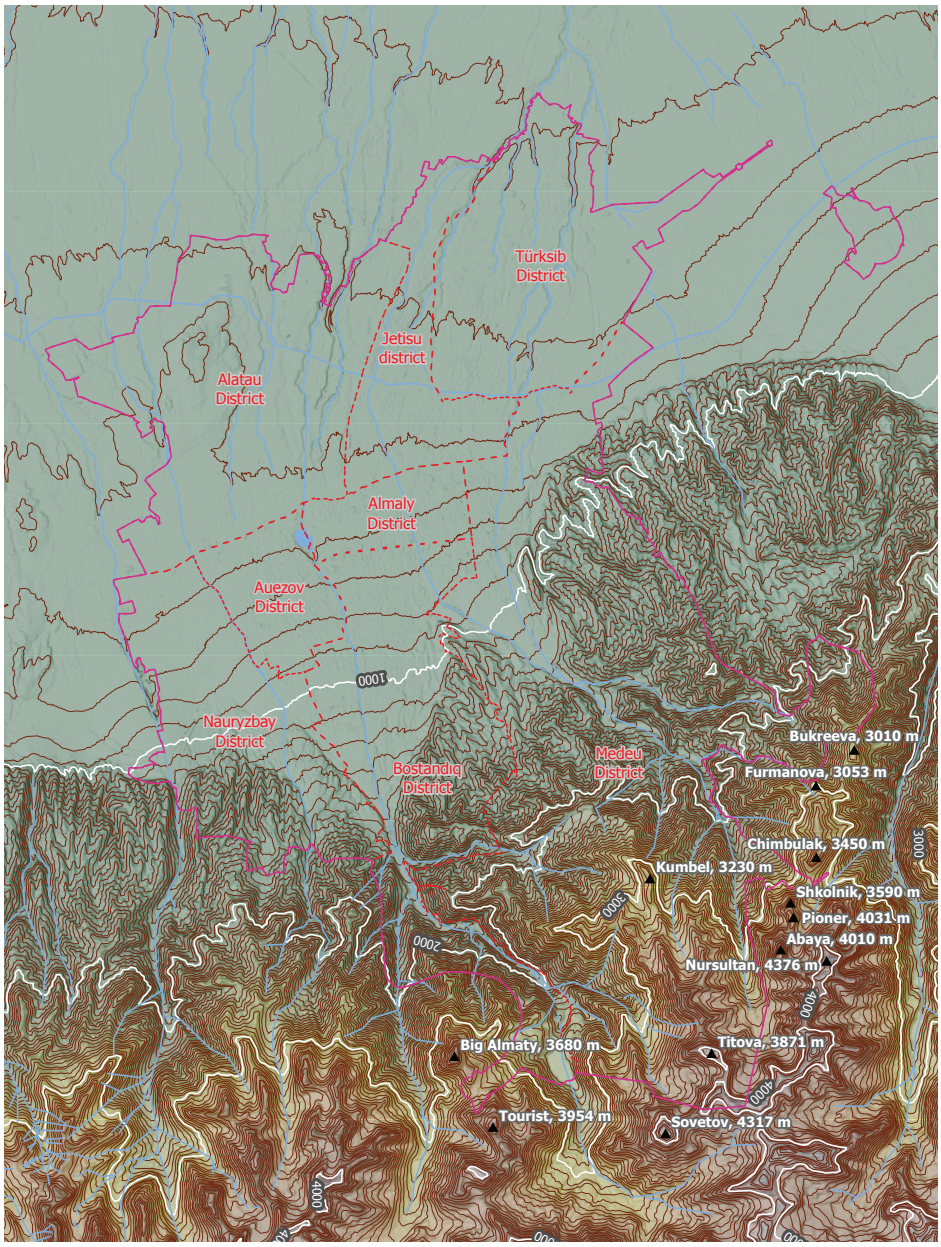


Fig. 8 — Hypsometric map of Almaty area

Geographical Description

Almaty has a humid continental climate that is influenced by the **mountain-valley circulation,** especially in the northern part of the city, which lies directly in the transition zone between the mountain slopes and the plain. The average annual temperature is 10.4 °C (50.7 °F). January is the coldest month with an average temperature of −3.9 °C (25 °F), while July is the warmest month with an average temperature of 24.2 °C (76 °F).

The city is characterized by a complex hydrographic network of natural rivers, tributaries, canals, and reservoirs. This is due to several factors, including the city's location in the foothills, the relatively high annual rainfall in the area (600–650 mm), the melting of the high mountain glaciers in summer, and, of course, the anthropogenic factor of canal construction.

The city is crossed by two rivers, Bolshaya Almatinka and Malaya Almatinka, along with their tributaries: Esentai (Vesnovka), Remizovka, Zharbulak, and Karasu. All these rivers are prone to mudflows and belong to the closed drainage basin of Lake Balkhash. Their waters are used for the city's industrial, economic and recreational needs. Another feature of Almaty's urban landscape is an **extensive network of ditches.**

Earthquake hazard zone

570,000
area population

34,703
total buildings in area

By floor count:

1	23,025
2–5	10,769
6–9	470
10–15	344
16–30	95

Year of construction:

before 1927	838
1927–1935	431
1936–1941	1,810
1942–1957	7,453
1958–1969	8,413
1970–1995	6,670
after 1995	9,088

Seismic Activity

Almaty is situated in a **seismically active region.** Three historic earthquakes hit Almaty, then known as Verny, in 1887, 1889, and 1911. Each time, the city sustained heavy damage and had to be rebuilt.

Based on data from the US Geological Survey, an area that would be most affected by a large earthquake has been identified (see Figure 9). The analysis examined 10,231 earthquakes with epicenters within 500 km of Almaty over the past 20 years, ranging in magnitude from 1.1 to 7.8. The calculations also took into account the location of tectonic faults in the city.

To assess the magnitude of the tremors around Almaty, a recalculation was performed based on the ratio of the magnitude at the epicenter to the magnitude observed in the city. This approach accounted for the heterogeneity of the geological environment and its tectonic and structural features.

According to tectonic modeling, areas with the highest density of tectonic disturbances are the most vulnerable to serious consequences. Based on this, and the distribution of aftershocks from major earthquakes in the region, we have **identified the city area that is most susceptible to the devastating effects** of major seismic events.

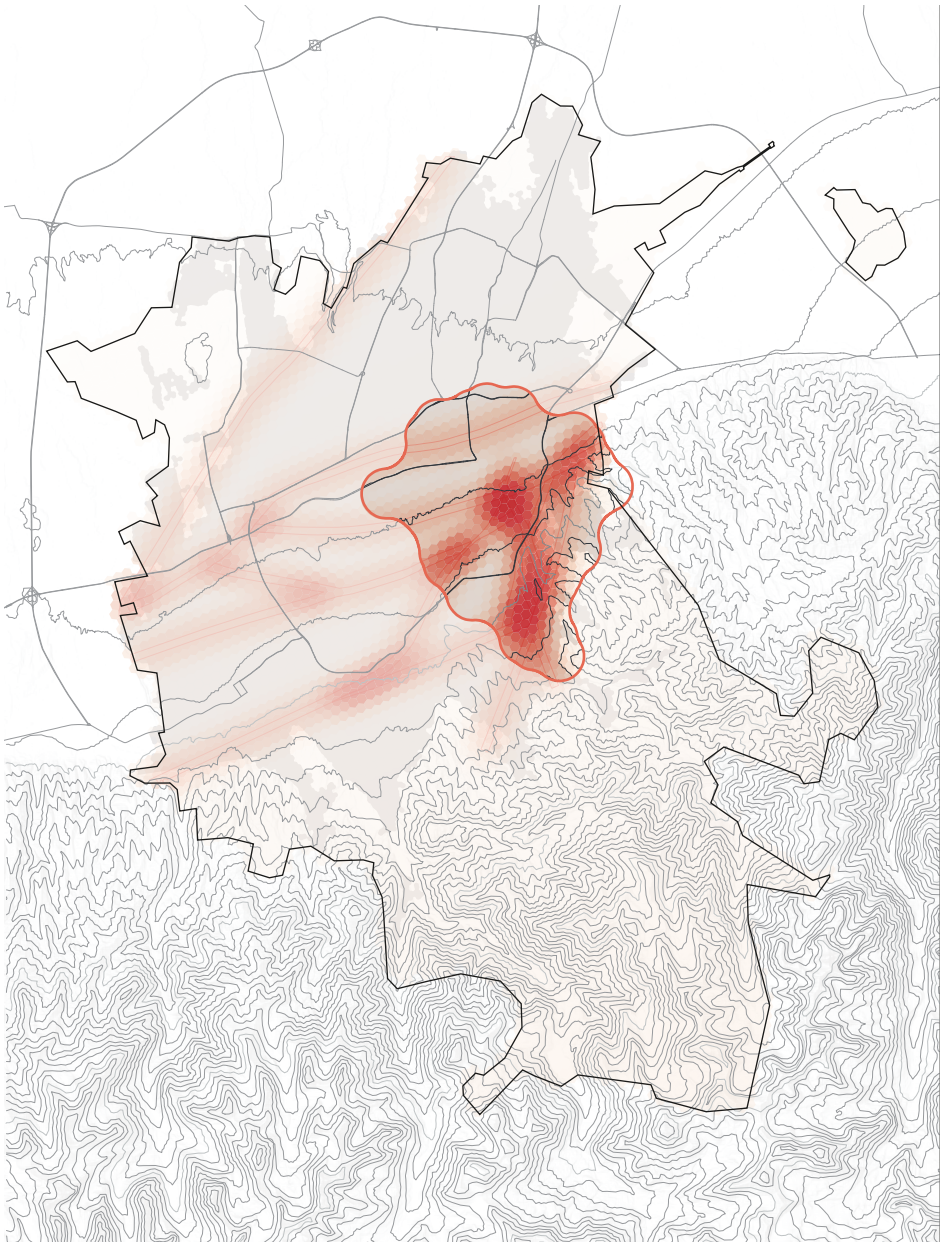


Fig. 9 — Earthquake hazard area

History

From Ancient Times to the Middle Ages

The history of Almaty dates back at least a thousand years. Its current territory has been inhabited by various tribes since ancient times, including the Scythian tribes from the 6th to the 3rd centuries BC. Their burial mounds have been found in the vicinity and even within the city itself. Recent evidence from the 8th to 10th centuries AD indicates the existence of several urban settlements close to Almaty, situated on the trade route from Europe to China known as the Great Silk Road. These settlements have developed various crafts, built plumbing and sewage systems, and used minted coins. In the beginning of the 13th century, the Mongol conquest brought hard times to the cities of the Ile Valley, including Almaty. In addition, the decline of the Great Silk Road had a negative impact on the city's development.

Defining the boundaries and layout of the ancient city of Almaty is challenging because its territory is completely occupied by the modern city. Today, only ruins remain on the southern and northern outskirts of the city [24].

Tsarist Era

The modern history of Almaty dates back to 1854, when the Russian Empire built a military fortification on this land and named it Verny. Later, it became the center of Semirechenskaya oblast and began to develop industries and crafts.

In 1868, the newly established city arrangement committee drafted the city's first general plan. It aimed to expand the city limits and featured a schematic layout with small blocks of 1.5 to 2 hectares and a 35-meter-wide street grid.

On May 28, 1887, a strong earthquake struck the city, resulting in the deaths of 322 people and destroying 1798 brick houses. Following this, a seismic and meteorological station was set up in the city under the direction of architect Andrey Zenkov. It aided in the development of a system for constructing buildings that accounted for seismic activity. As a result of the earthquake, wood became the city's primary construction material. Some buildings from that era have been preserved and are now historical and architectural monuments under state protection.

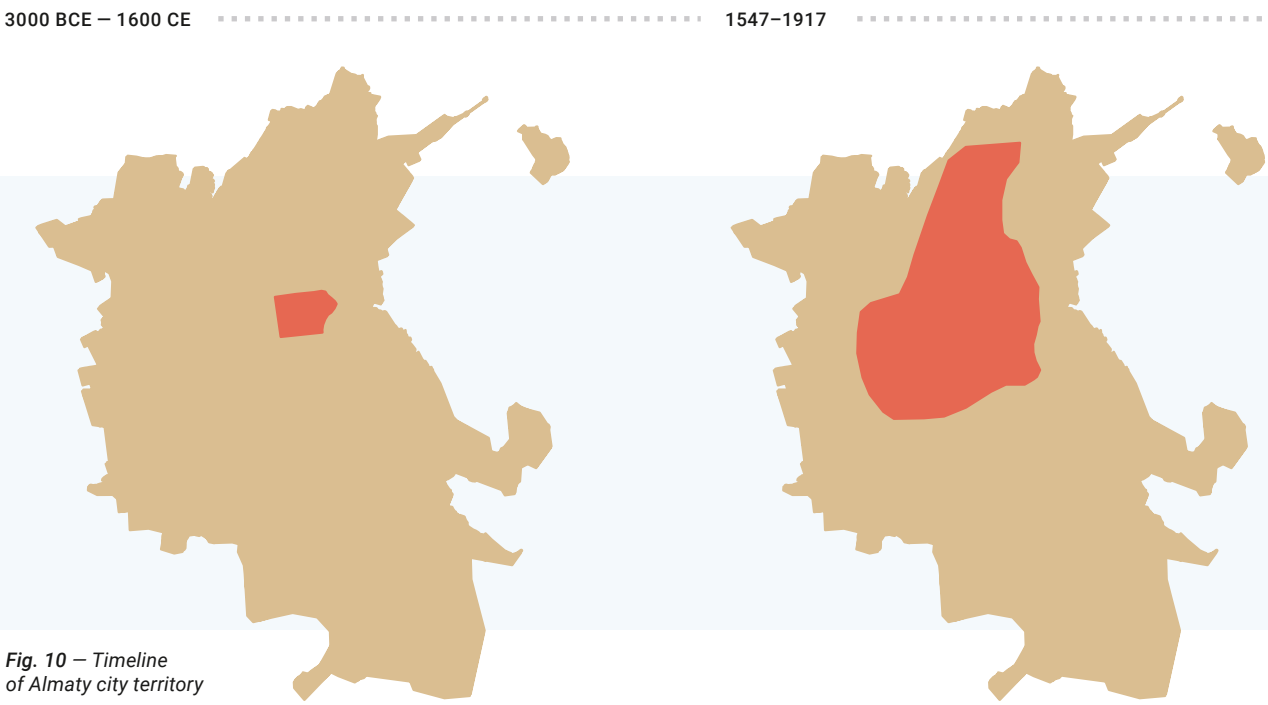


Fig. 10 — Timeline of Almaty city territory

ARCHCODE

Soviet Period: Becoming the Capital

In 1918, Verny came under Soviet control. At the time, the city was home to over 41,000 residents and 59 industrial enterprises. In 1921, the city was renamed to Alma-Ata, as the area had been called Almaty in the past. In 1929, it became the capital of the Kazakh ASSR, which was previously located in Kyzylorda. The decision to move the capital was made in 1927. At the same time, the USSR announced a nation-wide competition to design the city's Government House, with the participation of the country's leading architects. Moisey Ginzburg, one of the founders of Soviet Constructivism, was declared the winner and was also commissioned to design the ensemble of buildings surrounding the Government House.

The relocation of the republic's capital led to a surge of construction activity in the city. Dozens of new institutions and organizations had to be accommodated, and there was a need for additional housing to support the rapidly growing population. In 1929, the city's population was 71,000, but by 1937, it had almost tripled to nearly 200,000.

Before 1936, the city lacked a comprehensive general plan. Only the main streets and construction sites of major buildings were defined. In the late 1930s, the formula of Soviet architecture, as well as all Soviet art — "national in form, socialist in content" — began to be reflected in the architecture of Kazakhstan. In 1936, Alma-Ata became the capital of the Kazakh Soviet Socialist Republic. In 1937, the city's general development plan was published, and its main milestones were implemented. As planned, an industrial zone was developed in the north, while universities and academic buildings were constructed in the south, along the present-day Abay Avenue. Residential areas, consisting of four- and five-storey buildings, were built in the west.

Independent Kazakhstan Era

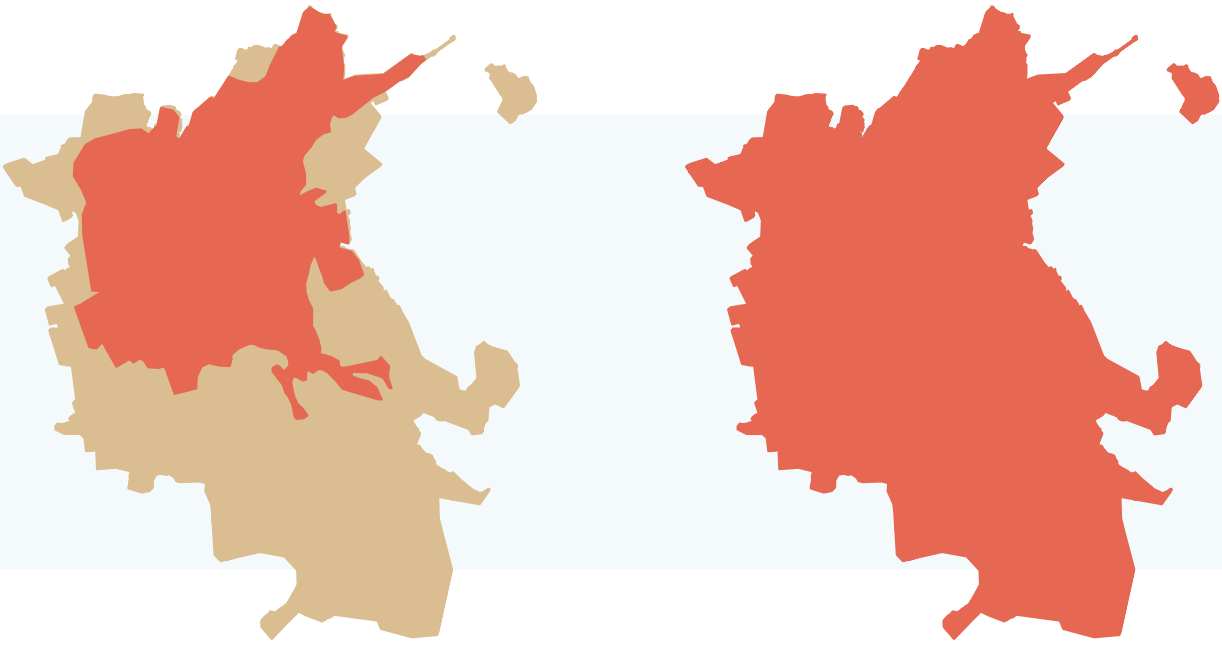
After Kazakhstan gained independence in 1991, Alma-Ata became the capital of the young state and regained its historical name Almaty. After the capital was moved to Astana in 1997, Almaty remains the country's important center for science, culture, industry, and finance. It is a must-see destination for anyone visiting Kazakhstan.

Following the general plan of 1937, five master plans were developed, each outlining the construction and development of the city up to a certain date [25]. The construction of the Almaty Metro began in 1988, but due to the collapse of the USSR in 1991 and the severing of economic ties that followed, the construction of the Almaty Metro could not be completed. It faced critical delays as many issues could not be resolved due to the liquidation of a number of ministries and departments.

The general plan of 2002 aimed to develop 31,900 hectares of land with a population forecast of 1.5 million people by 2020.

In 2014, the city boundaries were expanded to include new territories, such as Alatau, Bostandyk, Zhetysu, Medeu, Nauryzbay and Turksib districts, which also encompassed the Ile-Alatau National Park. As a result, the city's area increased to 68,200 hectares, and its population reached 1.64 million people. However, the 2014 expansion caused serious issues with the provision of social, transport and engineering infrastructure.

1917–1991 — 2014 — NOWDAYS



[25] *Theses by Askar Amrin, Deputy Akim of Almaty on the General Plan, 2023*

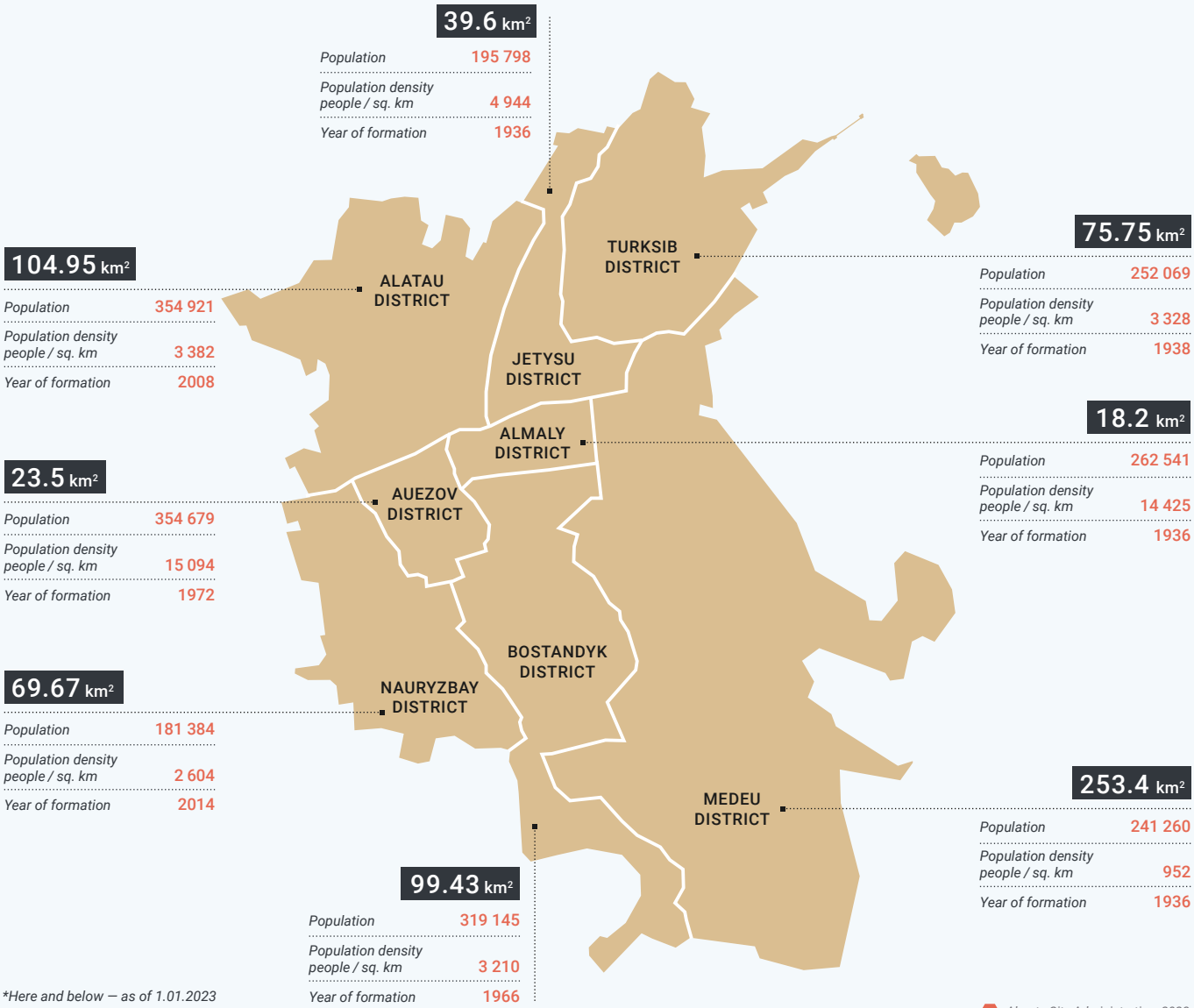
Today

Almaty is currently **the largest economic center in Kazakhstan and the most developed megacity in the Central Asian region.** It is home to international organizations, financial institutions, major companies, and universities. Almaty ranks second in terms of gross regional product (GRP) among the regions of Kazakhstan. Its economy is primarily driven by trade and tourism, while industry is a developing sector. The volume of gross regional product for 2022 was $41.6 billion **(more than 18% of Kazakhstan's GDP),** with the production of goods accounting for 7.6% of its structure, while services accounted for 84.1%.

As of December 1, 2023, the population of Almaty was 2.2 million people. Since 2012, the population of Kazakhstan has been growing exclusively due to the birth rate, which has increased by 16.9% over the past decade. Almaty's population is also growing due to migration. According to the Bureau of National Statistics of the Republic of Kazakhstan, Almaty's balance of migration in 2023 was 31,671 people, including 3,535 people from external migration and 28,136 people from internal migration.

Almaty has two railway stations, Almaty-1 and Almaty-2. Almaty-1 is a transit station located in the north of the city, on the way from the Siberian regions of Russia to Central Asia. The city's only airport is Almaty International Airport, located 15 km from the city center. It is the busiest airport in Kazakhstan in terms of passenger traffic, operating regular flights to over 55 cities worldwide. The airport offers a wide range of destinations for travelers.

Almaty has a metro system that was launched on December 1, 2011. It is the first and only metro in Kazakhstan and currently consists of a single line with 11 stations. Almaty has 21 bus fleets that operate 150 city routes for passenger transport. The fleet consists of 2441 mobile units (with back-up), including gas buses (515 units), trolley buses (196 units), electric buses (15 units) and diesel buses (1715 units). [26].



*Here and below — as of 1.01.2023

26 Almaty City Administration, 2023

Fig. 11 — The eight districts of Almaty

Almaty's Challenges

Almaty faces **significant environmental challenges due to its location** in a foothill basin. The city suffers from a shortage of construction sites within the city limits, severe air pollution, overcrowding, and mass migration of the rural population and residents of other cities. These issues are made worse by the population's preference for living closer to the city center rather than on its outskirts. The city was originally planned for a population of 400,000, but it has already surpassed two million residents.

Almaty is located in a seismically active area. Based on the city's seismic micro-zone map, the mountainous part of Almaty Region is located in a 10-point risk zone. The city center is also in a high-risk zone.

Cars are responsible for over 50% of the city's air pollution, with smog, CHPs and the private sector contributing 48 per cent [27]. Almaty has 530,000 cars as of January 2022, and this number is increasing daily. These vehicles emit thousands of tonnes of harmful waste into the air each year.

The city of Almaty is confronted with several challenges in terms of digital services and urban analysis. One of these is the accessibility and quality of data. Efficient urban analysis requires accurate and accessible data. The cities of Kazakhstan encounter challenges in collecting, managing and sharing data across different departments and agencies. Additionally, different city departments may be using incompatible systems that don't communicate well with each other. Achieving interoperability between different digital platforms is crucial for holistic urban analysis. Outdated or inadequate technology infrastructure should not hinder the implementation of advanced digital services.

Cities must learn to balance the vulnerabilities and opportunities of digital systems. This requires end-to-end and multi-system planning, effective skills and capability building, and an integrated approach to city leadership and management. Public and private sector asset owners and network operators should work together. Policy and regulation should also be considered.

Another point relates to the digital infrastructure, which limits many services and data exchange processes. In the next decade, these problems will become increasingly interdependent, especially at the city level.

Bayan Konirbayev

Chief Technology Officer of Digital Trade Corridor (member of Port Singapore Authority Group), worked as a Chief Digital Officer at Almaty City for more than 4 years and was responsible for the development and implementation of digitalization strategy in Almaty city, Smart City projects and development of IT talents

To evaluate the risks of environmental pollution for public health, as well as the economic losses caused by such risks in Almaty, we need to assess both the local risks within the framework of spatial planning and the risks for the city as a whole.

Boris Revich

Professor, Doctor of Medical Sciences, Head of the Laboratory of Environmental Quality and Public Health, Institute for Forecasting, RAS, Collective Nobel Peace Prize on IPCC, 2007

The dynamic business environment in Almaty requires a proactive approach to technology adoption. Businesses should not only use technology but also become strategic partners in the city's digital transformation. This shift in perspective aligns with the broader discourse on urban resilience, emphasizing the need for cities to harness the power of technology to address multifaceted challenges. The agenda is not limited to adopting technology, but rather aims to strategically deploy technology to enhance business performance and competitiveness within the changing urban landscape. This can be achieved through the implementation of smart infrastructure, data-driven decision-making, or the integration of digital platforms. As Almaty moves forward, the intersection of technological innovation and urban resilience will play a defining role in shaping its future as a dynamic, adaptable, and competitive urban center.

Andrew Beklemishev

Vice President, International Data Corporation (IDC), Vice President, International Academy of CIO, Chairman, Public Council, Ministry of Digital Development, Innovations and Aerospace Industry of the Republic of Kazakhstan

[27] *Ministry of Ecology and Natural Resources of the Republic of Kazakhstan, 2020*

City Level

The Resilient City Index provides a comprehensive overview of Almaty's overall resilience, covering various aspects critical to urban well-being. **The index is a valuable tool for urban planners and policymakers,** providing insights into the city's strengths and potential areas for improvement.

The Resilient City Index for Almaty has a composite score of 54.7 out of 100. The index value is affected by the Medeu district, which is located in the mountains and has a significant size but lower population density (93% lower than Auezov district), as well as less developed infrastructure. The maximum value in a hexagonal cell is 75. One-third of the city's population lives in areas with higher cumulative risks than the city average. This highlights **localized vulnerabilities** that may require **focused interventions.**

The spatial distribution of the Resilient City Index (see Fig. 12) indicates that the districts of Almaly, Auezov, and the north of Bostandyq have the highest resilience for all indicators. Isolated peaks are also visible in the Jetisu and Turksib districts, north of the city, suggesting areas with notable strength in resilience. This insight into spatial variation highlights the need for nuanced and targeted strategies to strengthen resilience in specific districts of the city.

If we look at the sub-indices (see Fig. 13), it is apparent that "Inequality and Human Capital" is the most significant contributor with a score of 75.8, followed closely by "Social and Commercial Infrastructure" (66.9) and "Urban Health and Environment" (59.9). At the same time, "Housing and the Built Environment" (28.8) and "Mobility and Connectivity" (42.1) present challenges and indicate areas for improvement.

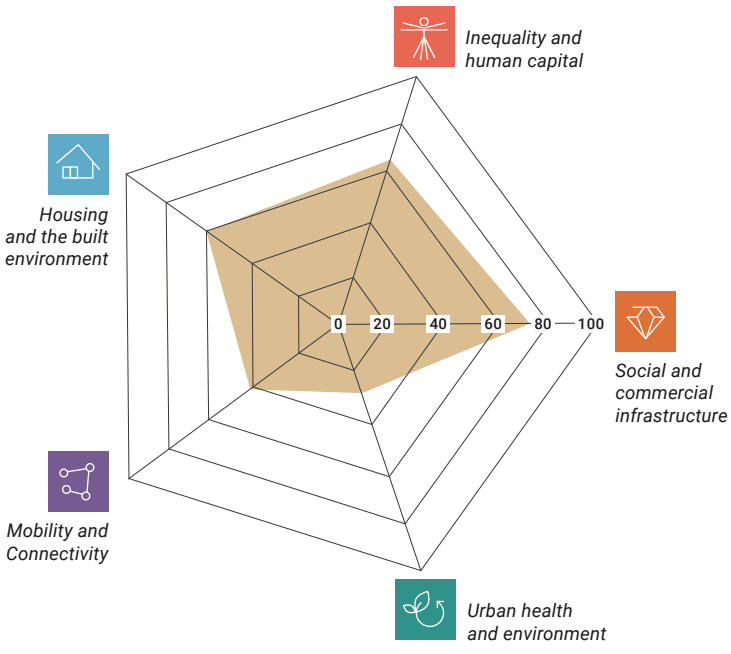
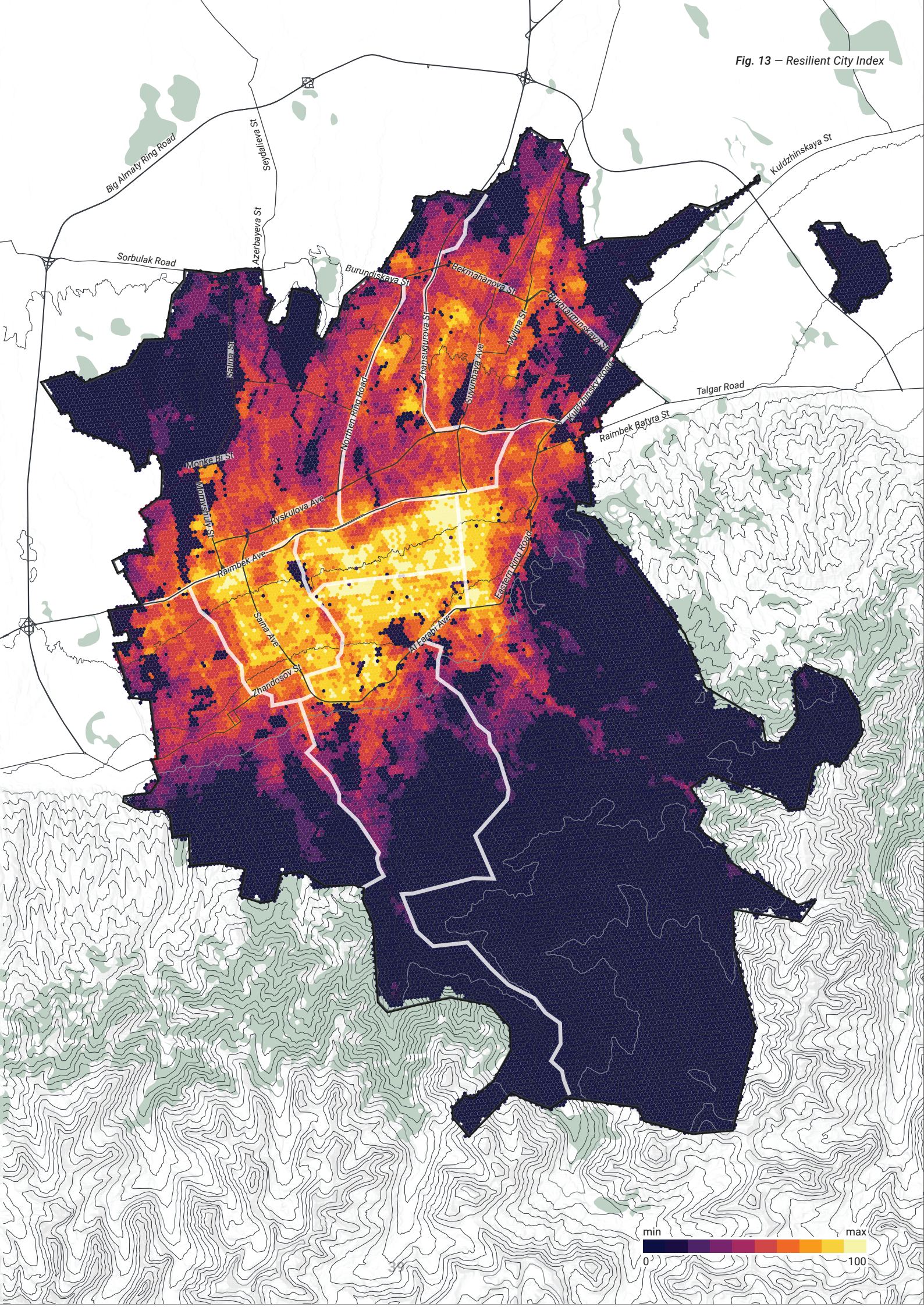


Fig. 12 — Distribution of the Resilient City Index sub-indices

Fig. 13 — Resilient City Index



Strengthening Almaty's resilience will require deliberate and focused interventions in areas such as housing, mobility, and the environment. Addressing these challenges head-on will lead to a stronger, more adaptable future, ensuring the well-being of the city's diverse population.

Inequality and Human Capital

The "Inequality and Human Capital" sub-index indicates that 26.5% of Almaty's population is at a high risk of spatial segregation. The areas in which they reside have the potential to improve the quality of human capital. The maximum value of the index is 79. The spatial distribution is evenly spread across most of the city, with peaks in the districts of Almaly, Auezov, and the northern part of Bostandyq (see Fig. 14).

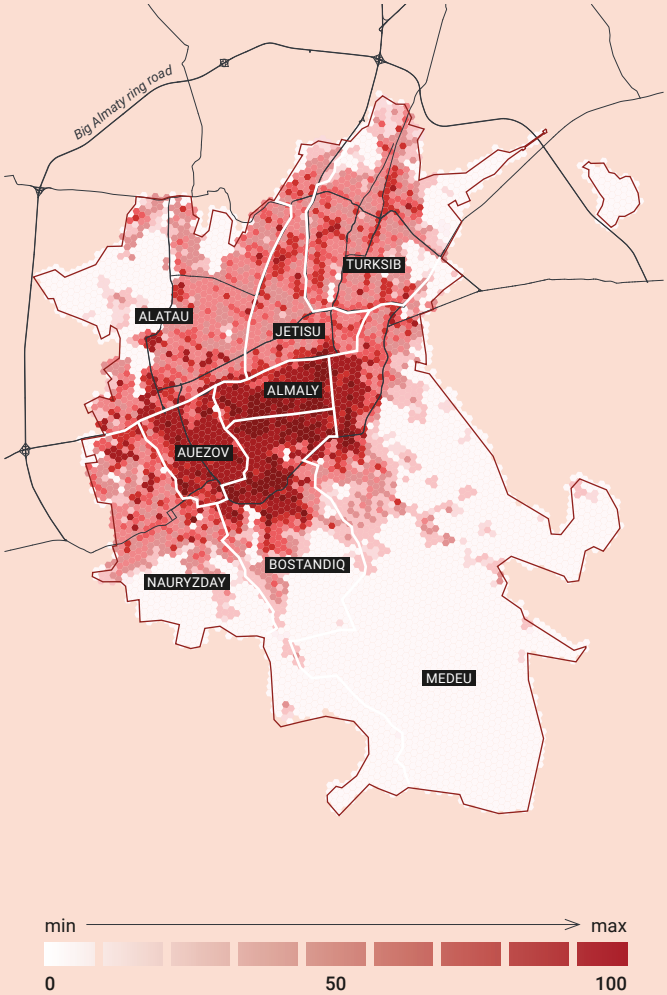


Fig. 14 — The "Inequality and Human Capital" sub-index

Urban Health and Environment

The "Urban Health and Environment" sub-index uses several indicators that reflect the natural and climatic state of the environment, as well as the main pollutants. Geographically, higher values are observed in the "upper" areas (see "Almaty: As Is" X for details). The final distribution reflects the overall situation in the city, with higher values in the populated areas (see Fig. 15). It is largely defined by Urban Health indicators that characterize behavioral risks, such as alcohol and tobacco consumption, unhealthy diets, and low physical activity. This sub-index has an average result among the other sub-indices with a maximum value of 75.

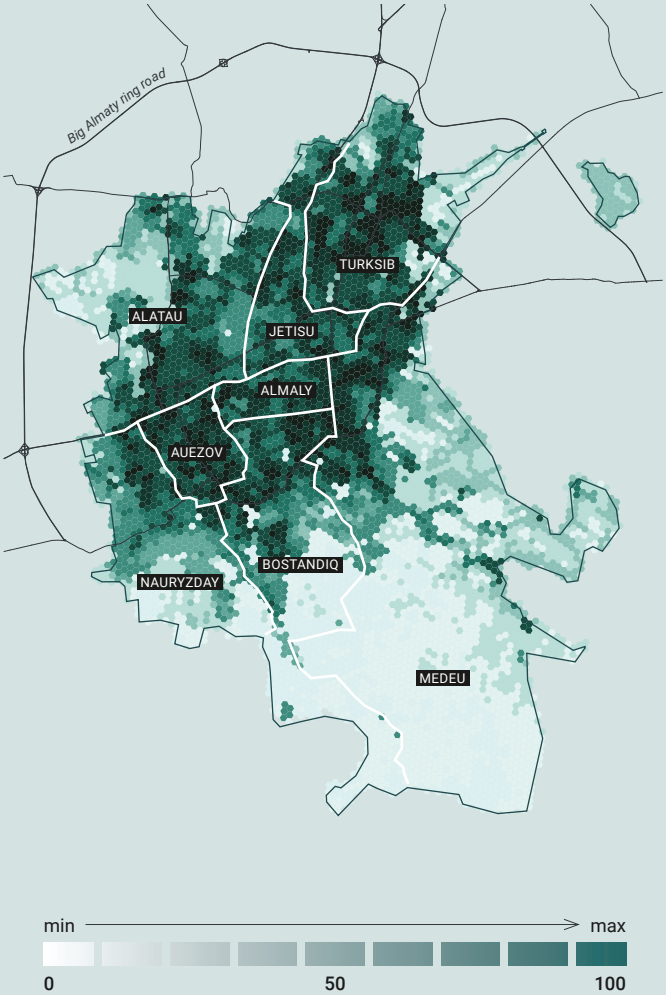


Fig. 15 — The "Urban Health and Environment" sub-index

Mobility and Connectivity

The "Mobility and Connectivity" sub-index also highlights significant risks to Almaty's sustainable development. Its spatial distribution is largely determined by the city's main transport arteries (see Fig. 16). 58.4% of the population has a medium or high level of mobility. The street and road network in the central part of the city is historically more developed and shows greater resilience despite the increase in traffic. In contrast, the periphery is losing ground in terms of both public and private transport.

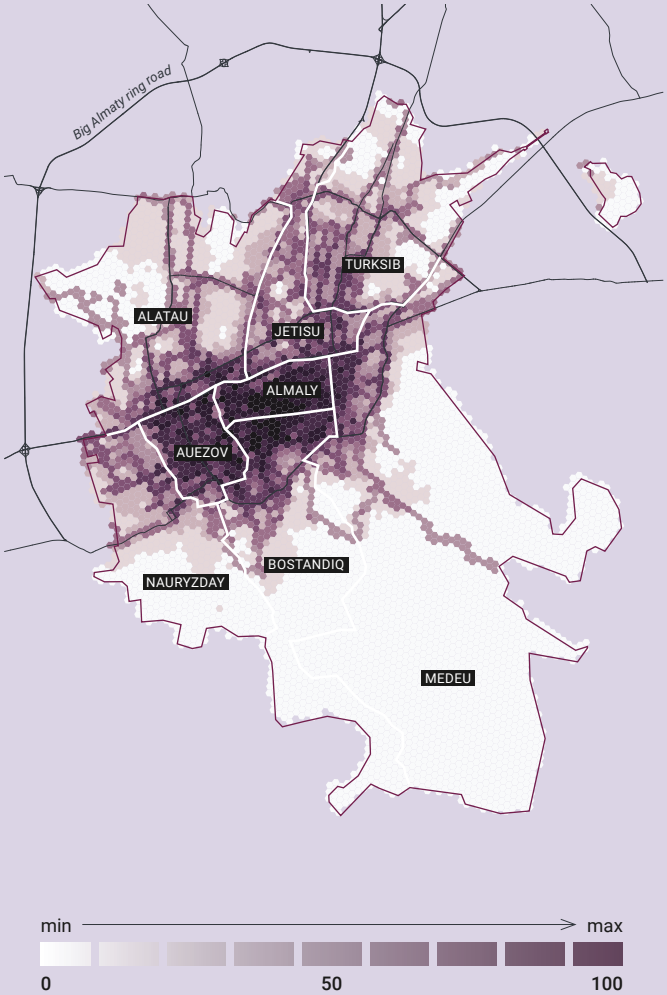


Fig. 16 — The "Mobility and Connectivity" sub-index

Housing and the Built Environment

The "Housing and the Built Environment" sub-index indicates a low level of resilience and high risks associated with the urban environment and spatial development. The worst result is that 43.9% of Almaty's population live in areas with below-average scores. The values in the periphery are much lower than those in the central areas, as shown in Fig. 17. Some areas with low values around the city's water bodies or private housing construction sites remain undeveloped. It is crucial to address the challenges in this critical aspect of urban life to ensure Almaty's future resilience. This stresses the need to improve housing conditions and spatial planning throughout the city.

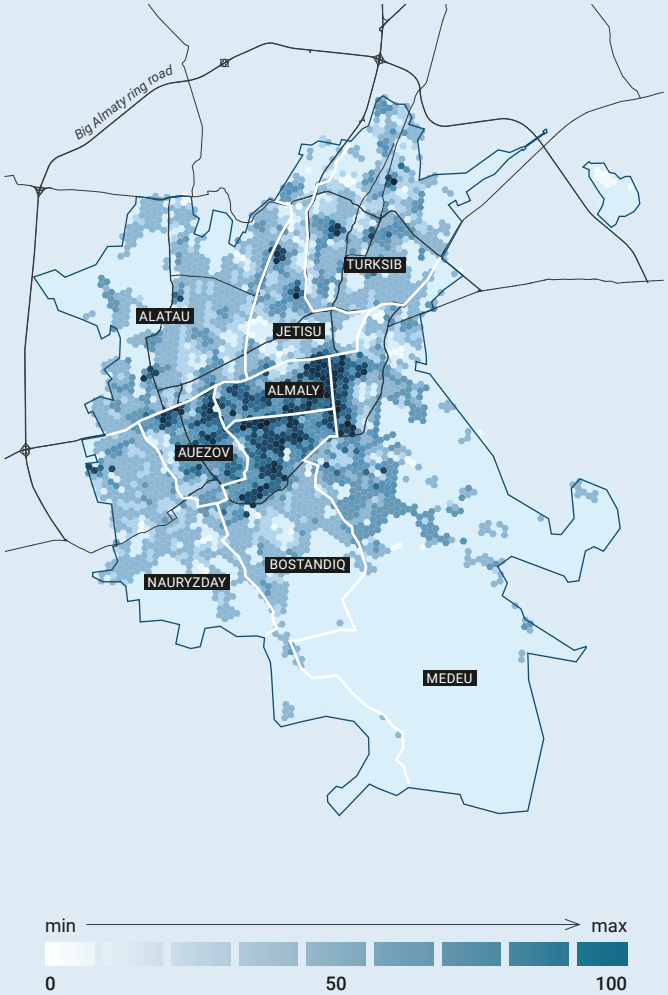


Fig. 17 — The "Housing and the Built Environment" sub-index

Social and Commercial Infrastructure

The spatial distribution of scores for the "Social and Commercial Infrastructure" sub-index (see Fig. 18) reflects the overall patterns of the index, with high averages in the densely populated areas of the city center and north, with the exception of most of the Alatau district. This sub-index is the only one that reaches a peak of 98 in the city (the next biggest sub-index has a maximum value of 81). 622,000 people are the most exposed to risks associated with the availability of the city's infrastructure.

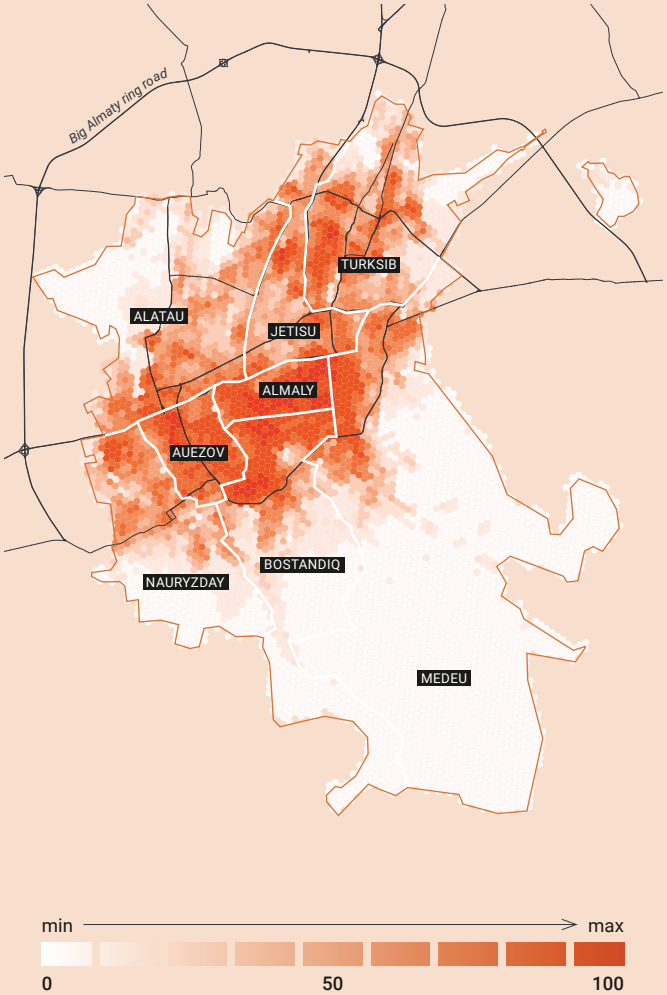


Fig. 18 — The "Social and Commercial Infrastructure" sub-index

District Level

Respecting the administrative boundaries of the city's districts is an important aspect of urban governance. **It is essential for city leaders to understand and assign responsibility for a specific area,** and to set clear goals and objectives to improve resilience.

Almaty is divided into eight administrative territories. The Resilient City Index (see Fig. 19) ranks Almaly, Auezov, and Bostandyk as the top three districts. Jetysu, Alatau and Turksib districts share the fourth place with a score of 51, while Nauryzbay district has the lowest score of 50. The difference between the highest and the lowest scoring districts is 26.9%.

Looking at the distribution of sub-indices by district, there is a significant gap between the "Housing and Built Environment" and "Social and Commercial Infrastructure" sub-indices, with 55% and 44%, respectively. Almaly consistently ranks as the city's most resilient district across all metrics (see Fig. 20).

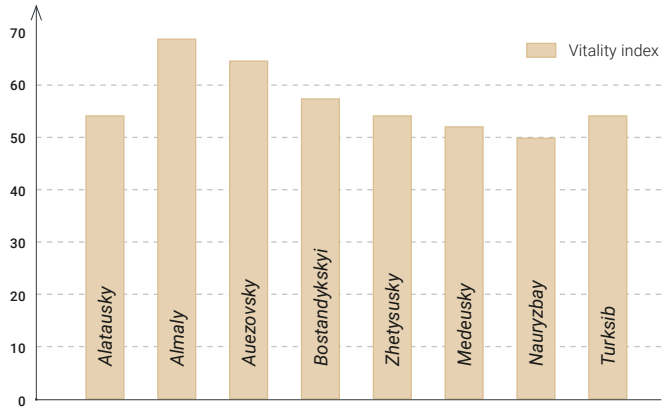


Fig. 19 — Distribution of the Resilient City Index by district

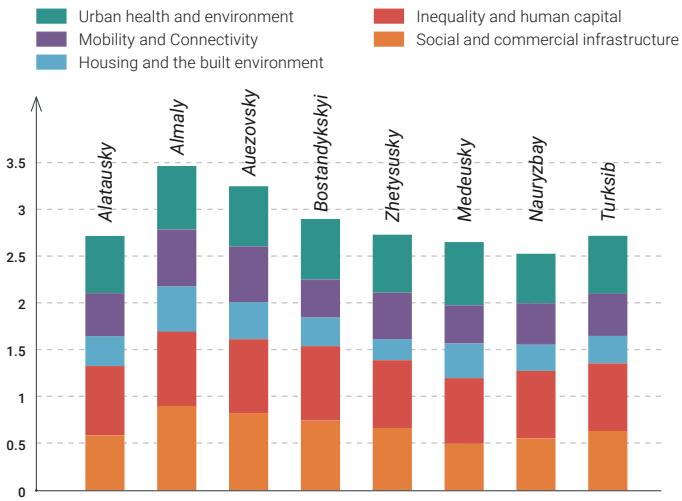


Fig. 20 — Distribution of the Resilient City Index sub-indices by district

Being **scored as the least resilient** means that this district is more vulnerable and faces greater challenges in adapting to various stressors and urban complexities. This suggests a lower capacity to withstand and recover from adverse conditions, which could potentially affect the well-being of its residents. In the context of the Resilient City Index, the Nauryzbay district, with the lowest score, may have deficiencies in housing quality, social and commercial infrastructure, environmental sustainability, or other factors that contribute to overall urban resilience (see Fig. 21).

Addressing these challenges will be critical to improving a district's ability to navigate and thrive in a dynamic urban environment. This approach aligns with the broader goal of achieving a more resilient and equitable city for all residents.

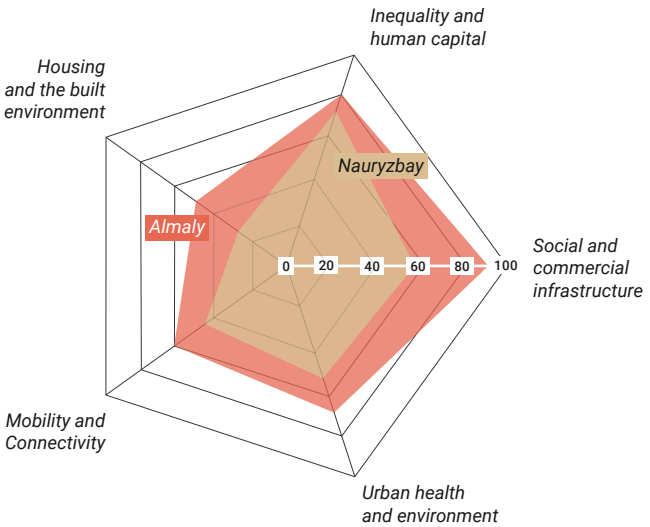


Fig. 21 — Comparing the best and worst district sub-indices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AL'FARABI 27
AL'FARABI 27

Intracity Level

Dependency Ratio

GLOBAL AGENDA

The **aging population** is one of the main challenges of the 21st century. By 2050, the number of elderly individuals worldwide is projected to more than double, reaching 1.6 billion [28]. This demographic shift places a burden on national economies by increasing the share of non-working individuals — a particularly critical problem in large cities.

Economic growth is slowing down. Over the past eight years, GDP growth per capita in OECD countries has decreased by an average of more than 1.5 percentage points due to population aging [29]. This has resulted in a decline in the tax base, leading to an increased **burden on the budget system,** which is crucial for pension provision and the functioning of the public healthcare system.

The **dependency ratio** is an indicator of these processes. It represents the average number of economically dependent individuals per 100 economically productive individuals. A higher value indicates a greater burden on the working-age population in the economy.

The programs and strategies of many cities in Western Europe, North America, and East Asia, which were the first to face the new demographic reality, reflect the agenda of the aging population. They are increasingly focusing on inclusiveness, active aging and the development of specific infrastructure. The Netherlands is already adopting **age-friendly urban planning practices** to accommodate all age groups [30].

LOCAL AGENDA

Almaty has a median dependency ratio of 66%, which indicates 66 children and elderly for every 100 economically active individuals. Although Kazakhstan has a relatively **young structure of population** and a higher ratio of children to elderly, which is a positive factor, population aging is a global trend that will also affect Almaty as life expectancy increases. In addition, 25% of the population lives in the high dependency ratio area. This spatial heterogeneity triggers social, economic, and cultural processes that impact fertility, mortality, and migration.

Today, Almaty benefits from a favorable demographic structure. However, to anticipate and effectively manage the potential impacts of population aging in the future, proactive measures and forward-looking policies are essential. It is critical to **balance the needs of different age groups** and promote an inclusive and supportive urban environment to ensure the continued resilience and vibrancy of Almaty.

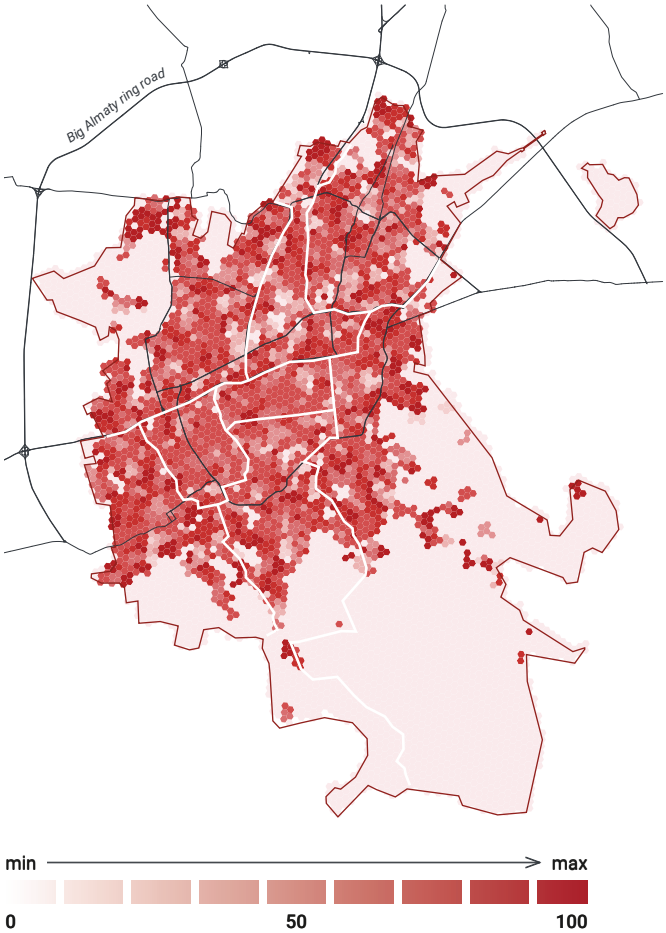

Fig. 22 — Dependency Ratio

[28] UN, 2023
[29] Daniele, F. et al., 2019
[30] Van Hoof, J. et al., 2019

Gender Pay Gap, %

GLOBAL AGENDA

In global megacities, social stratification has a significant impact. The spatial characteristics of **socio-economic inequality** make it possible to identify urban areas with high levels of segregation.

In its most obvious form, spatial inequality can lead to the formation of ghettos and slums, as well as imbalances in the **distribution of benefits** and their accessibility to the population. This issue affects both developed and developing countries, as the degree of inequality is not strongly correlated with the level of socio-economic development of a country.

The **poverty rate** is a fundamental indicator, calculated as the proportion of the population with income below a certain threshold (100,000 tenge per month). It can be used alongside other indicators to promptly assess risks and develop targeted solutions. Spatial segregation indicates the proportion of the population that is disconnected from city-wide processes. It will be high not only in the least affluent areas, but also in areas at risk of segregation due to poor accessibility.

The **gender pay gap** is an indicator of a city's economic inclusivity and gender equality. It has a significant impact on the city's overall resilience. Cities that successfully reduce the gender pay gap demonstrate a more robust and adaptable socio-economic framework. Recognizing and addressing this gap is critical to building cities that are resilient to economic shocks and can better respond to challenges of evolving social and economic dynamics.

The New York Regional Plan Association estimates that about 80% of a community's "health" can be attributed to socio-economic and built environment factors [31].

LOCAL AGENDA

In Almaty, the average income gap between men and women is 17%. An estimated 200,000 people are facing **gender inequality.** The districts of Almaly and Jetysu in the city center, as well as the outskirts of the city, are the most disadvantaged areas according to this indicator.

Kazakhstan has made progress in reducing the gender pay gap from 34.2% in 2018 to 21.7% in 2021. However, the gap has since rebounded to 25.2% in 2022, indicating the need for further efforts to address the problem. Bureau of National Statistics data for 2022 shows that women earn less than men in almost all economic areas and occupations, with very few exceptions [32].

The reasons for these disparities are likely multifaceted and include systemic gender pay gaps, unequal access to opportunities, and the concentration of marginalized communities in specific geographical areas of the city. Addressing these disparities in Almaty is critical to promoting a more equitable and resilient urban environment.

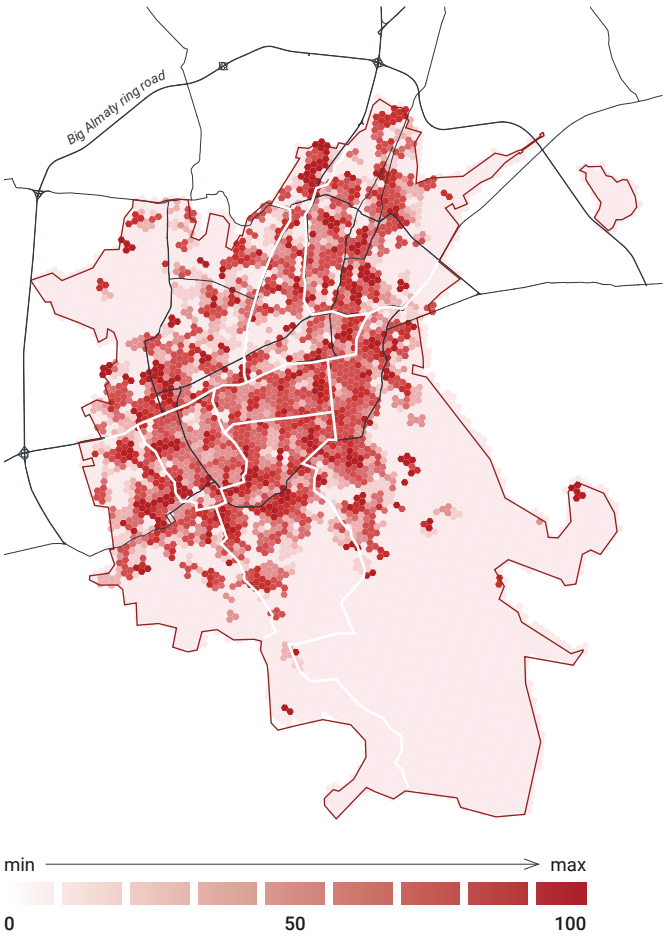

Fig. 23 — Gender Pay Gap

[31] *Regional Plan Association, 2016*
[32] *UNDP*


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Functional Diversity (The Herfindahl-Hirschman Index)

GLOBAL AGENDA

A more diverse urban environment and richer use scenarios leads to a higher level of socio-economic activity, which in turn drives the development of communities and the emergence of new business formats, and **makes a territory more attractive** to both residents and investors. The diversity of economic activities leads to greater adaptability of cities, allowing them to respond quickly to emerging risks.

The **functional diversity index** is calculated similarly to the market concentration index. A lower value indicates a more diverse local economy. For this purpose, the Herfindahl-Hirschman index is used to assess market monopolization and, in the context of functional diversity, the specialization of the local economy in a particular sector.

LOCAL AGENDA

The Herfindahl-Hirschman Index is highest in the most densely populated areas of the city. More than 70% of the population resides in areas with above-average scores.

Creating a polycentric urban structure is emerging as a key strategy for sustainable development in Almaty. It involves creating multiple centers of urban activity to avoid overburdening the central district with excessive financial, transport and labor flows. This **decentralization relieves pressure on the city center and promotes development in peripheral areas,** resulting in a more balanced and resilient urban structure.

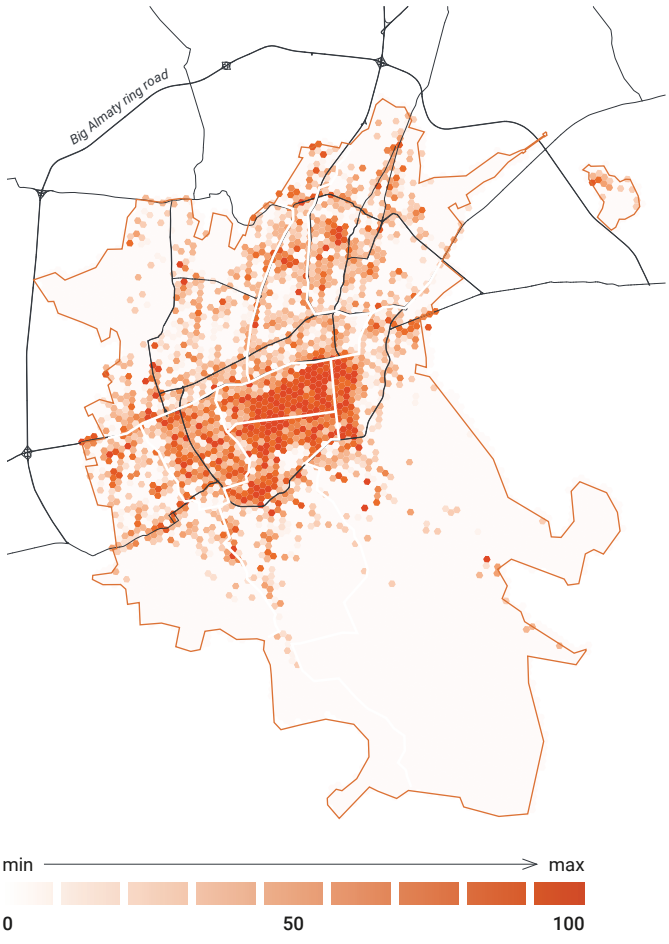

Fig. 24 — Functional Diversity

Rent-to-Income Ratio
Housing Supply, square meter per person

GLOBAL AGENDA

UN-Habitat estimates that by 2030, 3 billion people, or about 40% of the world's population, will require access to adequate housing. This equates to a demand for 96,000 new affordable and accessible housing units every day [33].

The ratio of average rent to average monthly income **(rent-to-income ratio)** is an essential economic indicator that reflects the affordability of housing for residents. A lower ratio indicates more **affordable housing,** which contributes to social resilience by ensuring that a reasonable portion of income is allocated to accommodation. This allows individuals to allocate resources to other essential needs.

Housing supply (in square meters per person) is a key metric for urban planning and sustainable development. It measures the availability of living space per person, addressing population density and housing adequacy. A higher supply indicates better access to housing resources, contributing to community well-being and reducing housing-related stress.

Together, these two indicators offer a comprehensive understanding of a city's economic inclusivity and housing accessibility. This is crucial for fostering resilience, ensuring social equity, and promoting sustainable urban development.

LOCAL AGENDA

Housing has long been a sensitive topic in Kazakhstan. The demand for rental properties in Almaty is fuelled by **population growth,** which is caused by migration flows and birth rate growth. This is happening against the backdrop of **reduced construction volumes** due to restrictions. In addition, housing has become less affordable as household incomes cannot keep pace with rising property prices and increasing loan rates. JLL experts predict that, while cyclical macroeconomic effects may put pressure on housing prices in the short term, the housing shortage is becoming worse and will continue to drive real estate price growth in Almaty in the long term. This will result in record-high rental demand and long-term rental growth [34].

An analysis of Almaty city based on these indicators reveals a **clear segregation of the population** and a significant difference between the city's central districts and the more distant areas. The people living in the city center, including parts of the Medeu and Almalin districts, spend a large proportion of their monthly income on rent, while for the majority of the population in Turksib, Alatau, and Auez districts, rent accounts for a much smaller percentage of income.

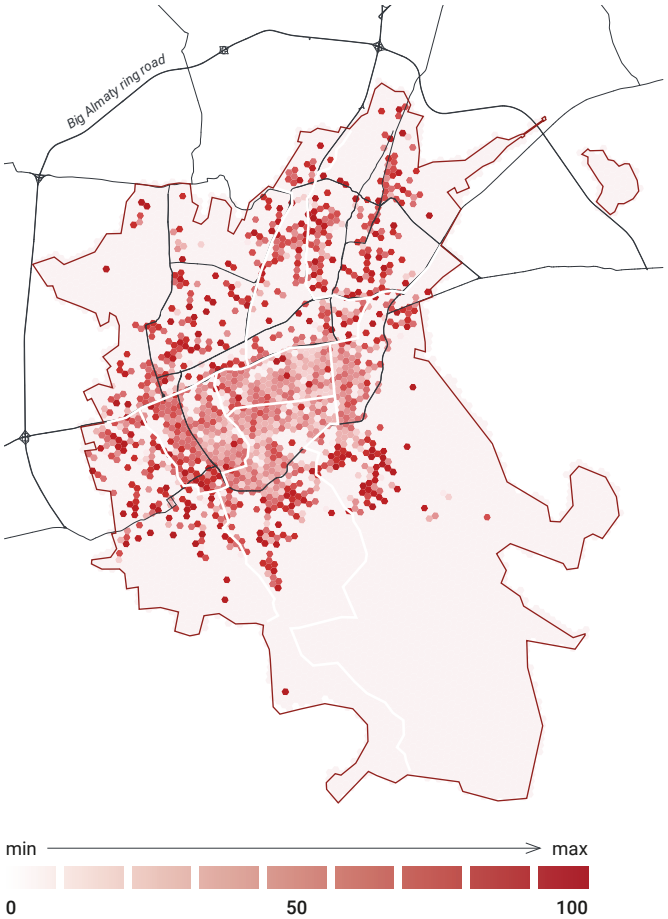

Fig. 25 — Rent-to-Income Ratio

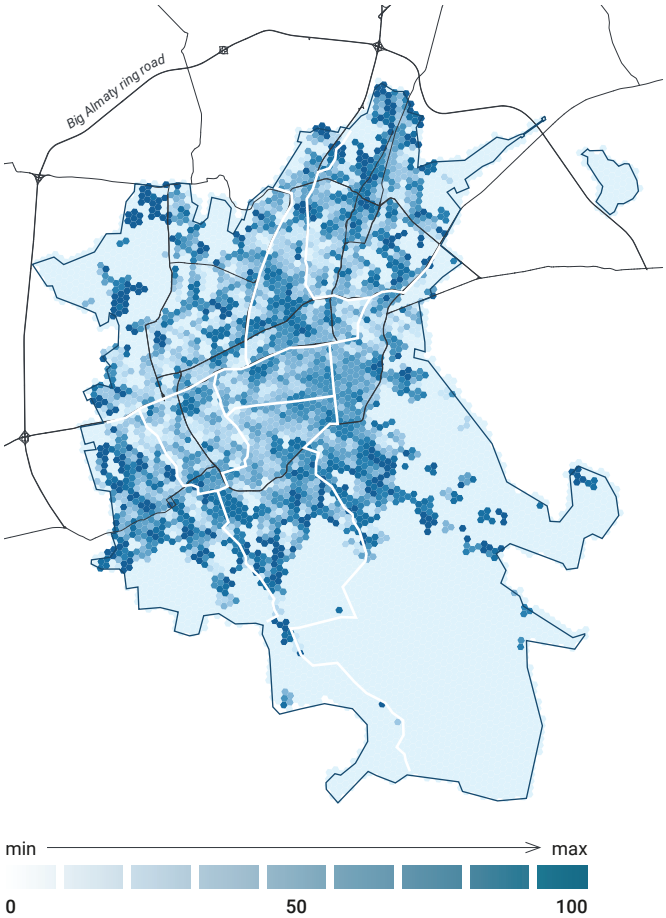

Fig. 26 — Housing Supply

[33] *UN-Habitat*
[34] *Kursiv, 2023*

Public Transport Network Efficiency: Ratio of provision and territorial accessibility, persons. Transportation Mode Balance Index

GLOBAL AGENDA

Because a city is home to a wide variety of interrelated economic functions, the mobility of people plays an important role. In the course of a single day, citizens may act as sellers, consumers, owners, and tenants, each role requiring travel to different parts of the city.

Due to the need to move actively around the city, the efficiency of residents and the economic benefits they receive are affected by mobility conditions. The **Public Transport Network Efficiency** index can be used to assess this. The index is calculated as the share of the population falling within a 30-minute isochrone from the centroids of the grid cells with data.

Improving the efficiency of the transport network can also be measured by the time it takes to travel a certain distance. This has a powerful positive effect on the economy. **Investment in public transportation creates 25% more jobs** in the wider economy than the same level of investment in roads or highways [35].

The **Transportation Mode Balance Index** is a useful metric for evaluating the sustainability and resilience of a city's transportation infrastructure. The methodology involves dividing the value of the "Public Transport Network Efficiency" indicator by the value of the "Road Network Efficiency" indicator. This ratio offers a quantitative measure of the balance between public and private transportation systems. A higher value indicates a more sustainable planning approach that prioritizes public transit systems over road networks. This interpretation signifies a city's commitment to reducing traffic congestion, lowering carbon emissions, and fostering a resilient urban environment by promoting eco-friendly and accessible public transportation alternatives.

LOCAL AGENDA

45.5% of Almaty's population, equivalent to 958,000 people, currently resides in an area with a below-average Public Transport Network Efficiency index. Most of the population that has access to an efficient public transport network lives in the Almaly district and the northern part of the Bostandyk district, both of which are served by the Almaty Metro line.

One of the main challenges facing transportation development in Almaty is the **inadequacy of the existing public transport route network.** It fails to distribute the city's population efficiently and is poorly connected to suburban routes, which many residents from the neighboring cities in the Almaty region use for their daily commute.

There are several ways to increase the proportion of Almaty's population that is directly served by the public transport system. These include accelerating the construction and commissioning of new metro stations, increasing the density of public transport stops, and prioritizing public transport by creating bus lanes.

Policies that strongly advocate for making Almaty a better place, prioritizing accessible and inclusive public transport as a vital component of social, economic and environmental change, can significantly improve the city's resilience and reduce urban risks.

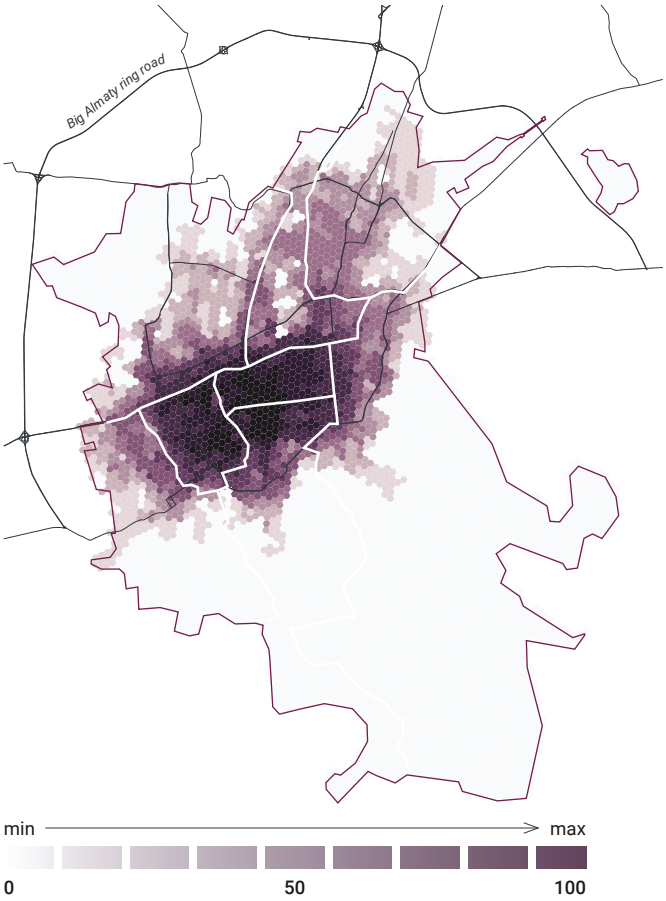

Fig. 27 — Public Transport Network Efficiency

[35] International Association of Public Transport (UITP)

Normalized Difference Vegetation Index (NDVI)

GLOBAL AGENDA

The **Normalized Difference Vegetation Index** is used for quantifying the health and density of vegetation in urban areas, offering insights into the city's environmental resilience. A higher NDVI indicates a greater concentration of vegetation on the ground, which suggests increased green cover and biodiversity. This **contributes to improved air quality, climate mitigation,** and overall urban well-being. NDVI studies indicate residents living in proximity to green areas have a significantly lower risk of developing depression, anxiety, and substance use, with a 55% decrease [36].

LOCAL AGENDA

The areas with low NDVI are mainly located in the urban areas of Almaty, where there is **poor vegetation cover,** and the land is covered with city buildings and hardened surfaces. Baum's Grove, a natural forest complex established in 1894, has one of the highest NDVI values among the city areas not adjacent to mountain slopes. The main tree species in the forest is elm, which accounts for over 90% of the trees. Until 1990, Baum's Grove was designated as an "especially valuable forest area" and received state protection. Since Kazakhstan gained independence, businesses have shown interest in the area. However, the Grove's condition and level of protection improved significantly only after it was designated as a Specially Protected Natural Area of the Republic of Kazakhstan, and was transferred to the balance of Ile-Alatau National Park in 2008. As a result, illegal clear-cutting of the forest and the sale and development of land plots on its territory have stopped.

Since NDVI values can change after several days of heavy rainfall or drought, studying a single satellite image cannot provide reliable data. To accurately assess NDVI values, it is important to take a comprehensive approach that involves analyzing a large number of satellite images. Continuous monitoring and availability of NDVI data can help understand changes in the city's green spaces.

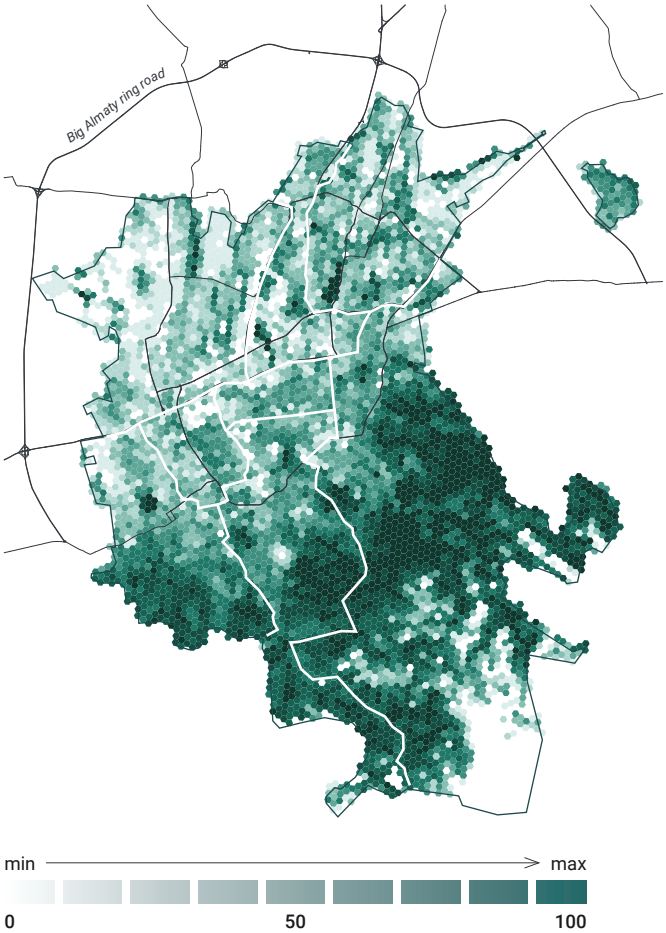

Fig. 28 — Normalized Difference Vegetation Index

[36] *Engemann, K. et al., 2019*

Urban Heat Islands

GLOBAL AGENDA

In urban areas, a significant portion of the land is covered by artificial surfaces such as concrete and asphalt. These surfaces can heat up to 60 °C when exposed to sunlight, leading to the release of micro dispersed particles harmful to humans. This phenomenon is known as the **urban heat island,** the cumulative heat mass generated by buildings and roads.

Addressing this problem is **a top priority for the Urban Health approach.** The heat island creates health risks for individuals with chronic diseases and the elderly, and puts a strain on the urban infrastructure by degrading water quality and increasing electricity consumption. For example, in Los Angeles alone, the heat island effect results in an estimated annual energy cost of 100 million USD [37].

In Europe, major climate action against the urban heat island effect began after the 2003 heatwave, which led to increased mortality. Today, most cities in developed countries consider this factor, along with climate change. For example, Singapore's long-term cooling strategy (Cooling Singapore) is based on reducing the urban heat island effect [38].

LOCAL AGENDA

The distribution of the urban heat island effect and associated risks is influenced by the city's topography, specifically the concepts of "up" and "down". In summer, the mean maximum surface temperature can reach 46.25 °C, while in mountainous regions, the mean minimum temperature can drop as low as -6.82 °C. According to the available data, 497,000 residents of the city could be the most severely affected.

Understanding temperature thresholds is critical, especially considering their potential impact on **population mortality.** Research often identifies specific temperature ranges above which the risk of adverse health effects increases. Almaty's urban planners and policy makers must consider these thresholds in order to implement effective heat mitigation strategies. These strategies include green spaces, climate-responsive urban design, and targeted interventions in areas most vulnerable to extreme temperatures. Such measures can help **increase the city's resilience to climate-related risks** and protect the well-being of its residents, particularly in the face of rising temperatures associated with urban heat islands.

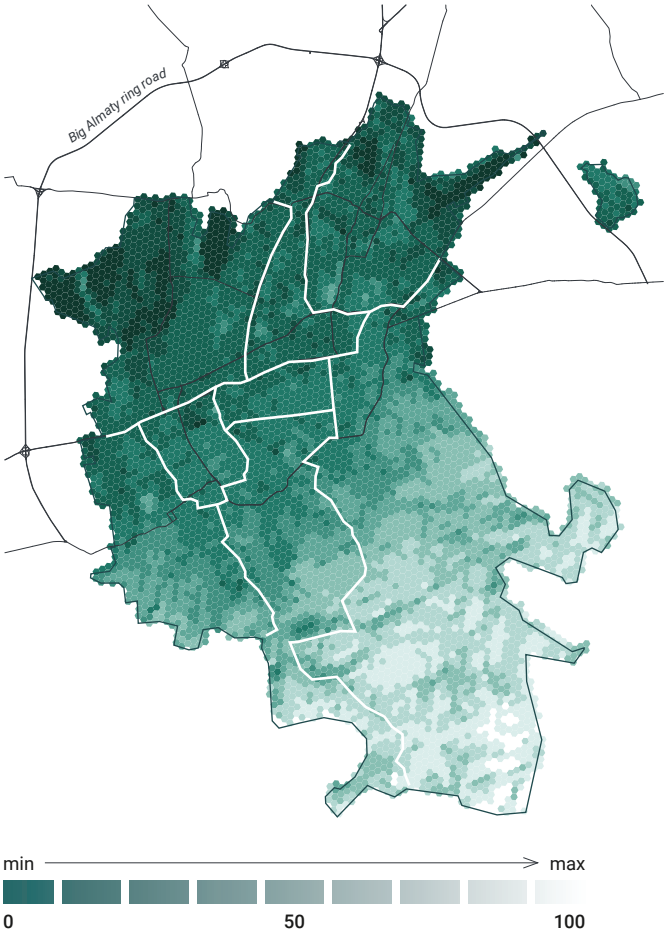

Fig. 29 — Urban Heat Islands

[37] Akbari, H., 2007
[38] ETH Zurich


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Travel Time Index
Number of Traffic Accidents

GLOBAL AGENDA

Globally, road traffic injuries result in approximately 1.35 million fatalities each year, with an additional 20 to 50 million individuals suffering non-fatal injuries, according to the World Health Organization (WHO). These injuries often result in disabilities, contributing to a substantial public health burden. A lower number of **traffic accidents** indicates the efficiency of a city's traffic management and safety infrastructure, as well as a higher level of resilience. According to WHO data, vulnerable road users such as pedestrians, cyclists, and motorcyclists make up a significant share of road traffic injuries [39]. The Resilient City Index incorporates specific figures to quantify a city's commitment to reducing accidents and creating a safe, resilient urban environment.

The **Travel Time Index** (the ratio between travel time at peak hours to travel time at off-peak hours) is a metric used to describe a city's transportation efficiency and its impact on overall resilience. This metric reflects the congestion dynamics during peak hours, which can indicate the city's ability to manage traffic flow effectively. High values suggest significant delays in traffic flow, highlighting potential issues with transportation infrastructure and urban planning. Prolonged travel times often correlate with increased accident risks due to congestion-related stress and frustration, linking this indicator to road safety.

In addition, extended commuting times contribute to **sedentary lifestyles, impacting public health by increasing stress levels** and the risk of conditions such as cardiovascular diseases [40]. Therefore, the ratio of travel time is a crucial gauge not only for transportation resilience but also as a proxy for broader implications on road safety and public health.implications on road safety and public health.

LOCAL AGENDA

As of 2022, Almaty has a car ownership ratio of 20.7 cars per 100 residents. Although road journey times and traffic jam duration have increased, the city's motorization rate has fallen by over 59% in the past decade. Therefore, it is important to consider the large number of non-resident cars entering the city daily from nearby settlements when planning the road network.

The ratio of travel time at peak hours to off-peak hours indicates that over half of Almaty's roads are congested throughout the day. The heavy traffic on the city's highways during rush hour suggests a high level of centralization, with many individuals commuting to and from the city center. One potential solution is to **reduce the dependence of residents** on this daily commute. This can be achieved by developing commercial and social functions in the residential areas of the city. This will allow for easier access to both jobs and daily necessities in close proximity to one's home.

When planning the network in highly populated areas of the city, it is essential to consider alternative ways of getting to and from **locations with irregular demand,** such as Almaty Airport. This is especially important given the increasing influx of tourists.

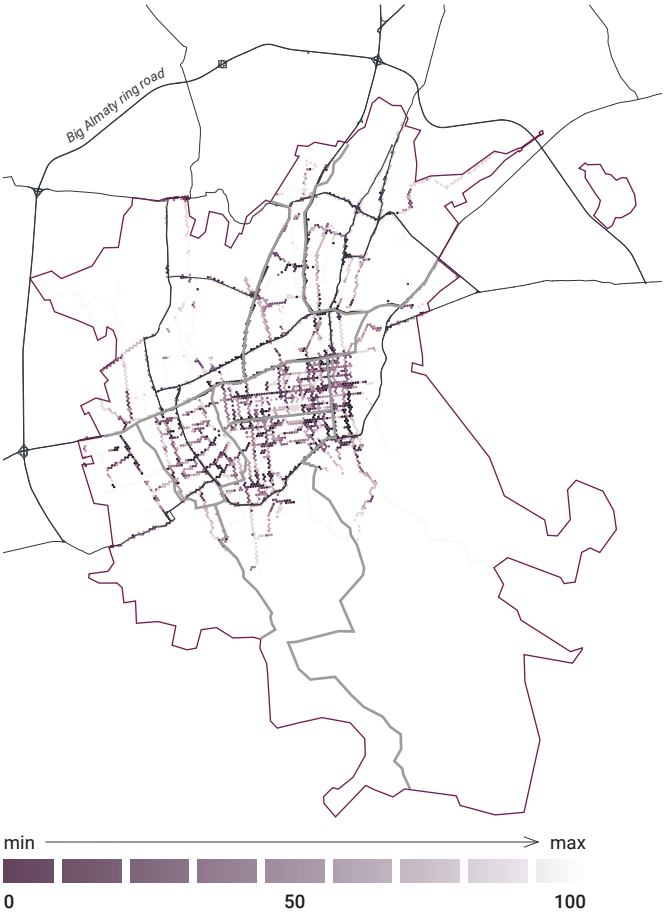

Fig. 30 — Travel Time Index

[39] World Health Organization (WHO), 2023
[40] Bailey, D. et al., 2019

Mixed-use

GLOBAL AGENDA

The assessment of **mixed-use** allows to calculate the ratio of three types of functions within a given territory: residential, public-business, and social-leisure. The absence of any one of these functions indicates a **lack of diversity in the urban environment.** Conversely, a combination of functions and integration of spaces creates the conditions for a more comfortable and prosperous life.

Mixed-use development has several advantages, including more efficient use of urban space by reducing distances between residential, commercial and recreational areas, reducing transportation costs, and promoting pedestrian activity. Making streets more **pedestrian-friendly** can have a positive impact on small businesses by encouraging comfortable socialization experiences between buyers and sellers, moving them away from the pragmatic function of purchasing goods [41].

In mixed-use development, city administrations spend less on building and maintaining infrastructure. This encourages people to take walks, use public transport, bicycles and personal mobility aids. This **lowers environmental risks** by reducing traffic and has a positive impact on public health, which consequently eases the burden on the health system. In England and Wales, mixed-use development in cities has saved over £17 billion in health costs over the last 20 years [42].

The Organization for Economic Cooperation and Development (OECD), in its assessment of **compact cities,** recommends mixed-use as a priority area of urban planning policies for large cities in developing foreign countries. The OECD also calls for **abandoning mono-functional land use** wherever possible [43].

LOCAL AGENDA

Mixed-use areas are primarily concentrated in Almaty's historic center, indicating a limited adoption of mixed-use principles in other parts of the city. Only 23% of the population lives in areas with average or above-average availability of mixed-use. The lack of widespread integration of functions between residential, commercial and recreational areas implies a **potential imbalance** in urban planning. It is possible that historical zoning practices, land use regulations or economic considerations have prevented the wider implementation of mixed-use development beyond the city center.

Almaty's mixed-use situation presents an opportunity for urban planners and policymakers to re-evaluate **land use regulations** and promote a more inclusive and diverse distribution of functions. Expanding mixed-use development beyond the historic center could yield numerous benefits, such as improved connectivity, shorter commute times, increased pedestrian activity, and a more socially and economically vibrant urban environment.

Share of the population living within a 5-minute walk of at least one outdoor sports field, %

GLOBAL AGENDA

This indicator emphasizes the importance of **easily accessible recreational areas for community well-being** and overall urban resilience. It evaluates the proximity of residents to outdoor sports facilities, promoting an active and healthy lifestyle. According to the U.S. Department of Health and Human Services, individuals should aim for at least 150 minutes of moderate exercise per week to significantly reduce the risks of heart disease, type 2 diabetes, and mental illness [44].

In accordance with initiatives like the Active Design Guidelines [45], published in 2010, architects and urban planners are encouraged to incorporate health-promoting elements into their designs, creating spaces that support physical activity. Urban planning can promote active lifestyles by focusing on **green zones and mixed-use zoning.** For example, strategically placing residences and workplaces within walking distance of parks and nature sites, and connecting them by pedestrian routes, can stimulate both physical and social activity. These initiatives aim to make physical activity a regular part of citizens' daily lives, strengthening resilience by promoting healthier and more vibrant urban communities.

LOCAL AGENDA

Only one-fifth of Almaty's population lives near an outdoor sports facility. In addition, almost half of the city's residents live in areas with above-average index scores. The Alatau and Zhetysu districts have the fewest street sports facilities, while nearly the whole city center, on average, is better equipped with such facilities.

Residential areas should be planned as active spaces, incorporating sustainable design to facilitate safe and easy movement and sports activities in people's daily lives, regardless of their income or proximity to the city center.

41 *Yoshimur et al., 2022*
42 *Jarrett, J. P. et al., 2012*
43 *OECD, 2012*
44 *U.S. Department of Health and Human Services*
45 *NYC Department of City Planning (DCP)*

Share of the population living within a 10-minute walk of at least one public school, %

GLOBAL AGENDA

City planning regulations vary from country to country but often share the common goal of improving the accessibility of educational facilities. **The 15-Minute City Project** advocates that all city residents should have access to essential urban services, including educational facilities, within a 15-minute walk or bike ride [46]. This concept prioritizes accessibility, promoting convenience, sustainability, and greater community cohesion. The concept aligns with the International Guidelines on Urban and Territorial Planning by UN-Habitat [47], which state that urban and territorial planning should ensure a fair distribution of costs, opportunities, and benefits of urban development.

The indicator of the **percentage of the population living within a 10-minute walk of at least one public school** assesses the accessibility of educational facilities for residents. A higher percentage indicates that a larger portion of the population can easily reach a public school within a reasonable walking distance, promoting convenience and inclusivity. Access to education not only enhances the overall resilience of a city but also fosters community engagement, supports childhood development, and contributes to a sustainable and interconnected urban environment.

LOCAL AGENDA

On average, 46% of the population in Almaty lives within a 10-minute walking distance of at least one public school. The spatial **distribution of schools is very uneven across the city.** Almaly, Auezov, and the north of Bostandyq are among the best-equipped districts. As the city experiences an influx of population, particularly in newer neighborhoods, and largely due to migration, it is crucial to address educational inequality.

[46] *C40 Knowledge Community*
[47] *UN-Habitat*

Green space provision per inhabitant (park, square, forest park within a 5-minute walk), hectare per capita

GLOBAL AGENDA

Another important aspect is to ensure the **provision of at least one green urban space within a 5-minute walk** for city residents. This metric reflects the city's commitment to providing quality and accessible green areas that promote the well-being of its residents. Green infrastructure is essential for urban ecosystems, providing space for rest, relaxation, and exercise, as well as regulating temperatures. In addition, green spaces can reduce noise pollution and improve air quality by absorbing carbon dioxide and other pollutants emitted by cars and other sources.

It is crucial to ensure that green spaces are accessible to all. Disparities in green infrastructure in urban areas can have a significant impact on people's lives and highlight inequalities. Studies have shown that people from low-income households are less likely to have access to green spaces [48]. If individuals have to travel long distances or incur expenses to visit natural environments within their town or city, it is not surprising that they will visit them less frequently. **The World Health Organization recommends that all individuals live within 300 meters of green space** [49]. The Global United Nations Sustainable Development Goal 11.7 explicitly aims to provide "universal access to safe, inclusive, and accessible public green spaces." [50]

Greener environments are linked to better physical and mentalhealth in children and young people. This includes improvements in memory, attention, and learning ability, as well as a reduction in stress [51] [52] [53]. The elderly also benefit from the use of green space for their physical and mental health.

These findings emphasize the intrinsic link between urban green spaces, mental well-being, and physical health. It is important to integrate such data in the comprehensive evaluation of a city's resilience.

LOCAL AGENDA

In Almaty, the residents of Bostandyk and Medeu districts enjoy the greatest proximity to green areas due to the city's location and close vicinity to mountain ranges. The Almaly district, with a development morphotype that implies a large number of green squares and parks, also has a sufficient number of small green areas within walking distance of residential areas.

However, almost half, or 1.1 million, of the city's residents live in areas with less green space than the city average. The Nauryzbay and Alatau districts have the least amount of green areas within walking distance, which is inadequate and **indicates an urgent need to create such spaces within residential developments.** This will provide the population with nearby green spaces for healthy and mental recreation, as well as help absorb harmful substances polluting the air.

In general, the urban policy of Almaty should aim to increase the provision of green spaces across all districts and for all population groups, particularly considering the city's growing population and demographic dependency ratio.

[48] *GroundWork, 2021*
[49] *European Environmental Agency, 2022*
[50] *United Nations, 2015*
[51] *Dadvand et al., 2015*
[52] *Vujcic & Tomicevic-Dubljevic, 2018*
[53] *Andrusaityte et al., 2020*

Correlations

Interconnections and cause-and-effect relationships are among the most interesting qualities of urban spaces. Conventional statistics often fail to reflect the factors that influence certain urban processes. In the case of Almaty, we conducted **a correlation analysis of the relationships between 70+ metrics of the five sub-indices** of our Resilience City Index.

For example, Figure X demonstrates that the efficiency of the public transport network, the ratio of provision and spatial accessibility strongly correlate with a neighborhood's pedestrian connectivity. Additionally, the efficiency of the public transport network is related to the share of residential buildings built before 1995, due to the morphotype of the built-up area and the post-Soviet legacy of Almaty's planning type. This metric demonstrates the importance of considering **the morphology of the city's built-up area** when planning the public transport system. Older buildings also tend to have more retail spaces on their ground floors. For example, buildings constructed before 1995 offer greater access to everyday facilities, indicated by the correlation analysis.

Importantly, the level of air pollution is also dependent on the efficiency of the public transport network. Big data analysis from Almaty indicates that **areas with a well-planned public transport network have much cleaner air.** Additionally, there is a correlation between Particulate Matter Emissions (PM10) and school student achievement levels, which is worth noting when discussing air quality. This indirectly highlights the segregation that exists in Almaty, where schools located in more expensive urban areas with better air quality demonstrate a higher quality of education.

The Resilience City Index allows us to identify correlations that will aid in producing predictive analytics for planning resilient cities. Understanding the intricate relationships between various factors that influence urban processes is essential for creating strategies that enhance a city's resilience to challenges such as climate change, population growth, and economic shifts.

Ultimately, **correlation analysis is indispensable** in the quest to create resilient cities. It illuminates complex relationships within urban systems and guides the formulation of targeted, evidence-based strategies. By understanding the factors influencing urban processes, cities can proactively enhance their resilience and better navigate the uncertainties of the future.

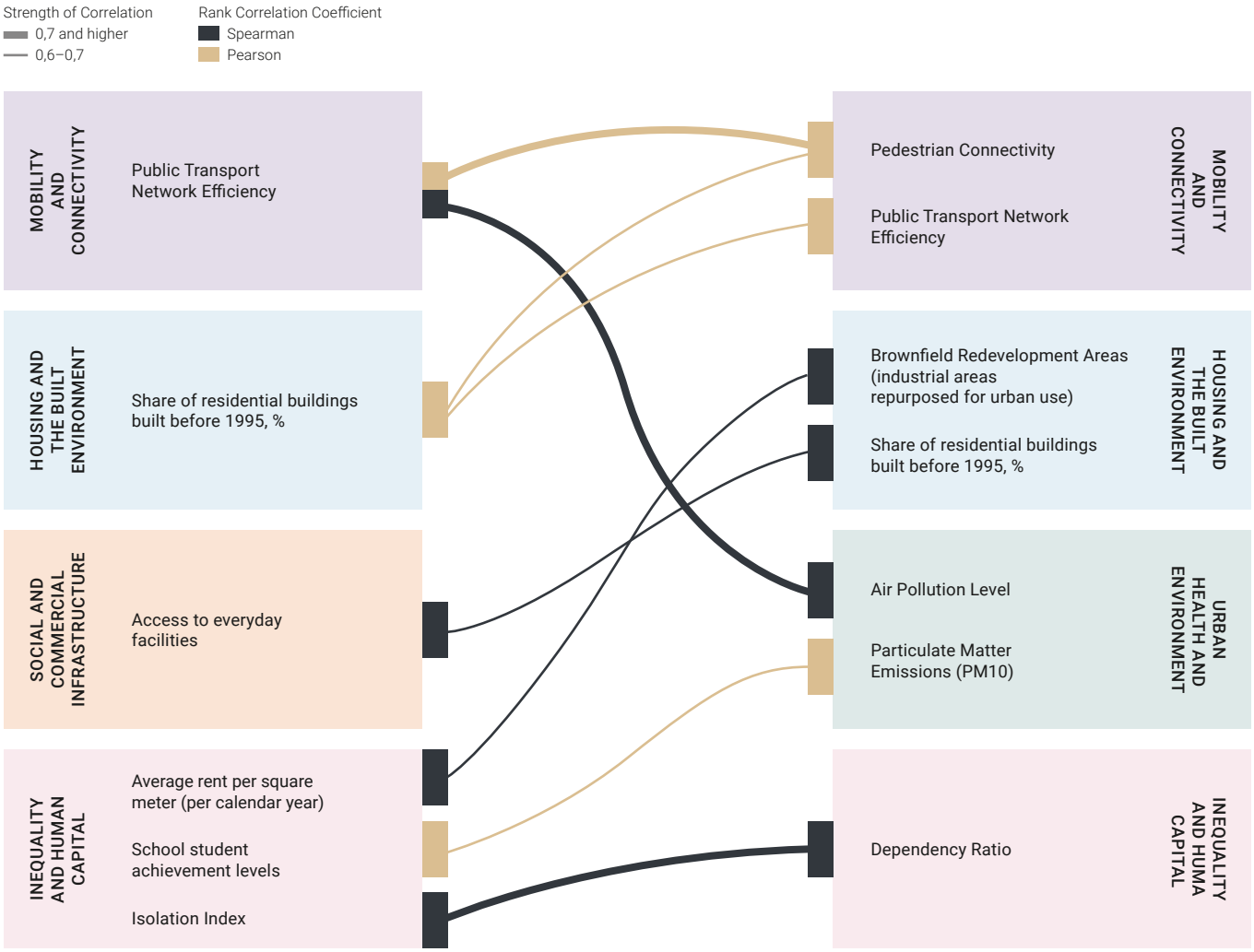

Fig. 31 — Key correlations

Key Recommendations

The following recommendations address the complexities of contemporary urban life, recognising that resilient urban ecosystems are built on a foundation of **effective governance structures, accessible services, and well-designed urban spaces.** The recommendations advocate a multi-faceted approach that reflects the interplay between these elements and emphasizes the importance of integrated solutions for resilient urban development.

Governance

- Encourage metropolitan-wide strategic planning for resilience and climate action enabled by multilevel governance
- Expand the variety of collected data to analyze urban development scenarios and predict risks
- Strengthen expertise on resilience through establishing a think tank to drive innovation, research, and collaborative solutions for urban challenges
- Develop capacity building and increase awareness among professionals and decision makers to build a local competence in urban resilience

Services

- Stimulate polycentric urban development to strengthen the resilience of city infrastructure
- Improve the accessibility of social and commercial services to mitigate spatial segregation
- Promote mixed-use development to increase the multifunctionality of urban areas and enhance economic benefits

Urban space

- Regenerate existing residential areas to promote high-quality urban design and a comfortable urban environment
- Promote transit-oriented development and walkable environments to reduce congestion and improve urban health
- Encourage the provision of affordable housing for all communities to achieve equality of opportunity

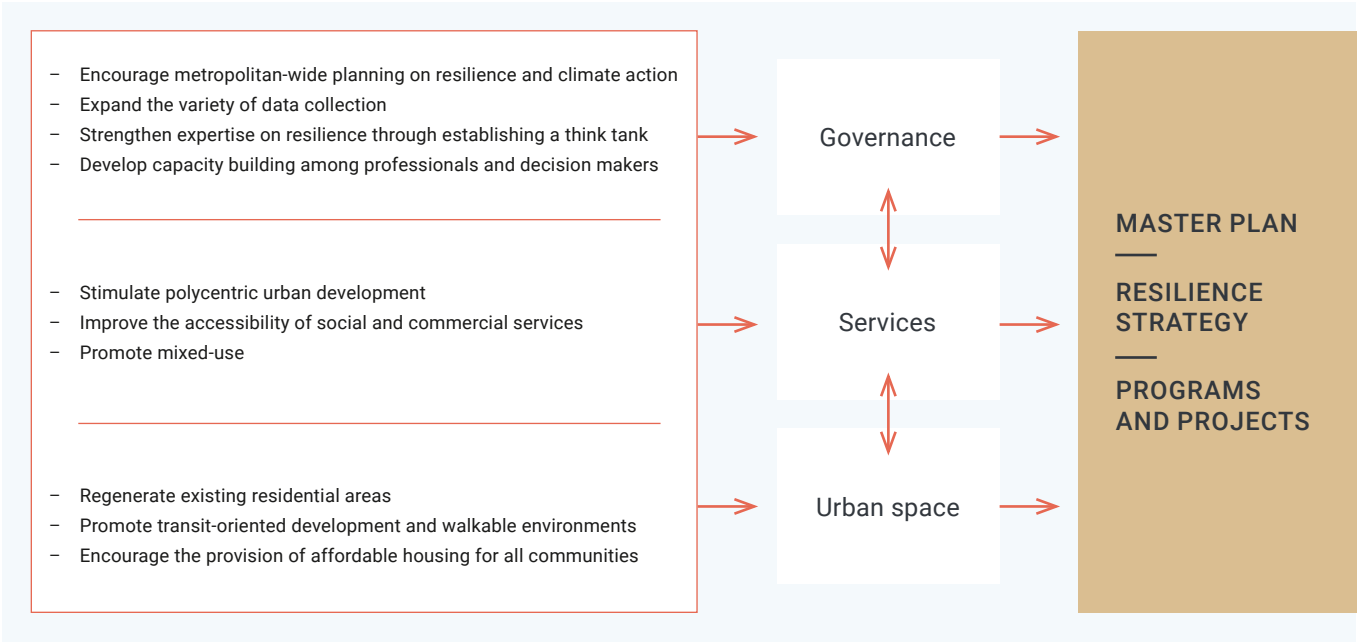

Fig. 32 — Resilience recommendations

By integrating these recommendations into a comprehensive **resilience strategy,** cities can establish a proactive framework that anticipates, mitigates, and adapts to various stressors. This strategic approach can promote a culture of preparedness and responsiveness, empowering cities to effectively manage both current and emerging urban challenges.

The creation and execution of a **resilience action plan** enables cities to turn strategic goals into tangible initiatives. This includes setting specific targets, timelines, and measurable indicators, ensuring that the resilience strategy becomes a functional and flexible tool for urban development. By continuously monitoring and adapting, cities can remain responsive to changing circumstances, promoting resilience as an ongoing and evolving process.

Almaty: To Be

In the near future, Almaty plans to improve its urban resilience through innovative governance strategies. Appointing a **Chief Resilience Officer** would demonstrate a proactive and adaptive approach to city governance. **Data-driven** decision-making processes will enable Almaty to effectively navigate challenges and respond to urban complexities.

Almaty's path to resilience should be based on a comprehensive strategy that aligns with **international best practices** and standards. The city should actively participate in **global associations** with a focus on resilience, positioning itself as a collaborative pioneer and ensuring compliance with international goals. This will not only elevate Almaty's status within Kazakhstan but also establish it as **one of the most resilient cities in Central Asia.**

Adopting a **human-centric approach** to urban development is a key aspect of building resilience. Almaty seeks to create a prosperous urban landscape with robust infrastructure, inclusive housing, and **equal opportunities** for all. The city aims to balance urban progress with the preservation of the natural environment, a high level of human capital, and a modern and age-friendly transport system. Almaty should also prioritize urban health to ensure that residents enjoy a high quality of life.

The path towards resilience can be long but rewarding. Making significant progress towards becoming a beacon of urban resilience will require a continuous effort to strengthen the already laid foundations, foster sustainable growth and ensure a **resilient and equitable future** for all residents. This is a **commitment** to creating a city where innovation, inclusivity, and adaptability converge to shape a thriving urban landscape.

Closing Remarks

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Data is becoming a crucial key to ensuring a city's sustainable development. However, the lack of transparency in certain data spheres is, by definition, a risk to the city's resilience. While this narrative may seem self-evident, problems related to data persist. Both developed and developing cities have a long way to go towards a high-quality, effective, and comprehensive data ecosystem that captures information about the city and its inhabitants.

The primary challenge is to collect and consolidate a wide variety of diverse data streams for analysis. This is where we first come in with our product to offer assistance to the city management. Next, we tackle the problem of producing clear and functional data analytics by assessing the city's present and future vulnerabilities, thanks to the extensive methodological and analytical work embedded in our product.

We are a team of professionals who are passionate about addressing the urban challenges of today. We consider this our calling, and see our mission in empowering cities and businesses with actionable insights to establish a resilient foundation for a better future. Our ultimate customers are ourselves, the residents of cities around the world.

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Today, resilience is the most discussed topic at expert platforms such as the World Economic Forum in Davos and the UN Climate Change Conference. In a world where disruptions are becoming more frequent and complex, resilience is a vital necessity.

Environmental, social and governance (ESG) principles are an important component of urban resilience. Environmental measures can help cities adapt to climate change and reduce vulnerability to natural disasters. Social policies aim to promote community engagement and inclusivity, contributing to social cohesion in challenging times. Effective governance is critical for planning and implementing resilience strategies.

Our team has extensive experience in urban consulting and big data, and the innovative products we develop can make cities more resilient by preparing them for the challenges of climate change, overpopulation, air pollution, and other risks.

By combining consulting and technology, we aim to provide Decision-as-a-Service solutions for city leaders and business owners.

Appendix

Fig. 33 — Mixed-use

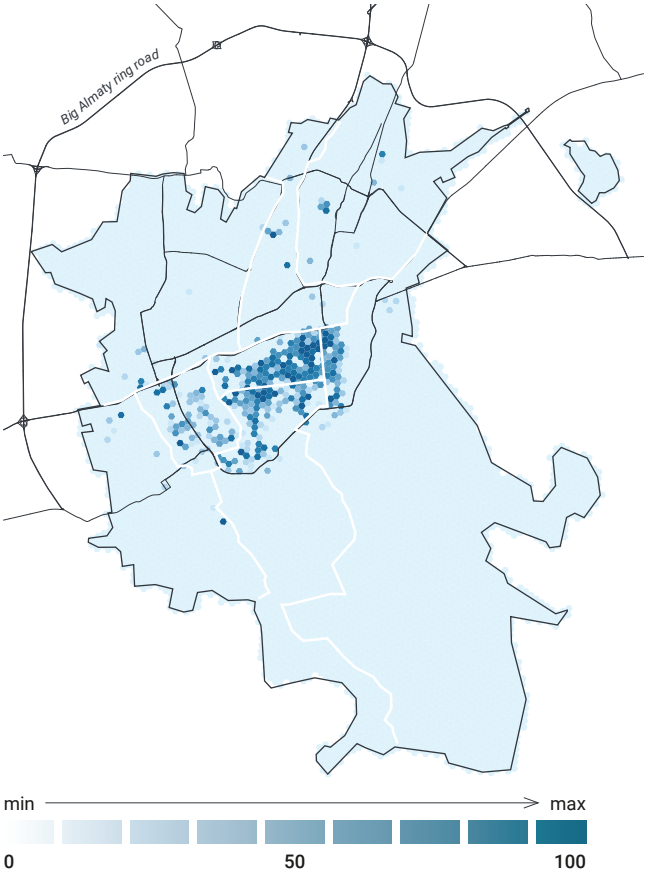

Fig. 34 — Share of the population living within a 5-minute walk of at least one outdoor sports field

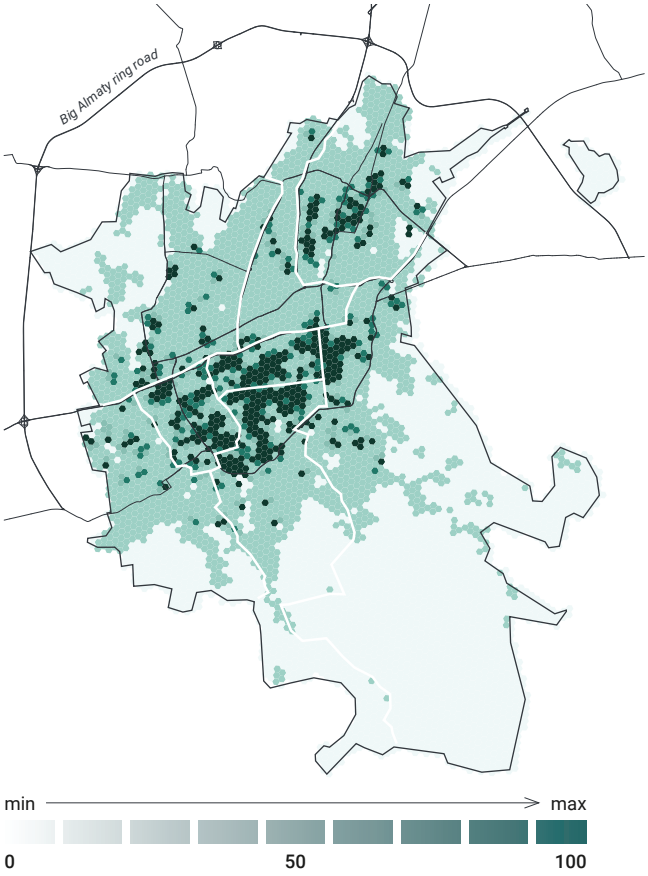

Fig. 35 — Transportation Mode Balance Index

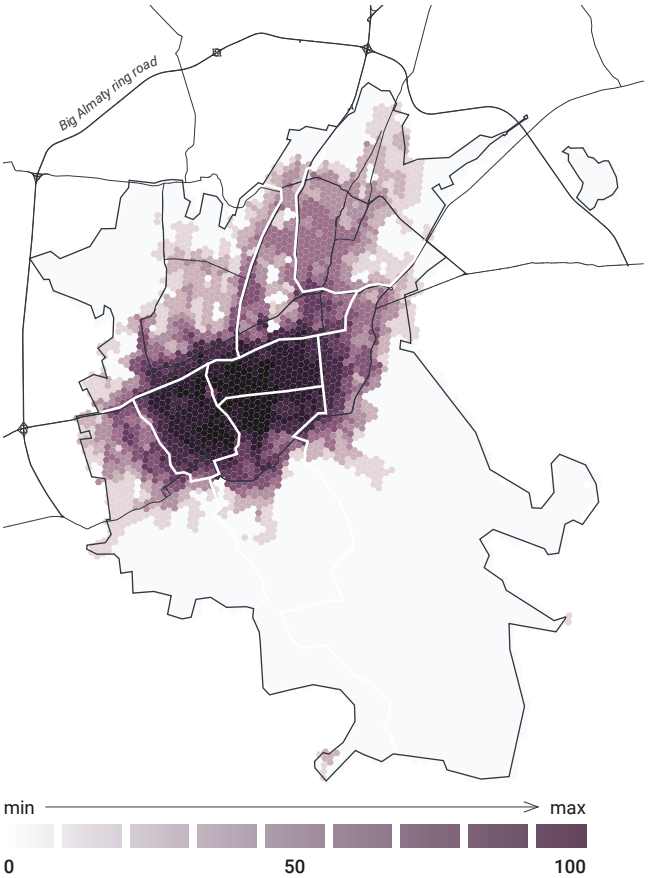

Fig. 36 — Share of the population living within a 10-minute walk of at least one public school

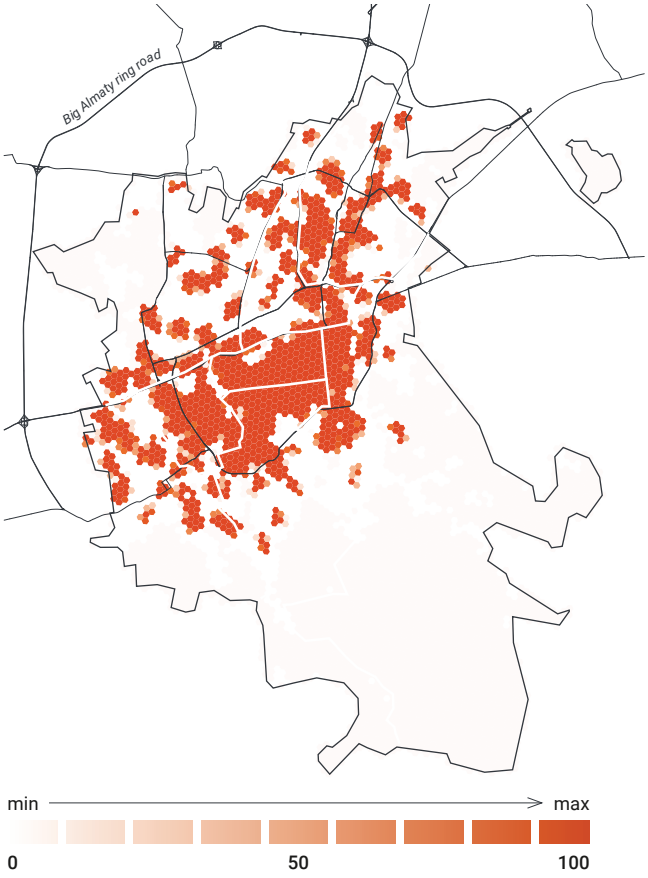

Fig. 37 — Green space provision per inhabitant

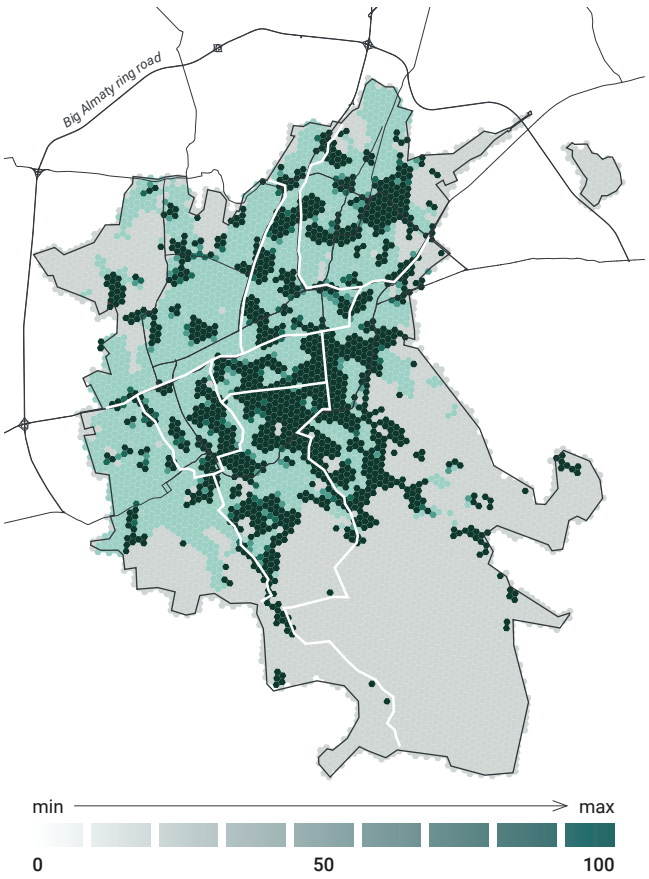

Fig. 38 — Number of Traffic Accidents

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The Resilient City Index by Qala AI is an innovative tool for assessing and improving urban resilience worldwide. The index applies geospatial analytics in data-driven decision-making to provide city leaders with valuable insights, fortify their infrastructure, and help them adapt to urban development risks, such as climate change and economic crises.

City leaders have a crucial role in protecting communities from the emerging threats associated with urbanization. This report emphasizes their responsibility to prioritize resilience as a fundamental aspect of urban development. It highlights the direct link between a city's adaptability and long-term prosperity.

2024