IMPLEMENTATION OF THE SMART CITY CONCEPT IN ALMATY: DIMENSIONS, CURRENT STATUS AND RESIDENTS' PERCEPTIONS

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Abstract. The aim of this study was to analyze the concept of a smart city through the lens of urban comfort dimensions and to identify problem areas in the development of the metropolis of Almaty. Based on content analysis of scientific publications, official documents, and international index data, key dimensions of urban comfort were defined. The empirical part of the research was implemented through a survey of 167 Almaty residents, whose responses revealed areas of high satisfaction (education, leisure, emergency healthcare) as well as problematic aspects (housing affordability, environmental conditions, cybersecurity). The results demonstrated discrepancies between objective statistical data and residents' subjective perceptions, highlighting the necessity for a comprehensive approach to smart city development. The conclusions of this research may serve as guidance for enhancing urban strategies aimed at improving the quality and sustainability of the urban environment.
Keywords: smart city, urban environment comfort, Almaty, quality of life indices, urban planning, urban studies, citizen perception

Аңдатпа. Бұл зерттеудің мақсаты қалалық жайлылық өлшемдерінің объективі арқылы ақылды қала тұжырымдамасын талдау және Алматы мегаполисінің дамуындағы проблемалық аймақтарды анықтау болды. Ғылыми басылымдардың, ресми құжаттардың және халықаралық индекс деректерінің мазмұнын талдау негізінде қала жайлылығының негізгі өлшемдері анықталды. Зерттеудің эмпирикалық бөлігі 167 алматылық қатысқан сауалнама арқылы жүзеге асырылды, олардың жауаптары қанағаттанушылықтың жоғары бағыттарын (білім беру, демалыс, шұғыл медициналық көмек), сонымен қатар проблемалық аспектілерді (тұрғын үйге қолжетімділік, қоршаған орта жағдайлары, киберқауіпсіздік) анықтады. Нәтижелер объективті статистикалық деректер мен тұрғындардың субъективті қабылдаулары арасындағы сәйкессіздікті көрсетті, бұл ақылды қаланы дамытуға кешенді көзқарастың қажеттілігін көрсетті. Бұл зерттеудің қорытындылары қалалық ортаның сапасы мен тұрақтылығын арттыруға бағытталған қалалық стратегияларды жақсарту үшін нұсқаулық болуы мүмкін.
Түйін сөздер: ақылды қала, қалалық орта жайлылығы, Алматы, өмір сапасының индекстері, қала құрылысы, қалатану, азаматтардың қабылдауы

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Аннотация. Целью данного исследования был анализ концепции умного города через призму аспектов городского комфорта и выявление проблемных зон в развитии мегаполиса Алматы. На основе контент-анализа научных публикаций, официальных документов и данных международных индексов были определены ключевые аспекты городского комфорта. Эмпирическая часть исследования была реализована путем опроса 167 жителей Алматы, ответы которых выявили как области высокой удовлетворенности (образование, досуг, экстренная медицинская помощь), так и проблемные аспекты (доступность жилья, экологическая обстановка, кибербезопасность). Результаты продемонстрировали расхождения между объективными статистическими данными и субъективным восприятием жителей, что подчеркивает необходимость комплексного подхода к развитию умного города. Выводы данного исследования могут послужить руководством для совершенствования городских стратегий, направленных на повышение качества и устойчивости городской среды.
Ключевые слова: умный город, комфортность городской среды, Алматы, индексы качества жизни, городское планирование, урбанистика, восприятие горожан

Introduction

Amid rapid urbanization and technological progress, the concept of the smart city has become one of the key priorities in the development strategies of modern megacities. Against the backdrop of global challenges – such as climate change, population growth, environmental degradation, and increasing pressure on urban infrastructure – there is a growing need for new approaches to urban management. The "smart city" concept has emerged as a transformative model, leveraging digital technologies and data-driven systems to optimize urban infrastructure and services. The smart city concept represents the integration of digital technologies, sustainable urban planning, and innovative solutions aimed at enhancing the efficiency of city operations and improving residents' quality of life [1, 2]. However, it is important to emphasize that technology in this model is not an end in itself but rather a tool intended to make cities more comfortable, inclusive, safe, and resilient to external impacts. Thus, at the heart of smart city design lies the human being – their daily living experience, perception of urban spaces, and overall satisfaction with life in the city.

One of the central factors determining the success of the smart city model's implementation is the understanding of what precisely makes an urban environment comfortable and conducive to quality living. Urban comfort is a multidimensional concept encompassing both objective parameters (such as access to infrastructure, noise levels, air pollution) and subjective perceptions and feelings of residents (sense of safety, satisfaction with housing and transportation, feeling of belonging to the community, etc.). Therefore, when planning and developing cities, it is crucial not only to rely on technological or economic indicators but also to systematically study the factors that shape quality of life in the urban environment. These factors serve as a guide for designing human-centered policies and solutions and for evaluating how effectively the concepts of a "smart" and "livable" city are being realized.

In order to effectively measure and compare the level of urban comfort, leading international organizations and research centers develop comprehensive indices based on multiple interrelated dimensions [3]. These indices not only formalize the notion of urban quality of life but also serve as tools for monitoring, ranking, and benchmarking cities in both global and regional contexts. Among the most authoritative is the Mercer Quality of Living Index, which annually ranks over 200 cities according to criteria such as political stability, healthcare, education, infrastructure, cultural environment, and natural environment [4]. Another widely recognized index is the Global Liveability Index, published by the Economist Intelligence Unit (EIU), which evaluates cities across five categories: stability, healthcare, culture and environment, education, and infrastructure [5]. Additionally, the IMD Smart City Index, developed by the International Institute for Management Development (IMD) in collaboration with the Singapore University of Technology and Design, assesses the level of digitalization and citizens' perceptions of smart solutions [6]. Also significant are indices such as the Green City Index, developed by Siemens and the EIU, which focuses on environmental sustainability, and the Urban Sustainability Index, developed by McKinsey & Company [7], which emphasizes balanced urban development. Comprehensive studies demonstrate that the dimensions of urban comfort are interrelated and multidimensional [8].

In Kazakhstan, the rapid development of metropolitan centers has brought both opportunities and challenges. Almaty – Kazakhstan's largest and most culturally vibrant city –faces pressing urban issues such as traffic congestion, environmental degradation, aging infrastructure, and unequal access to public services. These challenges, coupled with a growing population and rising citizen expectations, have prompted city planners and government officials to consider smart city approaches as a way forward.

Smart cities are commonly defined by their ability to integrate information and communication technologies (ICTs) across key urban domains: governance, transportation, energy, healthcare, education, and citizen engagement. While many global cities have adopted smart technologies at varying scales, the pace and nature of implementation differ based on socio-economic, political, and technological contexts.

This research paper explores the implementation of the smart city concept in Almaty. It also aims to evaluate the current status of smart city initiatives and assess how residents perceive their impact on urban life. By examining these aspects, the study seeks to offer nuanced insights into Almaty's journey toward becoming a smarter, more resilient city – and provide strategic recommendations for future development.

Methodology

This study is based on a combination of qualitative and quantitative methods, following a mixed methods research approach, which enables a comprehensive examination of the phenomenon of the smart city and urban environment comfort [9]. The research was conducted in several stages, each with specific objectives and corresponding data collection and analysis methods.

In the first stage, a qualitative content analysis of scientific publications was carried out to define the concept of a smart city and identify its key dimensions. Both academic sources (such as research articles and literature reviews) and materials from international organizations and institutes that develop indices for ranking cities by livability, such as the Mercer Quality of Living Index, the Global Liveability Index, the IMD Smart City Index, and others, were systematically reviewed [4, 6]. The aim of this stage was to determine the dimensions most frequently mentioned in different approaches to urban environment assessment and considered essential for urban comfort. During the same stage, document analysis was also conducted, focusing on official documents, in particular the Development Plan for the city of Almaty. The analysis of municipal programs and strategic documents enabled the identification of areas and dimensions that the city administration considers priorities for enhancing urban comfort and implementing the smart city concept. This allowed for the comparison of theoretical perspectives on the smart city's structure with practical objectives and projects being implemented at the local level.

In the second stage, based on the identified dimensions, a questionnaire was developed for conducting an empirical quantitative survey. The questionnaire included questions aimed at assessing residents' perceptions of urban comfort across various aspects of the urban environment, such as transport accessibility, environmental quality, safety, infrastructure, and other parameters. This approach made it possible to collect primary data on residents' subjective perceptions of the quality of urban life.

In the third stage, the analysis of the survey data was supplemented with data triangulation. To improve the objectivity of the results, respondents' answers were compared, where possible, with official statistical data and indicators for the corresponding dimensions. This approach made it possible to identify potential discrepancies between residents' subjective perceptions and the objective characteristics of the urban environment, thereby enabling a more accurate assessment of the city's current development state and the formulation of recommendations for further efforts to enhance urban comfort and implement the smart city concept.

Thus, the applied methodology integrated both qualitative and quantitative research methods, ensuring a comprehensive analysis of both the theoretical foundations of the smart city concept and the practical perception of urban comfort by Almaty residents.

Results

The concept of a "smart city" has evolved significantly over the past two decades, emerging as a multidisciplinary framework that integrates technology, governance, urban planning, and social innovation. At its core, a smart city seeks to leverage digital infrastructure, data analytics, and participatory governance to create more efficient, sustainable, and inclusive urban environments.

The concept of a Smart City has evolved as a multidimensional framework aimed at enhancing urban life through the integration of digital technologies, data analytics, and sustainable practices. According to [10], the Smart City Reference Model outlines six key dimensions-smart economy, smart mobility, smart environment, smart people, smart living, and smart governance-that collectively define the innovation ecosystem of a smart urban environment. These dimensions are echoed in broader

literature, which emphasizes the role of ICT, IoT, and AI in optimizing urban services, improving infrastructure efficiency, and fostering citizen engagement. Smart cities are not merely technologically advanced; they are designed to be inclusive, sustainable, and responsive to the evolving needs of their residents. As cities face increasing challenges due to urbanization, climate change, and resource constraints, the Smart City paradigm offers a strategic approach to urban planning and governance that aligns with global sustainability goals.

Smart cities are generally understood as urban spaces that use information and communication technologies (ICTs) to enhance the performance of services such as transportation, energy, health care, waste management, and public safety. However, definitions vary across institutions and scholars, reflecting differences in priorities and local conditions. Common features include:

- Technological Integration: Deployment of IoT devices, sensors, and digital platforms for data collection and urban management.
- Citizen-Centric Design: Emphasis on community engagement, transparency, and tailored services.
- Sustainability: Focus on energy efficiency, environmental monitoring, and sustainable mobility.

Among the key categories that modern indices include, we can highlight such dimensions as: *quality and accessibility of urban infrastructure (transport, housing, digital communications); level of well-being and health of the population; level of safety and environmental sustainability; level of greenery and availability of natural spaces; access to education and cultural services; quality of the urban economy and citizen participation in city governance* [11, 5].

Kazakhstan has actively pursued the Smart City agenda through a series of national programs and strategic initiatives. The cornerstone of this effort is the Digital Kazakhstan State Program (DKSP), launched in 2018, which aims to transform the country into a digital economy by enhancing public services, infrastructure, and citizen engagement through technology [12]. One of the program's pillars specifically targets the development of smart cities, beginning with pilot projects in major urban centers such as Almaty, Astana, and Aktobe. These initiatives focus on improving urban resilience, modernizing infrastructure, and addressing climate-related risks through digital solutions. The DKSP also supports the creation of innovation ecosystems, digital literacy programs, and the deployment of high-speed data infrastructure under the "Digital Silk Road" initiative.

In 2019, Kazakhstan formalized its approach by approving the Reference Standard of Smart Cities, which outlines priority areas such as safety, transport, housing, education, healthcare, and municipal governance. Cities like Almaty and Astana have led the way, with Almaty ranking highest in the internal Smart City rating system. Almaty's smart city development is shaped by Kazakhstan's national digital agenda, local governance structures, socio-economic conditions, and regional challenges. The conceptual framework thus connects global smart city principles to Almaty's unique context, enabling a nuanced evaluation of policy effectiveness and public perception. Almaty has emerged as a focal point for Kazakhstan's digital transformation efforts, spearheading initiatives that align with the country's broader "Digital Kazakhstan" program. The city's smart agenda encompasses improvements in digital governance, mobility, environmental sustainability, and public service delivery. Local authorities have launched a series of pilot programs and infrastructure investments aimed at modernizing urban management and improving the quality of life for residents.One of the most prominent domains of smart implementation is urban mobility. Almaty has introduced intelligent traffic lights, real-time public transport tracking systems, and mobile payment platforms for transit services. The expansion of bicycle lanes and shared mobility solutions – including e-scooters and bike-sharing – signals a shift toward eco-friendly travel. While these initiatives have improved urban navigation and commuter convenience, challenges persist in integrating legacy transport infrastructure with modern digital systems.

In the area of governance and public services, Almaty has made progress through e-government platforms such as the "Open Almaty" mobile app and online portals that enable access to municipal services. Residents can now submit complaints, request permits, and monitor utility payments digitally. Furthermore, the deployment of surveillance and smart policing technologies has strengthened public safety. However, there remain concerns about data privacy, digital inclusion, and the transparency of decision-making processes.

Environmental monitoring has also received attention, with the installation of air quality sensors and automated waste collection systems in select districts. Efforts to digitize energy use-such as smart meters for electricity and heating-have started to roll out, although they are not yet citywide.

Almaty's mountainous geography and high seismic risk further complicate infrastructural upgrades, pushing authorities to explore smart resilience planning tools and GIS-based hazard mapping.

Despite these developments, Almaty's smart city implementation is still in a transitional phase. The initiatives are unevenly distributed across the city, with technologically advanced zones concentrated in central and business districts. Peripheral neighborhoods often lack reliable digital connectivity and access to smart services, which risks deepening urban inequality. Additionally, resident awareness and engagement with smart city projects vary widely, indicating a need for more inclusive communication strategies and participatory planning mechanisms.

In Almaty, JSC "Almaty City Development Center" (ACDC) operates under the Akimat. To improve the quality of life in Almaty, various projects are being implemented, such as expansion of the metro network; automation of water supply systems, energy saving and lighting; opening of new world-class schools and universities, etc. Let us compare the areas of work of the Almaty City Development Center with the main dimensions of urban environment comfort that we have identified.

Table 1. Commitment of the work carried out on the development of Almaty to the goals of increasing the urban life quality

Sr No	Projects of ACDC	Dimensions of the urban life quality
1	Development of transport infrastructure	Quality and availability of urban infrastructure
2	Modernization of public utilities and digitalization	
3	Greening and improvement of the urban environment	Level of greenery and availability of natural spaces, level of environmental sustainability
4	Healthcare development	Health level of the population
5	Education development	Access to education and cultural services
6	Attracting investment into the economy and creative industries	Level of well-being of the population, quality of the urban economy
7		Security level
8		Citizen participation in city governance

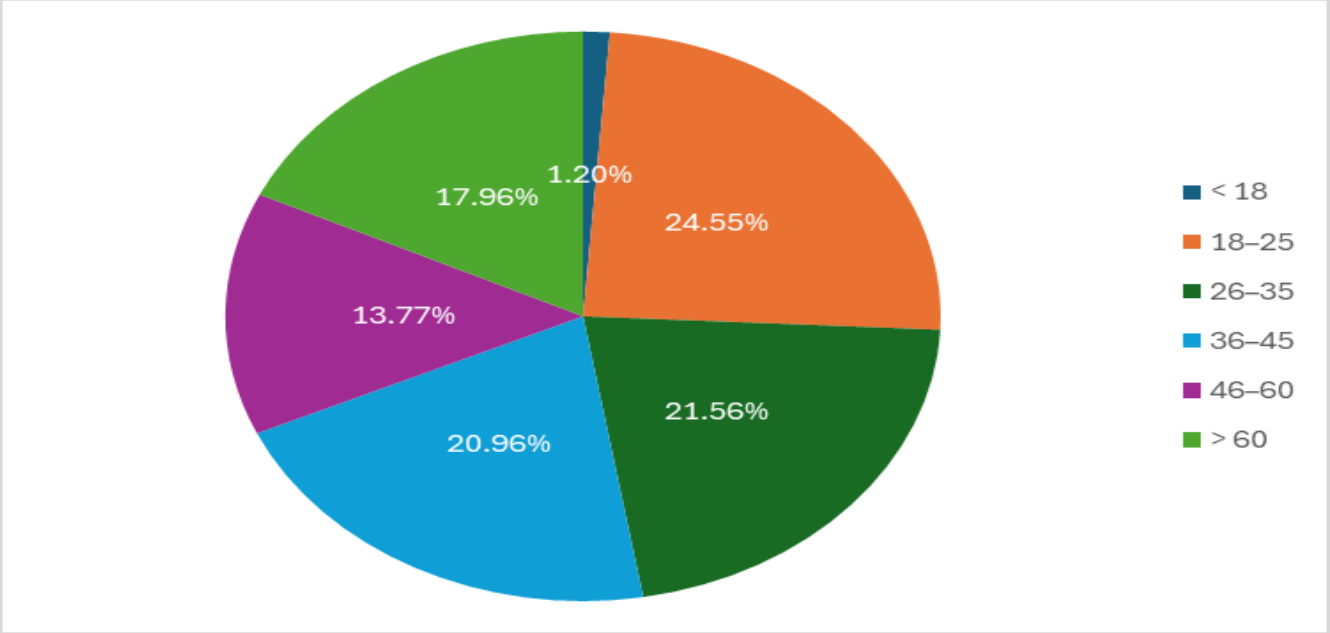
Note: compiled by the authors based on data from the Almaty City Development Center [13]

As can be seen from Table 1, all projects are aimed at improving the comfort of the urban environment. However, at the moment, work on improving city safety and citizen participation in city management has not been highlighted. Perhaps this seems to be the prerogative of other departments, or existing solutions (for example, e-otinish - a digital tool for submitting citizens' appeals to government agencies) seem sufficient to provide citizens with access to city management processes and solving citywide issues.

The above characteristics of a comfortable city formed the basis of a questionnaire for citizens, which we compiled to study their perception of the degree of city comfort. The object of the study was the city of Almaty. The questionnaire of 22 closed questions was designed in forms with a link and in the form of handouts, and sent out through various channels. As a result, over more than 2 months from March to May 2025, we managed to collect 167 responses from representatives of citizens of various age groups and levels of education.

The city of Almaty is a large metropolis of Kazakhstan with a population of 2,310.1 thousand people as of May 1, 2025. Of these, the economically active population is 49%.

Figure 1. Age categories of city residents who participated in the survey



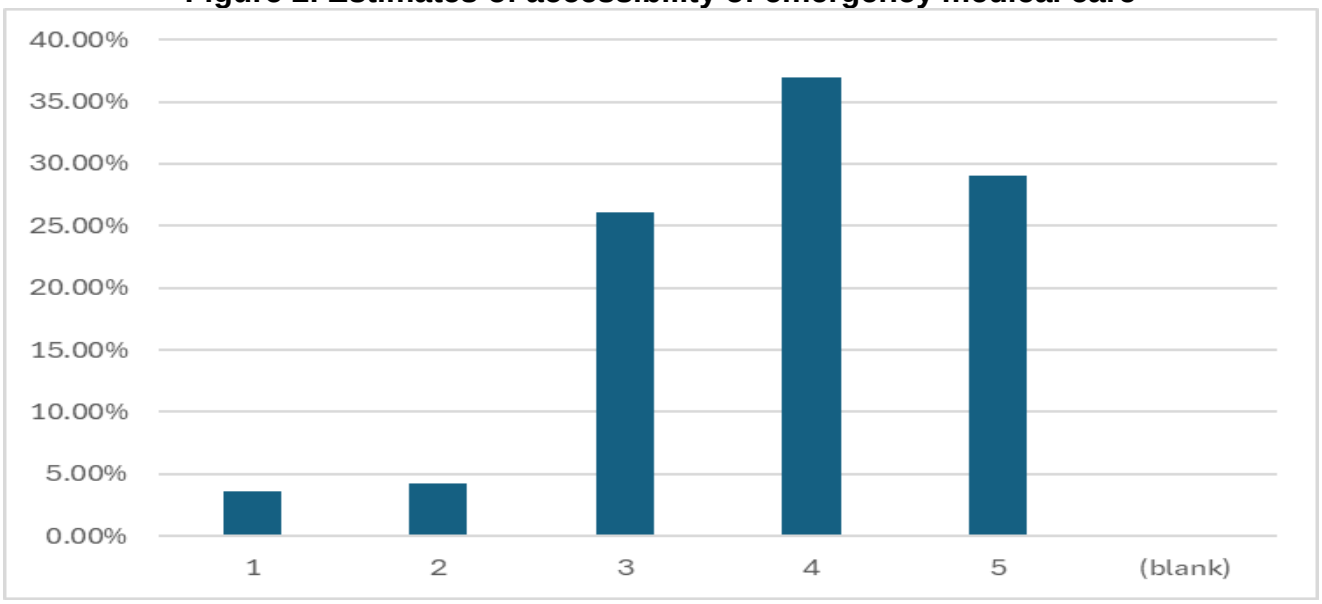
Note: Compiled by authors

Figure 1 shows that the survey was conducted among people of different ages, including teenagers under 18, although 1.2% of the total number of respondents. Basically, these are people with higher education and postgraduate (master's and/or doctoral degrees), which is typical for megacities. Only 5.4% of respondents have a school education as the last stage at the time of the survey.

Based on the processing of respondents' answers, as well as the results of the literature study, the most common problems faced by city residents were identified.

In some aspects of city life, Almaty can be considered one of the best (most comfortable) cities. For example, the availability of entertainment venues or educational services. 79.5% rated the number of places to spend leisure time as accessible and very accessible, and 86.1% were satisfied with the availability of educational resources, which included libraries and online platforms. Emergency medical care is approximately at the same level in terms of availability, according to residents - 92.2% satisfaction (Figure 2).

Figure 2. Estimates of accessibility of emergency medical care



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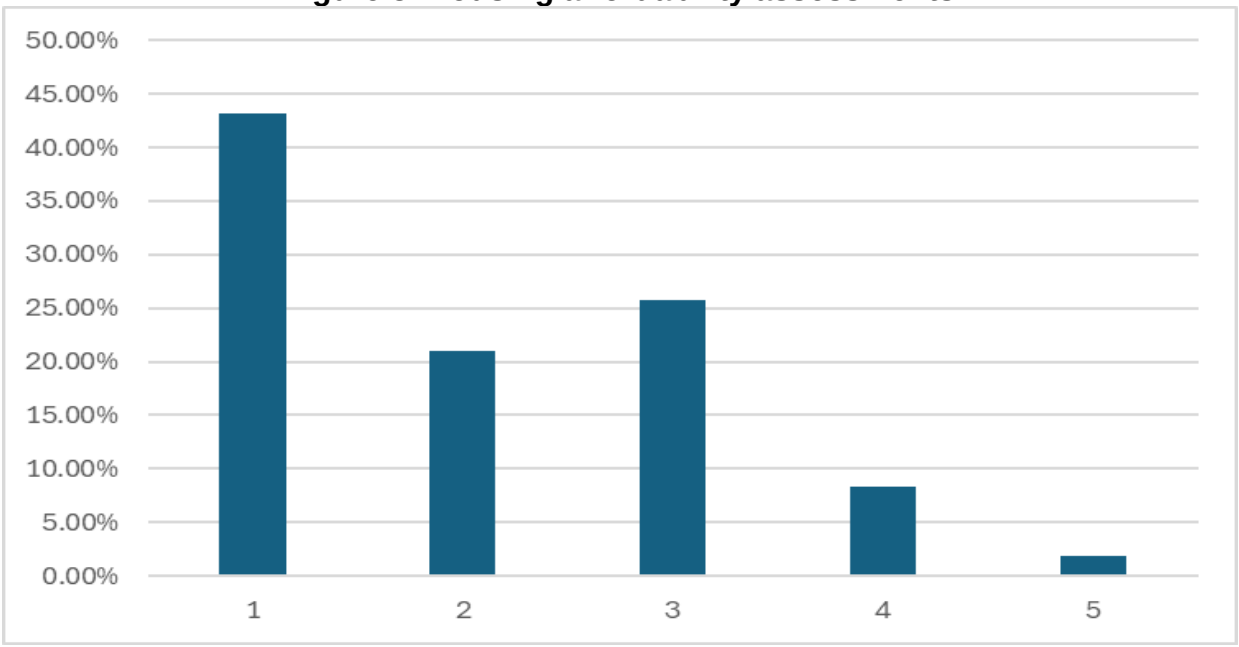
The high comfort ratings in healthcare, education, and entertainment can be partially attributed to the growing integration of digital services in these sectors in Almaty. In healthcare, the *Damumed* mobile application allows residents to book appointments with doctors, view medical records, and access laboratory results, significantly improving the efficiency and accessibility of medical services. In the field of education, platforms such as *Online Mektep* and *BilimClass* have expanded access to high-quality learning resources, particularly during and after the COVID-19 pandemic, enhancing flexibility and inclusion in educational provision. Regarding entertainment, applications like *Almaty Marathon* and *Ticketon* offer users easy access to event schedules, online ticket purchases, and cultural information, encouraging greater participation in leisure activities. The widespread use of such digital tools reflects Almaty's orientation toward smart service delivery and contributes directly to the residents' perception of convenience, accessibility, and overall urban comfort in these domains.

However, according to survey results housing is unaffordable for many (Figure 3). According to objective indicators, over the past 5-6 years, about 2 million square meters of residential buildings have been commissioned in the city annually [14]. Despite this, housing is perceived as unaffordable due to high prices and low purchasing power of the population. The average price per square meter in Almaty was 582,512 tenge by the end of 2024 [15]. The average monthly salary in the city was 518,857 tenge [16]. This means that with an average apartment price of 40 million tenge, a working person needs on average about 15-20 years to save up enough money to buy their own home (assuming that the marginal propensity to save is 40%). Thus, residents' opinions regarding the affordability of housing in the city are supported by economic data.

Figure 3. Housing affordability assessments



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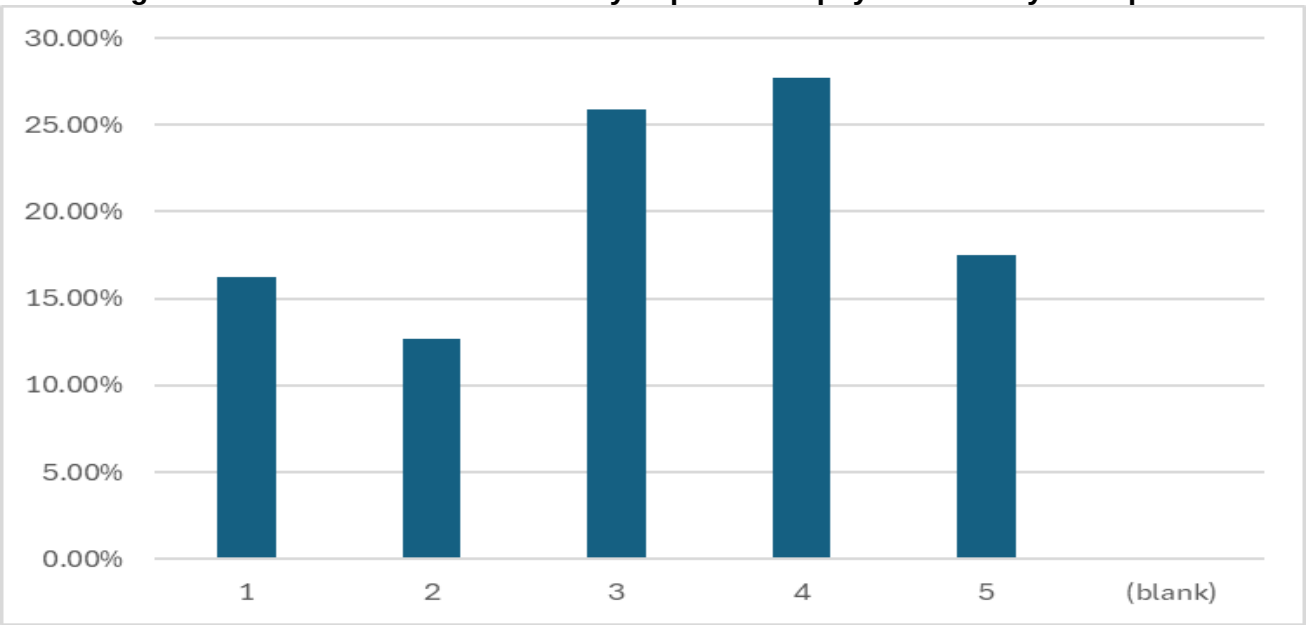
There are aspects that are generally rated as averagely developed. For example, employment opportunities and availability of places for physical activity (Figure 4). According to statistics, unemployment in 2024 was 4.6% of the city's population, which is the national average [17]. These figures suggest a relatively moderate level of unemployment compared to global urban standards, but they mask deeper structural issues.

Youth unemployment is particularly pronounced in Almaty. The city has the highest number of unemployed young people in Kazakhstan, with 11,100 individuals aged 15 to 28 actively seeking work [18]. This demographic faces challenges such as mismatches between education and labor market demands, limited entry-level opportunities, and competition in saturated sectors like retail and services. The most affected age groups nationally are 35 to 54 and 55 to 64, indicating that mid-career and older workers also struggle with job retention and re-entry into the workforce. Common causes of unemployment include family responsibilities, company layoffs, and difficulty finding suitable jobs, while health issues and post-graduation employment challenges also contribute [19].

In terms of unemployment types, Almaty experiences a mix of structural, frictional, and cyclical unemployment. Structural unemployment arises from the evolving nature of the urban economy, where traditional industries decline and new sectors demand different skill sets. Frictional unemployment is evident among recent graduates and job seekers transitioning between roles. Cyclical unemployment, though less dominant, can be influenced by broader economic fluctuations, especially in sectors like construction and manufacturing.

Almaty has made significant strides in enhancing accessibility to sports and physical activity facilities as part of its broader urban development strategy. The city's "Almaty City Development Program up to 2025" emphasizes the creation of a comfortable urban environment and equal access to social infrastructure, including sports and recreational spaces [19]. This initiative aligns with the Sustainable Development Goals, particularly in promoting physical culture and sports as essential components of a healthy lifestyle. The city is working toward a 15-minute neighborhood model, ensuring that residents can access sports facilities and green spaces within a short walk or bike ride from their homes.

Figure 4. Assessment of accessibility of places for physical activity and sports



Note: Compiled by authors

The government has invested in expanding sports infrastructure across the Almaty Region, with 90 new physical education and health centers built in 2024 alone [20]. These developments reflect Almaty's commitment to fostering a more active, inclusive, and health-conscious urban population. Availability of clean drinking water and transport infrastructure are also assessed by residents as average. 28.2% are dissatisfied, 28.1% assess the availability of clean drinking water as average, and 43.7% of city residents consider it accessible in the city. Residents also have mixed opinions about the development of the city's transport infrastructure: 21.6% consider public transport difficult to access and inconvenient to use, 31.7% are moderately satisfied, and 46.7% consider it convenient for moving around the city.To improve the usability and efficiency of public transportation in Almaty, the *Onaı* mobile application has been implemented. This digital platform enables residents and visitors to access real-time information on bus and trolleybus routes, track vehicle arrivals, and make contactless fare payments using smartphones or transit cards. The app enhances user convenience by integrating route planning, travel history, and balance tracking features, thereby reducing reliance on paper tickets and minimizing waiting times. As a complementary tool, *2GIS* offers map-based navigation, stop-by-stop updates, and multimodal transit options. These digital solutions collectively contribute to the development of a more accessible and intelligent urban mobility system, aligning with the principles of smart city planning and increasing the overall comfort of city life.

The ecology of the city and the presence of "green zones" is another factor that determines the comfort of the urban environment. Based on the responses of city residents, we can conclude that despite the prevalence of parks and green spaces in the city, the air quality is quite low and most

residents are concerned about this. Thus, the proximity of parks and forest park areas is rated highly by 66.4% of respondents, and only 6% are satisfied with the air quality and 57.5% are not satisfied at all and consider the air in the city to be very polluted. At the same time, almost 65% of people know that there are applications with real-time air quality information and many use them.

In terms of security, we surveyed city residents on both physical and cybercrimes. Residents rarely hear about crimes, so the crime rate can be assessed as low, although according to statistics, the number of registered crimes in 2024 was 24,965 units per 2,305.8 thousand residents (as of April 1, 2025), i.e. more than 1 crime per 100 people [21]. Almost 55% of the city's population feels unprotected in terms of cybersecurity, which indicates high anxiety among the population regarding digital threats, even if the statistics of cyber incidents may not be so high or complete.

Cybercrime in Almaty has seen a sharp rise in recent years, reflecting broader national trends in Kazakhstan. In the first quarter of 2025 alone, the country recorded 30,000 information security incidents, double the number from the same period in 2024 [22]. Almaty, as Kazakhstan’s leading IT hub, is particularly vulnerable due to its high concentration of digital infrastructure and services. The most prevalent types of cybercrime include botnet-related activities such as spam mailings, password cracking, and remote system intrusions, which surged to 17,600 cases in early 2025. Phishing attacks also increased significantly, with 2,000 reported incidents, marking a 37.2% rise compared to the previous year. In contrast, traditional malware attacks involving viruses and Trojans declined by nearly 18%. The city has also faced challenges with digital fraud, including social engineering scams, fake websites, and impersonation schemes. These often target individuals through deceptive emails or messages, tricking them into revealing personal or financial information [23]. In 2024, Kazakhstan registered 11,765 cases of internet fraud, with damages exceeding 17.5 billion tenge. Despite these threats, Almaty has made progress in combating cybercrime. The detection rate of IT-related crimes in the Almaty region increased by nearly 53%, thanks to coordinated efforts by cyber police and preventive measures [24].

This article does not aim to provide an integrated assessment of the level of comfort of living in Almaty, but an attempt was made to analyze various factors of urban comfort and identify so-called “bottlenecks”. Based on the survey and statistical data analysis, it can be concluded that the city of Almaty demonstrates high comfort in such areas as accessibility of leisure, educational services and emergency medical care, but faces serious problems in the field of housing affordability, environmental conditions, and ensuring the cybersecurity of residents. Moderate assessments of city residents are characteristic of such aspects of the urban environment as employment opportunities, transport infrastructure and availability of clean drinking water.

Thus, despite significant potential and positive aspects, the metropolis will have to solve a number of complex tasks to improve the overall comfort of living. This may explain the fact that, according to EIU estimates for 2024, Almaty took 123 place out of 173 cities in the Global Liveability Index [5].

Conclusion

This study made it possible not only to systematize the key dimensions of urban environment comfort within the context of the smart city concept but also to identify the real “bottlenecks” in Almaty’s urban development. Despite significant achievements in areas such as the availability of leisure facilities, educational services, and emergency medical care, the city still faces substantial challenges in housing affordability, environmental conditions, and ensuring cybersecurity for its residents. These issues reflect both objective economic and environmental constraints and the subjective perceptions of the urban population, which must be taken into account in future planning processes.

The analysis has also revealed that some aspects of the urban environment are perceived by citizens as moderately developed, including public transport infrastructure, access to clean drinking water, and employment opportunities. These areas represent “latent risks” in urban management, where current performance may be acceptable but insufficient to meet the demands of a growing and increasingly diverse population. Given the strategic importance of Almaty as a major economic and cultural center in Kazakhstan, a failure to address these moderate areas could lead to growing dissatisfaction and quality-of-life disparities among different social groups.

A critical challenge for smart cities-highlighted both in global literature and local context-is the issue of cybersecurity. As Almaty expands its digital infrastructure, the risk of cyberattacks on

municipal systems, data breaches, and surveillance misuse becomes increasingly significant. The integration of IoT devices, AI-driven platforms, and cloud-based services must be accompanied by robust cybersecurity protocols, including encryption, intrusion detection, and ethical data governance. Equally pressing is the digital divide, which threatens to exclude vulnerable populations from the benefits of smart city innovations. Ensuring equitable access to digital services, internet connectivity, and digital literacy is essential for fostering inclusive urban transformation.

In light of the findings, it becomes evident that the development of a smart city must go beyond technological solutions and place greater emphasis on equity, inclusivity, and sustainability. Smart urban planning must be human-centered, integrating citizens' perceptions into policy frameworks and fostering participatory governance. For example, digital tools such as feedback platforms and open data systems could be further developed to enhance civic engagement and transparency in urban decision-making.

In an international context, Almaty's smart city development shares similarities with other regional and global urban centers. Compared to Astana, which has adopted a more centralized and technologically ambitious approach through projects like "Smart Astana," Almaty's model appears more decentralized and citizen-driven. Tashkent, meanwhile, is in the early stages of smart city implementation, focusing primarily on transport and e-governance. In contrast, European cities such as Barcelona and Amsterdam have embraced participatory governance, open data platforms, and sustainability as core pillars of their smart city strategies. These comparative insights suggest that Almaty could benefit from adopting best practices in civic engagement and environmental resilience while tailoring them to its unique socio-economic context.

Furthermore, the results of this study may serve as a diagnostic framework for other cities with similar socio-economic contexts. By identifying both strengths and weaknesses in the urban comfort landscape, municipal authorities and policymakers can prioritize investments and reforms that are not only technologically advanced but also socially responsive. In this way, smart cities can truly fulfill their mission of improving urban life in a holistic, sustainable, and inclusive manner.

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РЕАЛИЗАЦИЯ КОНЦЕПЦИИ «УМНОГО ГОРОДА» В АЛМАТЫ: ИЗМЕРЕНИЯ, ТЕКУЩЕЕ СОСТОЯНИЕ И ВОСПРИЯТИЕ ЖИТЕЛЕЙ

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