Analysis of the Provision of Public Educational Institutions in the City of Almaty

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Abstract
The usefulness of spatial perspectives in educational research is well known, especially in areas such as school choice, which are implemented in various institutional, demographic, and local geographic regions. But spatial research methods, even if they can potentially be used in complex research strategies, tend to be fragmented and isolated, without taking into account numerous aspects of contextual factors. The analysis of the coverage of educational institutions in the city using geographic information system (GIS) technologies involves an assessment of the spatial distribution of schools, colleges, universities and other educational institutions in order to understand their accessibility to the population. Spatial data on the location of educational institutions within the city is collected based on data including addresses, types of educational institutions (for example, primary, secondary, higher education) and other relevant attributes. Buffer zones are created around each educational institution to represent service areas or catchment areas. The buffer distance can be based on factors such as walking distance or transport accessibility. The imposition of buffer zones of all educational institutions is focused on visualizing coverage throughout the city and the analysis can help identify areas with gaps or areas that are served by educational institutions with a higher frequency or with a longer interval. The analysis of population distribution overlays population data on the coverage map of an educational institution to assess the distribution of educational services in relation to the population. The identification of areas with high population density and limited coverage of educational institutions will allow to reorganize the approach to improving educational services on the ground. Given the long-term importance of education in urban society, scientists have carefully investigated the relationship between education and the dynamics of housing construction and their socio-spatial consequences.

Keywords: Almaty City, GIS, Public Education, Spatial Relationship, Walking Distance

1. Introduction

The city of Almaty consists of 8 districts, but today there is an open problem of monocentricity, which increases the burden on historically established points of attraction. According to the document "Almaty City Development Program until 2025 and medium-term prospects until 2030", presented by Almaty Mayor Yerbolat Dosayev in June 2022, the annual population growth averages about 50 thousand people, taking into account natural population growth (about 40%) and the migration balance (about 60%). The natural increase is about 20 thousand, which is expressed every 6-7 years in the need to create an equal number of educational places.

Educational institutions are a bulwark for building a healthy population capable of meeting their needs at the expense of highly intelligent citizens. The basic basis is laid when studying in schools, which in the time period occupy the largest part (from 9 to 11 years according to the standards of the Ministry of Education of the Republic of Kazakhstan). The shortage of places in schools is a problem that is on a par with the irreversible growth of the city, and in our case, the Almaly district. Almaly district is represented by 42 organizations in the field of education, 29 of which are public and 13 are private. The 2020-2021 academic year is represented by a student body of 36,258 students, of whom 33,169 attended public schools and 3,089 attended private schools [1]. The year 2021 was marked by the construction of two extensions for 300 students to gymnasium No. 34 and gymnasium No.144, but in recent decades no construction of a single public school has been recorded, which would increase the level of educational services according to the trends of the new digital age.

This situation is partly based on the reason for the lowest natural population growth in recent years in the context of districts (722 people in 2021), several times inferior to the leader in this indicator for 2021 – Alatau with an indicator of 7,148 people. The input data for the analysis of coverage of social facilities (educational institutions) were data on the dynamics of provision of social facilities for 2006-2022 and the dynamics of the number of students in schools in Almaty for 2006-2022 [2]. As of 2022, there are 333 educational institutions in Almaty (in 2006, this figure was 241 schools) and the largest number is represented in Bostandyk district (71 schools) with 54,105 students over the same period, which is equal to an average of ~721 students in each educational institution. The smallest number of educational institutions is represented in Zhetysu and Nauryzbai districts (22 and 23 schools, respectively) with a load of 29,291 and 25,453 students, respectively (the average for the districts is ~1,331 and ~1,106 students) [3].

2. Study Area

Almaly district is represented by 46 educational institutions and, in comparison with 2006, the number of institutions has increased by 11, and the number of students since 2006 has increased from ~24,600 to 38,485 students as of 2022 [4]. The difference in dynamics over this period (2006-2022) corresponds to an increase in the average number of students from 702 to 836 students, which demonstrates an increase in the burden on the historically developed part of the city [5]. In the dynamics of 2015-2022, the growth of students in the Almaly district was ~13.8 thousand students, where the highest growth occurred from 2015 to 2016 (~3,100 students), and the lowest was recorded from 2019 to 2020 (~800 students), which in turn is equal to the average increase in ~1.6 thousand students per year (Figure 1). Next, it was necessary to refer to the existing structure, according to which students are admitted to educational institutions. This process is based on the created geographical zones, which are called microstates [6]. Each micro-stage covers a certain territory with coverage of nearby educational institutions, depending on the form of education (schools with mixed education, as well as with Kazakh and Russian languages of instruction).

The list of micro-sections of Almaly district was presented in the following order in the number of 29 zones. This study allowed us to look at the problem from a different angle, namely with the use of geoinformation technologies based on the visualization of objects with the introduction of a number of attribute data. The data used in this study are inherently open and are presented for the year 2020-2021 [7]. The annual increase in schoolchildren from year to year is on average about 10%, which increases the level of shortage of student places and leads to the need to build new state educational institutions with the introduction of mixed (in Kazakh and Russian) education.

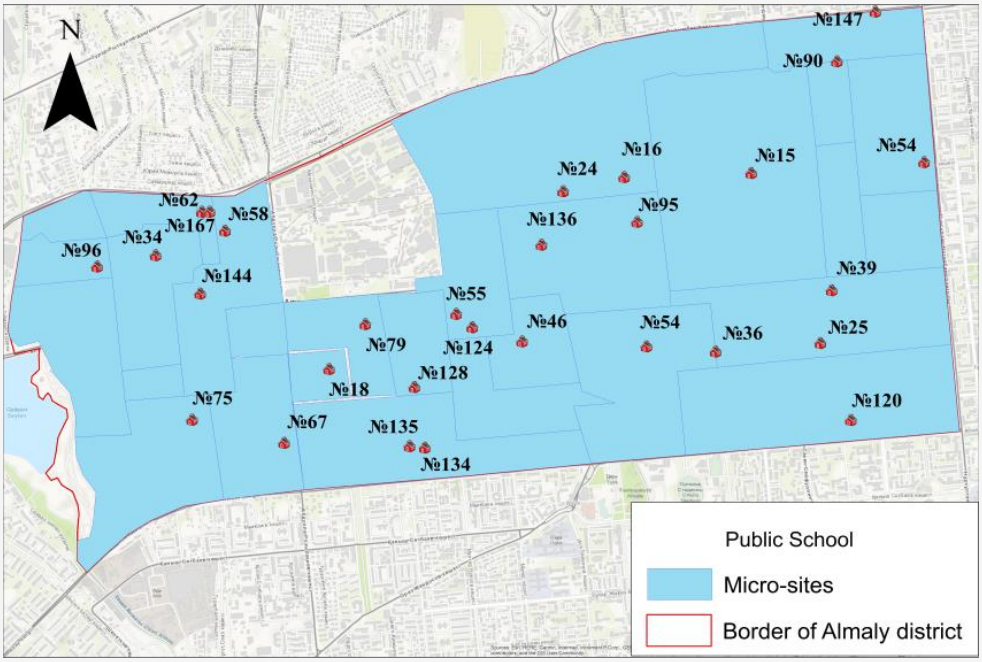

Figure 1: Locations of schools and micro-sites of Almaly district

In order to consider in detail the issues of the number of services provided in the educational sphere, it became necessary to take an individual approach when studying each of the micro-sites and educational institutions [8].

In the dynamics of 2008-2022, the Alatau district increased the number of educational institutions from 15 to 33, demonstrating a twofold increase, and the number of students increased from ~18900 to 53900 students. This situation has led to an increase in the average number of students from 1,260 to ~1,633 students, which demonstrates the need to increase the number of educational institutions to reduce the average workload in the district. In the dynamics of 2015-2022, the growth of students in the Alatau district was ~24.8 thousand students, where the highest growth occurred from 2015 to 2016 (~4,500 students), and the lowest was recorded from 2019 to 2020 (~2000 students), which in turn is equal to the average increase in ~3.1 thousand students per year [9]. The Auezovsky district, along with the Zhetysu and Turksib districts, has a negative dynamics in terms of the number of educational institutions (56 schools in 2006 compared to 54 schools in 2022) [10]. The number of students in the Auezovsky district increased from ~49,500 in 2006 to 57,136 students in 2022, which is manifested in an increase in the dynamics of the average number of students per educational institution from ~883 to ~1,058 in the period from 2006 to 2022. In the dynamics of 2015-2022, the growth of students in the Auezovsky district was ~19.4 thousand students, where the highest growth occurred from 2015 to 2016 (~ 3,600 students), and the lowest was recorded from 2019 to 2020 (~1400 students), which in turn is equal to the average increase in ~2,400 students per year [11]. Bostandyk district increased the number of educational institutions in the dynamics of 2006-2022 from 50 to 71, and the average number of students increased from ~31300 to 54105 students [12]. Based on the above, the average number of students per educational institution increased from 626 to ~762. In the dynamics of 2015-2022, the growth of students in the Bostandyk district was ~29.1 thousand students, where the highest growth occurred from 2015 to 2016 (~6,700 students), and the lowest was recorded from 2017 to 2018 (~2,200 students), which in turn is equal to the average increase in ~3.6 thousand students per year (Figure 2). In the above dynamics, Zhetysu district reduced the number of educational institutions from 32 to 22, while the number of students increased from ~26,800 to 29,291 students. According to these indicators, the average number of students increased from ~837 to ~1,331 students, which also indicates an increase in the number of students and a lack of educational institutions.

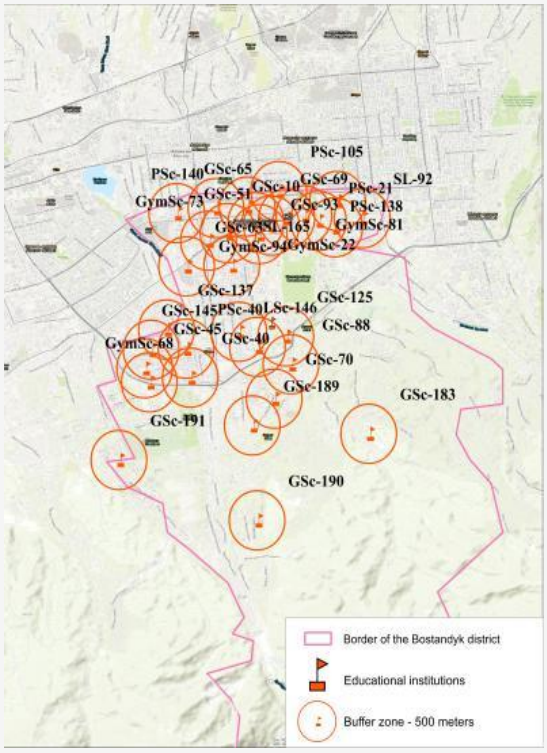

Figure 2: Map of the location of educational institutions in the Bostandyk district

In the dynamics of 2015-2022, the growth of students in the Zhetysu district was ~9.5 thousand students, where the highest growth occurred from 2015 to 2016 (~2,200 students), and the lowest was recorded from 2021 to 2022 (~600 students), which in turn is equal to the average increase in ~1.1 thousand students per year. Medeu district is represented by 53 schools by the end of 2022, which has a positive trend compared to 2006 (36 schools), and the number of students has decreased in dynamics from ~22700 to 37736 students [13]. The average number of students increased slightly from ~630 students to ~712 students over the dynamics of 2006-2022, which demonstrates the planned actions taken to organize a sufficient number of student places.

In the dynamics of 2015-2022, the growth of students in the Medeu district was indicated in the figure of ~15.3 thousand students, where the highest growth occurred from 2015 to 2016 (~3000 students), and the lowest was recorded from 2016 to 2017 (~1300 students), which in turn is equal to the average increase in ~1.9 thousand students per year [14]. In the dynamics of 2014-2022, Nauryzbay district increased the number of educational institutions from 10 to 23 schools, and the number of students increased from ~8,700 to 25,453 students, which corresponds to an increase in the average number of students from 870 to ~1106 per educational institution. In the dynamics of 2015-2022, the growth of students in the Nauryzbay district was ~16.7 thousand students, where the highest growth occurred from 2020 to 2021 (~ 2.6 thousand students), and the lowest was recorded from 2014 to 2015 (~900 students), which in turn It is equal to an average increase of ~2,000 students per year. In the dynamics of 2006-2022, the Turksib district reduced the number of educational institutions from 32 to 31, and the lowest of 28 schools remained in the period from 2011 to 2019 [15]. The number of students in the Turksib district in the dynamics of 2006-2022 increased from ~23,500 to 35,330 students, which corresponds to an increase in the load on one educational institution from ~734 to ~1139 students. In the dynamics of 2015-2022, the growth of students in the Turksib district was indicated in the figure of ~11.8 thousand students, where the highest growth occurred from 2015 to 2016 (~2.5 thousand students), and the lowest was recorded from 2019 to 2020 (~800 students), which in turn is equal to the average increase in ~1,4 thousand students per year (Figure 3).

The above statistics lead to the fact that from year to year there is a tendency to increase the burden on educational institutions and the solution to this issue may be based on an increase in the number of specialists in the teaching industry and the consolidation of elements of social service, since the current situation leads to a complication of the processes of providing social service due to an increase in the proportion of the number of students to representatives of the teaching staff the composition of educational institutions [16].

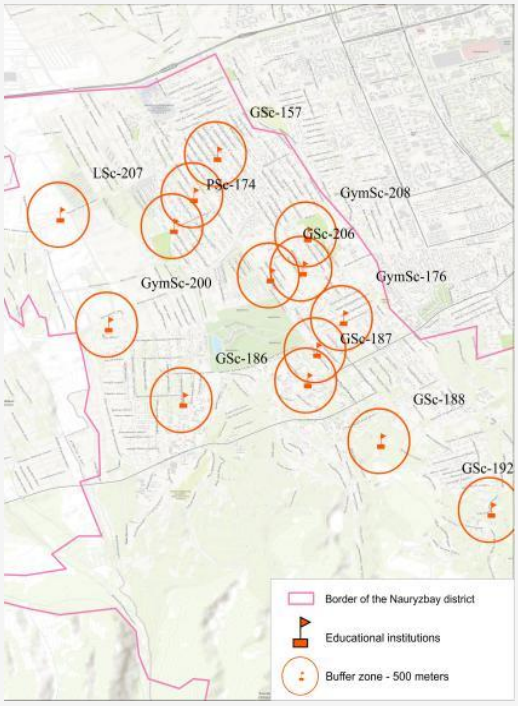

Figure 3: Map of the location of educational institutions in the Nauryzbay district

In comparison with 2021 and 2022, the increase in the number of students is about 8.3 thousand students, where the largest increase is observed in Nauryzbay (3.7 thousand) and Alatau (3.4 thousand), and the smallest is recorded in Almaly (~700) and Zhetysu (~600).

3. Methodology

The usefulness of spatial perspectives in educational research is well known, especially in areas such as school choice, which are implemented in various institutional, demographic, and local geographic regions. But spatial research methods, even if they can potentially be used in complex research strategies, tend to be fragmented and isolated, without taking into account numerous aspects of contextual factors. In recent years, a significant amount of research has accumulated on geographic education policy, as researchers from a wide variety of disciplines have recognized the value of studying educational phenomena from a spatial point of view [16]. Although the importance of early childhood education is well documented, insufficient attention has been paid to access to early childhood education facilities. The uneven distribution of pre-school facilities in isolated urban areas can lead to unequal educational opportunities. Education is one of the most important aspects of human life, contributing to economic and social well-being. The lack of adequate access to educational services for children can affect their overall well-being. In addition, an insufficient supply of educational opportunities can increase social inequality [17]. School choice policies aim to increase access to education by loosening the link between a student's place of residence and their chosen enrollment, but long commutes and other barriers can prevent families from choosing schools that would otherwise be desirable.

The analysis of the coverage of educational institutions in the city using geographic information system (GIS) technologies involves an assessment of the spatial distribution of schools, colleges, universities and other educational institutions in order to understand their accessibility to the population. Territorial equality in the provision of educational services is an essential element in creating healthy and joyful living conditions in cities [18]. Spatial data on the location of educational institutions within the city is collected based on data including addresses, types of educational institutions (for example, primary, secondary, higher education) and other relevant attributes. Geocoding addresses of educational institutions converts them into spatial coordinates (latitude and longitude), allowing you to display locations on a GIS map. Buffer zones are created around each educational institution to represent service areas or catchment areas. The buffer distance can be based on factors such as walking distance or transport accessibility. The imposition of buffer zones of all educational institutions is focused on visualizing coverage throughout the city and the analysis can help identify areas with gaps or areas that are served by educational institutions with a higher frequency or with a longer interval.

The analysis of population distribution overlays population data on the coverage map of an educational institution to assess the distribution of educational services in relation to the population [19]. The identification of areas with high population density and limited coverage of educational institutions will allow to reorganize the approach to improving educational services on the ground. As a highly sought-after resource for parents, quality schools have a strong impact on the housing market and other aspects of social life around the world. Given the long-term importance of education in urban society, scientists have carefully investigated the relationship between education and the dynamics of housing construction and their socio-spatial consequences. Institutional mechanism for Accessibility analysis determines the ease of access to educational institutions from different parts of the city, and is performed when calculating travel time or distance from residential areas to the nearest schools or institutions. Demographic analysis is carried out by data groups (e.g. age groups, income levels, education) in relation to educational institutions in order to identify inequalities or underserved groups of the population. Planning and prioritization uses the results of the analysis to justify urban planning decisions and prioritize the creation of new educational institutions in areas with limited coverage or high demand. The distance between home and school is crucial for children's mobility and equality in education. Compared to choice-based enrollment systems, proximity-based systems place much less emphasis on distance to school, as if an allocating children to nearby schools could avoid the problem of long distances to school [20].

4. Results

The impact of the new development on the coverage of educational institutions is made by applying them to the map and entering attribute data (approx. number of apartments). This aspect evaluates how changes in the urban landscape can affect access to educational institutions. Monitoring and evaluation focused on tracking changes in educational institutions' enrollment over time and the effectiveness of initiatives aimed at improving accessibility.

By using GIS technologies to analyze educational coverage, urban planners and policy makers can make data-driven decisions to ensure equal access to educational services for all residents. The analysis provides valuable information on the distribution of educational institutions and helps to identify areas where additional investments or strategic measures are needed to increase access to education and inclusivity. While educational inequality has attracted widespread academic attention, little attention has been paid to the spatial structures of schools, or more specifically, the spatial equality of secondary schools.

Improving the quality of social services in cities is important for improving the well-being and quality of life of residents. As urban areas face increasing challenges related to population growth, diversity, and changing social needs, several trends are emerging to improve and innovate social services. The open enrollment policy assumes that students living in disadvantaged areas can attend the best schools outside their area. However, the characteristics of individuals, the quality of school education and the characteristics of the district interact in a very complex way, creating heterogeneous models of school choice in local educational markets. Cities are using digital technologies to optimize and improve the provision of social services. Online platforms, mobile applications and digital portals make it easier for residents to access information, apply for services and communicate with service providers. The use of data analytics and large amounts of data is becoming increasingly common in the planning and evaluation of social services. Data-driven analytics helps identify emerging needs, assess the impact of programs, and allocate resources more efficiently. Parts of public service facilities such as schools, hospitals, or government buildings that provide basic urban functions can better meet public demands by promoting elements of smart cities.

5. Discussion

Social services are moving towards a more personalized and holistic approach that takes into account individual needs, circumstances and preferences. Customized services improve outcomes and better meet the diverse needs of city residents [21]. Cities are working to eliminate the disparity between different institutions and departments of social services. Integrated service delivery systems provide coordinated and uninterrupted support to individuals and families, reducing duplication and increasing efficiency. Inequality in education is a serious social problem in developing countries. Cities collaborate with community organizations and grassroots initiatives to address local social issues. Empowering community members to play an active role in the provision of services contributes to greater inclusiveness and responsiveness. Cooperation between public sector institutions and private organizations can expand the range and quality of social services available to residents. Private sector involvement can bring innovation, efficiency and additional resources to support social programs. Cities are prioritizing mental health services and well-being programs to address the growing mental health problems faced by urban populations. There are positive correlations between social capital, design and diversity, while the impact of population density on social capital is negative and unclear.

Urban areas are working to become more age-oriented by providing social services and infrastructure that meet the needs of older people, promoting social integration and active aging. Cities are exploring innovative financing models for social services, such as social impact bonds and public-private financing mechanisms, to attract more investment in social programs. The optimal allocation of educational resources has been an urgent problem, and studying the accessibility of educational institutions in poor areas helps to intelligently plan the location of educational institutions and promote balanced educational development. To ensure equal access to social services, cities are implementing digital technology initiatives aimed at bridging the digital divide and providing Internet access and digital skills training to low-income segments of the population. Social services are introducing culturally sensitive approaches that take into account the diversity of backgrounds and needs of urban residents, leading to more inclusive and culturally competent care. Partnerships with non-governmental organizations (NGOs) and non-profit organizations allow cities to use their expertise and public relations to effectively provide social services [22]. Cities are increasingly implementing evidence-based programs and interventions that have proven effective in solving social problems and achieving positive results. Spatial visualization and rendering of social issues is an invaluable strategy for implementing policy changes. As cities increasingly move towards a “de-spatial” geography of schooling, where coverage areas determine to a lesser extent where a student attends school, it is important to consider where desirable schools are located and where they are not. A more detailed visualization of the location of schools than demographic data by district offers a new perspective to explore the (not) anticipated effects of school closures on students, communities, and development.

6. Conclusion

By taking these trends into account and implementing innovative strategies, cities can improve the quality and effectiveness of social services, contributing to greater social cohesion, equality and general well-being in urban communities. These efforts contribute to the creation of cities that are more inclusive and sustainable. In recent years, attention has been paid to the construction and development of new educational centers, but less attention has been paid to their spatial distribution across cities.

The ongoing growth of Almaty, with an annual population increase of approximately 50,000 people, places significant pressure on its urban infrastructure, particularly in education. Almaly district, despite having a robust network of 42 educational institutions, faces a chronic shortage of student places, exacerbated by the lack of new state school construction over recent decades. This issue is mirrored across other districts, where the increasing student population outpaces the expansion of educational facilities, resulting in overcrowding and uneven accessibility. The analysis highlights the importance of spatial planning and geographic zoning (micro-sites) in addressing these challenges. While some districts, like Alatau and Nauryzbay, have seen considerable investment in educational infrastructure, others, such as Zhetysu and Auezovsky, lag behind. Geoinformation technologies prove essential in visualizing and addressing the disparities in educational service coverage, emphasizing the urgent need for equitable access to quality education across Almaty.

7. Recommendations

To address the pressing challenges in Almaty's education system, a multifaceted approach is required. First, it is crucial to prioritize the construction of new state schools in overburdened districts like Almaly, Zhetysu, and Turksib, where the population growth has outpaced infrastructure development. Existing schools should be expanded by adding classrooms or new buildings to accommodate the increasing student population. Equally important is the recruitment and training of qualified teachers to maintain the quality of education in the face of rising enrollment. Early childhood education must be enhanced by building more preschools and improving access for all families. The introduction of mixed-language education in schools can better serve the diverse needs of the population, particularly in bilingual districts. Investments in digital infrastructure, such as e-learning platforms and modern equipment, are also essential to prepare students for the demands of the digital age. Urban planning efforts should integrate educational facility development to ensure schools are located near residential areas and accessible by efficient transportation systems. Updated geographic zoning, supported by GIS technologies, can help distribute students more evenly across schools and reduce overcrowding. Public-private partnerships should be encouraged to attract investments in the construction and modernization of educational facilities. Inclusive policies must be developed to support students with disabilities and ensure equal access to quality education for all. Green and recreational spaces should be incorporated into school campuses to create a healthier learning environment. Community engagement is also vital; local residents and parents should be involved in decision-making to align educational projects with their needs. To reduce disparities between districts, targeted funding allocations should focus on underserved areas. Monitoring systems are needed to evaluate progress and ensure that resources are effectively utilized. Additionally, integrating long-term education strategies into Almaty's urban development plan can promote sustainable growth. At the national level, advocating for policies that address systemic issues, such as overcrowding and regional inequities, is essential.

Finally, collaboration among government agencies, NGOs, and the private sector will foster innovation and ensure a comprehensive response to the city's educational challenges. By implementing these measures, Almaty can develop a resilient and equitable education system that meets the demands of its growing population. This research was funded by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant "Comprehensive geographical assessment of sustainable development of large cities of the Republic of Kazakhstan" No. AP19677682)

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