### ABSTRACT

of the dissertation for the degree of Doctor of Philosophy (PhD) in the educational program "8D05202 - Geography"

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#### Organization and management of urban planning using GIS technologies on the example of the city of Almaty

**Relevance of the research topic.** The work is devoted to the spatial study of the city of Almaty. The environmental, social and transport components of urban space were selected as models, for which recommendations were developed to improve the quality of service provision in accordance with the canons of the United Nations Sustainable Development Goals (United Nations) based on cartographic material with spatial data on qualitative and quantitative characteristics. This study is consistent with the document "Almaty City Development Program until 2025 and medium-term prospects until 2030".

The degree of scientific knowledge of the problem. The theoretical and methodological basis of the dissertation research is based on the developments of leading scientific schools and their representatives in the field of urban planning, land cadastre, geoinformation technologies, etc. In the study of urban planning in Almaty, theoretical and methodological provisions developed by Li Y., Zhao Q., Zhong C. [1]; Torinos-Aguado B., Rabanaque I., López-Escolano C. were used. [2]; Peslyak O. [3], Medvedev V. [4], Bitarova M. [5], Mikhailov A. [6], Logan T.M., Hobbs M.H., Conrow L.C., Reid N.L., Young R.A., Anderson M.J. [7]; Khaled Al Shawabkeh R., Esraa Alobaidat, Mwfeq Ibraheem Alhaddad, Ahmad M. Alzouby [8]; Popov A. [9], Xu, Ronghua, Wenze Yue, Feiyang Wei, Guofu Yang, Tingting He, Kaixuan Pan [10]; Xu Ronghua [11], Elsheikh Ranya Fadlalla [12], Ogryzek M., Konrad P., Agnieszka C. [13]; Brueckner J. K. [14], Ataev Peter [15], Kolobov S. [16], Sokolskaya E. [17], Shevlyakova E. [18], Bachurina S. [19], Fan T. K. [20], Fieraru V. [21], Smirnova O. [23] Fraser T. [25], Plotnikova L. [26], Izhguzina N. [27], Plahotnik A. [29], Manaeva I. [30], Sefervan L. [31] and other researchers.

**The purpose of the dissertation research** is to form recommendations for the integration of innovative methods of geoinformation analysis in urban planning based on empirical research.

In order to achieve this goal, the following **tasks** were identified during the study:

- to study the theoretical basis of the provision of social services and familiarize yourself with the methodology of building the processes of geoinformation systems when creating service zones based on spatial statistics;

- to consider the main trends in the integration of geoinformation systems in the field of public transport with the introduction of attribute statistics to obtain qualitative indicators based on quantitative indicators GTFS (General Transit Feed Specification);

- identify priority directives for the potential operation of photovoltaic panels for the modernization of the infrastructural environment through the analysis of remote sensing data;

- to identify factors that can contribute to the continuous formation of urban heat islands using innovative methods of geoinformation analysis and will identify areas with a shortage of green spaces.

The object of the study is the city of Almaty.

**The subject of the research** is geographical information systems in the field of urban planning, urban studies and geographical design.

The methodology of the dissertation research is based on a comprehensive interdisciplinary study, which was based on work with spatial data. The cartographic method was the leading one in the visualization of socioeconomic, technical and environmental parameters of the city of Almaty. The use of tools for spatial statistics, decryption of data from a digital terrain model and calculation of atmospheric coefficients made it possible to produce cartographic material that displayed various kinds of differences within urban space.

The information base was the official data of the Bureau of National Statistics of the Agency for Strategic Planning and Reforms of the Republic of Kazakhstan, the Ministry of Science and Higher Education of the Republic of Kazakhstan, the European Space Agency, the Environmental Systems Research Institute (ESRI), Almatygenplan Research Institute LLP, Kazhydromet RSE, monographs, articles in scientific journals, Internet resources and regulatory legal acts of the Republic of Kazakhstan.

The scientific novelty of the study lies in the comprehensive presentation of recommendations on the identified issues of the socio-economic nature of the city of Almaty, shortcomings in its transport infrastructure and environmental deviations, which together has a direct impact on proactive urban planning, taking into account the aspect of land use.

Among the **provisions** reflecting **the scientific novelty of the conducted research** are the following:

- for the first time, an assessment of the level of provision of social services was carried out on the example of educational institutions in the Almaly district, indicating service areas that have spatial statistics;

- for the first time, an assessment of the level of coverage of public transport based on GTFS technology was given, which allowed using attribute data to identify a number of difficulties arising in the provision of services and generally affecting the existing route network of the city of Almaty;

- for the first time, an analysis of the potential of using photovoltaic panels on the roofs of city buildings using a digital terrain model was carried out, which showed the potential of using "green technologies" to increase social satisfaction of the population, improve the environmental situation and restructure the approach to providing the city with electricity; - for the first time, an assessment of the identification of urban heat islands based on a satellite image was carried out, which made it possible to identify potential zones with high temperatures relative to the entire territory of the city of Almaty.

The theoretical significance of the research consists in obtaining new scientific knowledge in the field of urban planning, characterized by the presence of socio-economic, transport and environmental problems. The results obtained are a scientific and practical recommendation for the development of modern technical solutions aimed at the comprehensive development of urban planning issues in order to increase the efficiency of land use to improve the quality of the environment, socio-economic indicators and the transport framework of the city of Almaty.

**Practical significance.** The results of this study are reduced to providing practical recommendations by providing the structures of the local executive body with cartographic material that accumulates quantitative and qualitative indicators for conducting a comprehensive and proactive analysis of urban planning based on scientifically based indicators. The results of this study can contribute to the development of software based on cartographic material aimed at creating subsequent development programs and prospects for improving the quality of urban planning.

## The main provisions submitted for defense:

- the system of identification of problem areas of social services with the application of a service zone will allow to obtain a modified form of urban planning organization when studying the issue of increasing the density of social institutions, taking into account socio-economic components and subsequent integration in the formation of the development program of the city of Almaty in accordance with the UN Sustainable Development Goals;

- a proven tool for calculating the potential generation of solar electric energy on the roofs of city buildings will contribute to the development of renewable energy sources, and will also help reduce dependence on traditional energy sources;

- the application of the proposed method for determining urban heat islands based on remote sensing data will improve the environmental conditions and conduct widespread monitoring of the state of temperature indicators of the city of Almaty;

- the analysis of the state of public transport in the city and the urban agglomeration will make it possible to identify priority areas for the development of public transport with the creation of a competitive advantage to increase the mobility of citizens of Almaty.

# According to the results of the study, the following conclusions were obtained:

1. Based on the analysis of foreign and domestic research experience, the geographical meaning of the concept of "urban planning" as an evaluative factor of the quality of life of the population of a certain territory, which at the same time has natural features and individual socio-economic indicators, has been clarified,

which made it possible to formulate the methodological foundations of the study and select a methodology for assessing the level of urban planning and how educational, energy issues, environmental and transport aspects can be integrated into the form of proactive planning.

2. The identification of socio-economic, energy, environmental and transport indicators made it possible to form a methodology that was used to assess the level of service provision in the conduct of urban planning processes. The position of the integrated approach made it possible to orient the toolkit according to the features of spatial statistics. The combination of the above indicators is the basis for calculating the indicators characterizing the level of planning of the city of Almaty.

3. The assessment of socio-economic, energy, environmental and transport indicators has demonstrated a number of inconsistencies that in the future may lower the standard of living in the city of Almaty. Widespread urbanization entails difficulties in the form of increased stress on social facilities and transport infrastructure, sprawl of urban territory with self-occupation of land, disruption of urban connections and monocentricity. This trend cannot ignore the city of Almaty, which is actively manifested in the high level of natural population growth and migration processes.

4. As a result of a comprehensive geographical assessment using GIS technologies, the main reasons influencing the level of urban development were identified, according to which it is necessary to increase the connectivity of factors (socio-economic, transport, environmental, etc.) in urban planning, based on which spatial statistics were provided, which made it possible to identify shortcomings in the modern form of urban planning of the city Almaty.

The author's personal contribution to solving the problems put forward in the study is:

- in carrying out an assessment of the structural organization of urban infrastructure based on spatial statistics;

- in conducting scientific research on the study of a digital terrain model for the subsequent determination of the solar potential;

- in the development and creation of cartographic material of urban space with visualization of attribute indicators;

- in the preparation and publication of scientific results on the subject of the conducted research in rating journals (approx. GeoJournal of Tourism and Geosites -Q2). The main provisions of scientific articles are reflected in the sections of the dissertation for the PhD degree.

**Approbation of the work.** The main results and provisions of this dissertation research were reported and discussed:

- at the International Scientific Conference of Students and Young Scientists "Farabi alemi" (2021, Almaty, Republic of Kazakhstan);

- at the XVI International conference "GIS in Central Asia – GISCA 2022" (2022, Almaty, Republic of Kazakhstan);

- at the I-th International Conference on Engineering, Natural and Social Sciences "ICENSOS" (2022, Konya, Turkey);

- at the International Scientific Conference of Students and Young Scientists "Farabi alemi" (2023, Almaty, Republic of Kazakhstan).

**Publication of the research results.** Based on the materials of the dissertation research, 8 works have been published, including 1 article included in the Scopus database, 3 articles in publications recommended by the Committee for Quality Assurance in the Sphere of Education of the Ministry of Education of the Republic of Kazakhstan and 4 articles in the materials of international conferences.

The structure of the work. The dissertation is presented on 168 pages and consists of normative references, definitions, designations and abbreviations, an introduction, 3 sections, a conclusion and a list of used sources from 156 titles, 124 of them in foreign languages, and also contains 27 figures, 11 tables and 9 diagrams.