USING GIS TO ANALYZE AND PLAN THE INTEGRATION OF GREEN AREAS INTO URBANIZED AREAS

R. Zh. Dissenov

Al-Farabi Kazakh National University, Al-Farabi Av., 71, 050040, Almaty, Kazakhstan, email: dissenov_rinat@mail.ru

The expansion of urban areas and suburbs significantly affects the nature and well-being of the population, provoking problems such as deteriorating air quality, the formation of urban thermal islands and difficulties in managing water resources. The concept of multi-functional landscaping is becoming an important tool combining environmental, social and medical aspects.

Keywords: blue-green infrastructure; geographic information systems; urban climate; urbanization; water resources management; green areas; improving the quality of life.

Within the framework of this study the aim was to identify promising sites for three types of blue-green infrastructure (BGI): biohazards, infiltration trenches and landscaped bus stops. Using remote sensing data, geographic information systems (GIS) and spatial modeling, the researchers developed primary maps identifying suitable areas in Olsztyn (Poland) for the implementation of BGI.

The models included an analysis of the city's surface heat island (SUHI) and a demographic assessment describing the age structure of the population. An integrated approach made it possible to create a highly accurate map with a detail of up to 1 meter, providing an accurate representation of geographical features and infrastructure elements necessary for effective planning.

Blue-green infrastructure is seen as a key measure to strengthen ecosystem sustainability, improve the quality of the urban environment and improve public health.

The integration of blue-green infrastructure (BGI) into the urban environment is seen as an important strategy to reduce the effects of temperature increases associated with climate change and improve public health. Research confirms the effectiveness of BGI using natural solutions (Nature-Based Solutions, NBS), which harmoniously combine aquatic and natural elements such as bio-settling tanks, infiltration ditches and landscaped bus stops.

Main features and benefits of blue-green infrastructure (BGI) are vital for enhancing urban resilience and ecological health. First, BGI plays a key role in water management by promoting water retention, purification, and reuse, which helps to reduce the risk of flooding and ensure long-term environmental sustainability. This is achieved through various elements like green roofs, bio-swales, and infiltration ditches that manage stormwater effectively. Second, temperature reduction is another significant benefit, as green spaces and water elements help counteract urban heat islands by regulating the air temperature, thus mitigating the impacts of extreme heat in cities. Lastly, BGI fosters ecological balance by creating habitats for a diverse range of plants and animals, improving urban biodiversity, and promoting ecological continuity by connecting fragmented natural areas. These three features of BGI not only address environmental challenges but also contribute to creating healthier and more sustainable urban spaces.

Social and aesthetic effects: these elements enhance the visual appeal of territories, promote environmental education and improve the quality of life of citizens.

Mental and Physical health: BGI has been found to have a positive effect on the well-being of the population, reduces stress levels and improves mental health.

When designing using spatial solutions based on the characteristics of a particular territory, BGI allows to create systems that enhance each other by providing integrated ecosystem services. This makes BGI a key tool for adapting cities to climate change and increasing their resilience.

The technology under discussion provides efficient collection, storage and processing of spatial data, which allows analysis and research of this data to create accurate and reliable information related to specific geographical points. Some studies consider the use of GIS platforms to determine the current blue-green infrastructure (BGI) and assess its sufficiency to ensure optimal living conditions for the population, as well as compliance with these elements with current regulatory requirements.

According to the literature there are several difficulties in measuring the quality of life due to the variety of approaches to interpreting this concept and the lack of a uniform definition. In this context it is assumed that the quality of life can be defined as a combination of objective and subjective indicators covering various aspects of life, such as personal autonomy and individual preferences, along with real assessments. This suggests that the statistical measurement of the quality of life should consider its multifaceted nature, including not only objective living conditions (material conditions, health, education, etc.), but also the subjective perception of human well-being.

Thus, blue-green infrastructure (BGI) has an impact on both objective improvements in living conditions and the subjective perception of well-being. This holistic approach to implementing BGI is an important element in improving the quality of life by creating a healthier, more sustainable and comfortable environment for urban residents.

Research also shows that GIS tools play a key role in identifying areas that need further development to increase sustainability and effectively select components of blue-green infrastructure. In addition, important attention is paid to the use of remote sensing data to analyze changes in land cover, which is especially important in the context of a rapid urbanization process. An important trend follows from these studies – automation of analysis and the ability to work with large geographical areas, which also supports the purpose of this study. Geospatial analysis performed using GIS allows you to accurately identify changes and processes occurring in dynamic suburban areas.

The analysis of the implementation of blue-green infrastructure (BGI) plays a key role in urban planning, helping to integrate nature-based solutions into the urban environment. Such solutions can serve as both an alternative and an addition to traditional engineering systems aimed at sustainable development, improving the quality of life and protecting the environment. The importance of these technologies is enhanced by the need for effective land management, which is the basis for sustainable development of both urban and rural areas.

BGI offers critical ecosystem services such as cooling and insulation, CO_2 absorption, use of low-carbon materials, and support for the Sustainable Development Goals (SDGs), including improving urban biodiversity and ecosystem continuity in the urban environment. These measures contribute to the fight against climate change and enhance the adaptive capabilities of urban infrastructure, as well as contribute to solving problems of water and thermal comfort.

Determining the BGI components that are most suitable for different types of urban areas is an important step to achieve maximum efficiency. Some elements of BGI, such as irrigation and shading systems, can synergistically improve the ecological and thermal condition of the city. The placement of these elements in the complex helps to reduce overheating of urban areas, prevent flooding and improve the water balance by filtering and absorbing water. In addition, the appropriate vegetation significantly improves the aesthetic characteristics of the city, making it more attractive and comfortable to live in.

The integration of these elements requires consideration of environmental objectives, accessibility of space and climatic conditions, which contributes to the creation of sustainable, functional and environmentally healthy urban spaces.

The integration of various cartographic models using data on the location of blue-green infrastructure (BGI) components makes it possible to effectively consider factors such as temperature, age structure of the population and geospatial parameters, which may exclude certain areas for the implementation of these components. The main purpose of this approach is to identify optimal locations for BGI, which contributes to improving living conditions and reducing the negative impact of high temperatures in cities. An important aspect of this process is to consider local climatic and geographical features, such as the need for cooling and humidification in hot and dry regions or the role of vertical landscaping in an urban microclimate with a high solar load.

Mapping models can identify which BGI elements will be most effective in different climatic and urban contexts. This allows not only to increase thermal and environmental comfort, but also to minimize the risks associated with high temperatures, such as hyperthermia and dehydration in vulnerable segments of the population, especially the elderly. The social and cultural context should also be considered, as the use and maintenance of green areas can vary greatly from country to country. Economic factors, such as the availability of finance, also play a significant role in the implementation and maintenance of BGI, determining the scale and quality of implemented solutions.

Thus, cartographic models integrating a variety of data allow urban planners to make informed decisions to create sustainable and healthy urban spaces, efficiently allocating resources and minimizing risks to public health. The adaptation of these models to the specific conditions of different cities emphasizes the versatility and practical value of the developed tools for improving the quality of life in the face of climate change.

References

1. *Zalewski M., Wagner I., Fratczak W.* Blue-green city for compensating global climate change // Parliam. Mag. 2012. Vol. 350. P. 2–3.

2. *Cieślak I., Czyża S., Szuniewicz K.* Assessment of residential areas of city on the example of Olsztyn // IOP Conf. Ser. Mater. Sci. Eng. 2019. Vol. 471. P. 102001.

3. *Antoszewski P., Świerk D., Krzyżaniak M.* Statistical review of quality parameters of blue-green infrastructure elements important in mitigating the effect of the urban heat island in the temperate climate (C) zone // Int. J. Environ. Res. Public Health. 2020. Vol. 17. P. 7093.

4. *Almaaitah T., Appleby M., Rosenblat H.* The potential of Blue-Green infrastructure as a climate change adaptation strategy: A systematic literature review // Blue-Green Syst. 2021. Vol. 3. P. 223–248.

5. *Siehr S. A., Sun M., Aranda Nucamendi J. L.* Blue-green infrastructure for climate resilience and urban multifunctionality in Chinese cities // Wiley Interdiscip. Rev. Energy Environ. 2022. Vol. 11. e447.

6. *Arshad H. S. H., Routray J. K.* Multi-functional urban greening: A policy review assessing the integration of urban agriculture into the urban planning system of Punjab province, Pakistan // Urban and Transit Planning: A Culmination of Selected Research Papers from IEREK Conferences on Urban Planning, Architecture and Green Urbanism, Italy and Netherlands (2017); Springer International Publishing: Cham, Switzerland, 2020. P. 103–111.

7. *Panlasigui S., Spotswood E., Beller E.* Biophilia beyond the building: Applying the tools of urban biodiversity planning to create biophilic cities // Sustainability. 2021. Vol. 13. P. 2450.

8. *Pluto-Kossakowska J., Władyka M., Tulkowska W.* Wykorzystanie technologii GIS w analizie zielonej i błękitnej infrastruktury // Rocz. Geomatyki XVIII [Ann. Geomat.]. 2020. Vol. 1, P. 33–50.

9. *O'Donnell E., Netusil N., Chan F.* International Perceptions of Urban Blue-Green Infrastructure: A Comparison across Four Cities // Water. 2021. Vol. 13. P. 544.

10. *Rall E., Hansen R., Pauleit S.* The added value of public participation GIS (PPGIS) for urban green infrastructure planning // Urban For. Urban Green. 2019. Vol. 40. P. 264–274.

11. *Zhou C., Wu Y. A.* Planning Support Tool for Layout Integral Optimization of Urban Blue–Green Infrastructure // Sustainability. 2020. Vol. 12. P. 1613.

12. *Völker S., Baumeister H., Claßen T.* Evidence for the temperature-mitigating capacity of urban blue space – A health geographic perspective // Erdkunde. 2013. Vol. 67. P. 355–371.

13. *Xie Q., Li J.* Detecting the cool island effect of urban parks in Wuhan: A city on rivers // Int. J. Environ. Res. Public Health. 2021. Vol. 18. P. 132.

14. Mapping Urban Green Infrastructure: A Novel Landscape-Based Approach to Incorporating Land Use and Land Cover in the Mapping of Human-Dominated Systems / M. Dennis [et al.] // Land. 2018. Vol. 7. P. 17.