

Forecasting the quality of the thermal urban environment based on morphological parameters and climatopes: an approach to sustainable planning in a temperate climate

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Keywords: urban thermal comfort, climatopes, LCZ, UHI, SVF, green infrastructure, urban planning, GIS

Abstract Rising urbanization and climate change are exacerbating overheating in cities, especially in the summer, raising risks to the health and sustainability of the urban environment. Despite the presence of global models — LCZ to reduce the UHI effect — there are no engineering and applied solutions adapted to the national conditions of the temperate continental climate and urban planning standards.

The paper proposes an integrated approach to forecasting the quality of urban thermal environment (UTE), based on the adaptation of LCZ/UHI theories to local climatopes, morphological parameters of development and remote sensing data. The scientific novelty of the study is as follows:

- Express methods for assessing the quality of UTE;
- Grid model (100×100 m) of temperature calculation by morphological variables;
- Enabling the Sky View Factor (SVF) to take into account the density of tree crowns;
- Analysis and adaptation of urban planning standards to the tasks of thermal comfort.

The model is based on the leveling of multiple linear regression with variables: building density, landscaping (trees, shrubs, grasses), road and soil pavements (based on GIS data). Temperature characteristics were obtained on the basis of remote sensing data. It was found that landscaping with trees has the greatest impact on temperature reduction. The lack of multicollinearity and MAE, MSE, RMSE metrics confirmed the high accuracy of the model. Verification performed in Envi-Met, data reliability confirmed

Full-scale SVF measurements for various tree species (oak, maple, elm, poplar) made it possible to clarify their influence on the heat balance. A formula has been developed for calculating the effective proportion of landscaping, taking into account the area and density of the crown. It was integrated into the model.

A numerical experiment was carried out with various types of buildings and landscaping scenarios (0-30%), depicting that an increase in the proportion of trees to 30% allows to achieve a high class of UTE. A map of the distribution of climatopes by classes of thermal urban environment (UTE) was created, on the basis of the model. An express method for assessing the quality of the projected territory is proposed.

The analysis of urban planning standards revealed that the current standards do not provide the required level of thermal comfort.

Recommendations:

- Increase the standard of landscaping by trees to 30% for cities with a temperate continental climate;
- Specify the type of vegetation in the regulations;
- Include the indicator of thermal comfort in the quality index of the urban environment.

The proposed approach is scalable and applicable in the practice of sustainable planning and contributes to the achievement of the UN SDGs (Goal 11).