Technologies for Creating Geographic Information Resources for Monitoring the Socio-Ecological Conditions of Cities

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Abstract. Geo-information resources have been developed for monitoring socio-ecological conditions (using the example of cities in Central Russia). The technologies of the developed GIS allow to take into account the variability of scale, the transformation of cartographic projections, changing the composition of the mapped objects, the formation of queries in numerous databases in real time, variations in the ways of displaying objects. The developed GIS system consists of hierarchically subordinate database sections and thematic cartographic tools reflecting the natural resource potential, the socio-economic and environmental-hygienic situation in the cities of Central Russia.

1. Introduction

Modern large urbanized areas are centers of acute environmental problems, which determines the high relevance of conducting monitoring studies of social and environmental conditions for the population [1, 2, 3]. At the beginning of the 21st century, a significant increase in the socio-economic potential is observed in Russia and a number of other developed countries of the world, which, in addition to positive effects, causes an increase in environmental tensions in large cities [4, 5, 6].

Among other factors that determine the environmental comfort of urbanized areas, it is necessary to highlight the natural frame surrounding this territory [7, 8].

Under the natural (ecological) framework of the territory, according to the environmental design documentation, we mean the set of the most active and interrelated in terms of the environment spatial elements (rivers and river valleys, forests, etc.), on which the ecological stability of the environment depends. Эффективное управление развитием территории основано на системе критериев качества структуры и функционирования природного каркаса.

The basic elements of the natural frame include:

• valuable natural-territorial complexes occupying a significant part of the territory of the district (as a rule, these are federal reserves and reserves, national and natural parks, large monuments of nature in area, botanical gardens) [9];
• natural-territorial complexes of the main watershed surfaces of the formation of river flows;
• large forest tracts (as a rule, these are protective forests);
• large marsh and forest natural-territorial complexes (NTC) that do not have protection status. Key elements of the natural complex are territories that have preserved unique ecological communities that are “points of ecological activity”.

Thus, the natural frame of the territory, improving the quality of aeration of urbanized territories, as well as increasing the diversity of landscapes, is one of the factors determining the ecological safety of the territory [10, 11].
2. Equipment and devices used in studies

To assess the socio-ecological conditions of the urbanized areas of Central Russia, an analysis of the natural framework around the studied cities of Central Russia (Voronezh, Lipetsk, Belgorod, Kursk, Tambov) was carried out. The data of remote sensing of the Earth and the subsequent analysis of the effect of the natural framework on the ecological comfort of urbanized areas implies the need to use large data arrays, their processing and mapping. This requires the use of modern geo-information technologies that allow for the collection, analysis, processing and visualization of geodata, as well as obtaining on their basis new information about spatial-coordinated phenomena [6].

The results obtained during the interpretation of satellite images, as well as the data processing of statistical information are summarized in the GIS environment Ecological and Socio-Economic Conditions of the Urbanized territories of Central Russia, which will be used to develop a model of the effect of the natural framework on the integral value of the environmental comfort of the studied territory.

GIS offers a wide variety of approaches to the analysis of spatial data. Sometimes it is enough to use visual analysis: on the basis of the created map, see everything you need to make a decision. However, there are times when it is difficult to make a decision only on the basis of a map. Simple data visualization does not allow to make an unambiguously correct decision. When creating a map, cartographers can choose which objects are included in the map, which characters are assigned to them, which classification scheme is used, what the inscriptions look like, etc. All these cartographic elements help to understand the content of the map and determine the boundaries of the problem being analyzed, but they can also change the characteristics of the information and affect its perception and interpretation.

Created digital maps of the study area should provide accurate binding, systematization, selection and integration of all incoming and stored information (a single address space); complexity and clarity of information for decision-making; the possibility of dynamic modeling of processes and phenomena; the possibility of automated problem solving associated with the analysis of the characteristics of the territory; the possibility of operational analysis of the situation in case of emergency.

Geo-information resources being developed are considered as a certain extension of the database technology for coordinate-related information with the possibilities of organizing a database request together with the means of generating a “graphical” report, as well as analyzing spatial relationships between objects [12]. It becomes possible to display on the screen or on a hard copy only those objects or their sets that the user needs at the moment. That is, the transition from complex complex cards to a series of interconnected private cards is actually carried out. This ensures better structured information, which allows it to be used effectively (manipulation, data analysis, etc.).

3. Results and Discussion

GIS "Ecological and socio-economic conditions of urbanized areas of Central Russia" consists of a system of hierarchically subordinate sections of databases and tools for thematic mapping, reflecting the natural resource potential, socio-economic and ecological-hygienic situation of urbanized territories (fig.1).

The basis is the data of remote sensing of the Earth obtained from the Landsat-8 satellite, as well as official statistical data of environmental protection agencies and government bodies, presented in the form of textual descriptions, tabular reference data and graphic illustrations (maps, diagrams, pictures, photo slides).

The collection of information to characterize the functional planning structure and landscape-environmental conditions for model regions was carried out on the basis of special field studies, stock processing, including cartographic, material from regional integrated and sectoral environmental departments.

An array of official statistical information for a 20-year period, from 1998 to 2018, has been selected for mathematical-cartographic modeling.

GIS "Environmental and socio-economic conditions of urbanized areas of Central Russia" contain 4 sections.
The first section is “Natural Potential”. This section assumes the collection and synthesis of data characterizing the diversity of the landscape, which makes it more sustainable. The predominant influence of the natural frame on the quality of the environment are zones of external and internal landscaping.

Protective green areas, according to the town planning code of the Russian Federation, should be located on the windward side of the city. In urban settlements, it is necessary to provide, as a rule, an uninterrupted system of green areas and other open spaces. The share of green areas for various purposes within the building (level of greening of the building area) must be at least 40%, and within the territory of a residential area at least 25% (including the total area of greened territory of the microdistrict). The general principle of the organization of the green zone is the maximum preservation of natural green spaces, as well as the introduction of gas-dust-resistant woody plants.

The area of green areas of common use – parks, gardens, squares, boulevards, located on the residential territory of urban and rural settlements, take at the rate of 10 m² / person. for large, large, largest cities and 7-8 m² / person. for medium and small cities.

The natural potential of the territory largely influences the microclimatic conditions of the territory, as well as is itself influenced by the microclimate.

The study of the natural potential of the urbanized areas of Central Russia is carried out according to remote sensing of the earth (satellite images from the Landsat-8 satellite) using NDVI (Normalized Difference Vegetation Index) analysis [13]. As a result of the development of this section, it is assumed to calculate the coefficient of the natural potential of the territory involved in determining the integral indicator of the value of the ecological safety of the territory.

The second section is “Microclimatic conditions”. This section assumes the collection and synthesis of data characterizing the microclimate of the territory - wind rose, average monthly temperatures, average wind speeds, and the meteorological potential of the atmosphere.
The microclimate of the city is formed under the influence of local conditions and urban development. Assessment of microclimatic conditions is carried out in order to identify possible ways and means of maintaining and improving the quality of the environment surrounding the building (using favorable factors and neutralizing negative impacts). Among the microclimatic factors that are essential for the population, include aeration, insolation and the degree of natural self-purification of the atmosphere.

The degree of self-purification of the atmosphere is estimated by a number of climatic indicators, and the meteorological self-purification potential of the atmosphere is considered the most common which is determined by the ratio of factors contributing to the accumulation of pollutants in the atmosphere (calm, fog), with factors contributing to the dispersion of pollutants (precipitation and wind at a speed of more than 6 m/s). For residential development, the town planning code of the Russian Federation recommends selecting areas with a favorable meteorological potential for self-cleaning of the atmosphere when the frequency of atmospheric processes contributing to the dispersion of atmospheric impurities is greater than the frequency of processes leading to accumulation of atmospheric pollution.

The forecast of the formation of the microclimate under the influence of urban development of the territory is carried out on the basis of the established efficiency of the architectural and planning means of microclimate control. To do this, you need the following information: the layout of the road network; density and number of floors of the building; nature of landscaping and improvement.

Thus, microclimatic conditions have a direct impact, and also depend on the other two blocks (natural potential and socio-ecological conditions).

As a result of the development of this section, it is assumed to calculate the coefficient of comfort of the natural conditions involved in determining the integral indicator of the value of the environmental safety of a territory.

The third section is "Social and environmental conditions". In this section, databases are maintained both on the ecological conditions of the territory and on social factors that directly or indirectly affect the ecological situation of the urbanized territory.

The main environmental factor is atmospheric pollution with man-made pollutants (nitrogen dioxide, sulfur dioxide, dust, lead, formaldehyde, phenol, carbon monoxide). These indicators are the main factors affecting the incidence of the population and the amount of environmental risk. Based on these data, it is possible to identify and quantify risk levels, as well as plan measures for organizing environmental monitoring and risk reduction in ecologically unfavorable areas.

Social factors affecting the ecological situation of an urbanized area can be attributed to - the density of roads, the number of personal vehicles among the population, the quality of housing stock, the average monthly income of the population, etc.

In compiling the database, the following annually updated information on regional statistics (Voronezh Oblast, Lipetsk Oblast, Belgorod Oblast, Kursk Oblast, and Tambov Oblast) is used, which is obtained by generating official queries on the websites of federal statistics services:
- Regional statistics (Voronezh, Lipetsk, Belgorod, Kursk, Tambov regions);
- Main public health departments of the Voronezh Lipetsk, Belgorod, Kursk, Tambov regions;
- Territorial bodies of the Federal State Statistics Service in the Voronezh, Lipetsk, Belgorod, Kursk, Tambov regions;
- Federal State Healthcare Institution "Center for Hygiene and Epidemiology in the Voronezh Region";
- Voronezh Regional Information Fund of Socio-Hygienic Monitoring (monitoring is carried out on the basis of FGUZ Center for Hygiene and Epidemiology in the Voronezh Region);
- Office of the Federal Service for Supervision of Consumer Rights Protection and Human Welfare in the Voronezh, Lipetsk, Belgorod, Kursk, Tambov regions.

Annual reports on the sanitary-epidemiological situation in the Voronezh, Lipetsk, Belgorod, Kursk, and Tambov regions:
- Annual information reports (presented on the website of the Office of Rospotrebnadzor in the Voronezh, Lipetsk, Belgorod, Kursk, Tambov regions);
- Reports on the sanitary-epidemiological situation in the Voronezh, Lipetsk, Belgorod, Kursk, Tambov regions for 2000–2018.

All of the above data sources are available via the Internet.
As a result of the operation of this section, the values of environmental risk and social comfort coefficient are calculated. These indicators will be used in determining the integral indicator of the value of ecological safety of the territory.

The fourth section of the model "Environmental safety of the population". It assumes the development of an integral indicator showing environmental comfort for the population living in the area. The integral indicator assumes that all factors of the previous three blocks are taken into account. This indicator will allow differentiating both various urbanized territories of the Voronezh, Lipetsk, Belgorod, Kursk, and Tambov regions, as well as highlight zones with different levels of environmental safety within one city.

4. Conclusion

Thus, the developed geo-information resources providing monitoring studies of the socio-ecological conditions for the population contain 4 sections: “Natural potential”, “Microclimatic conditions”, “Social-ecological conditions”, “Ecological safety of the population”

Data analysis in the GIS environment will allow to create maps reflecting the socio-ecological situation in the region, indicating environmentally hazardous man-made objects, degraded and disturbed landscapes, manifestations of exogenous processes; information on the socio-economic situation in the territory of the studied region; results of the analysis of the medico-ecological situation in the urbanized territories of the Voronezh Region.

On the basis of such maps, it is planned to develop a set of environmental design measures that would increase the integral indicator of the environmental safety of the population in a specific urbanized territory of the Voronezh Region.

These activities may include optimization of ecological-functional zoning of urbanized areas, transport networks, fuel and industrial complexes, and natural frameworks of territories.

The developed set of measures seems possible to be included in the recommendations on the optimization of territorial planning and environmental policy of the region.

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