Geospatial analysis of the territory for solving urban planning problems

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Abstract. The purpose of the study is to conduct a geospatial analysis of the territory, taking into account urban planning characteristics, for the location of a shopping center. The study characterizes the factors that turn cities into diverse and complex forms of settlements that are constantly changing. The process of urban settlement, which is reflected in their space, is analyzed. It is determined that spatial factors lead to differences in the scale and shape of cities, types of development and methods of spatial planning. The necessity of studying the spatial structure of cities, which has the characteristics of a relatively complete theoretical justification and wide coverage, is established. It is determined that the process of spatial development of cities is multidimensional and complex, which is manifested in spatial planning, transformation of many functions and expansion of the territory. The direction of research on the spatial analysis of the selected city territory is determined. Various characteristics of the site are considered, including views, transport links, access and other constraints that may affect the future development of each approach to the shopping center. A spatial analysis of the shopping center location was conducted. This analysis determines the transport accessibility of the shopping center, the accessible distance to residential development, service areas, etc. It also determines which parts of the territory are suitable for a particular type of use. The results are obtained regarding the location of the shopping center in the city. The estimated number of regular visitors to the projected shopping center is determined, provided that the level of its attractiveness is the same as that of its competitors. The increase in the level of attractiveness of the projected shopping center in comparison with competitors is calculated. Based on the results of the geospatial analysis, the stages of design and survey work were developed to draw up a large-scale topographic basis for the development area.

1 Introduction

Different types of public facilities are needed in cities to achieve specific urban planning objectives. In this context, it is necessary to develop planning standards to help achieve
adequacy and quality of services and facilities. Population growth and the lack of shopping centers lead to an imbalance between the supply of public facilities and the demand of the population. Disparities in population density, density in central areas, and provisioning capacity create accessibility problems for the population and increase the time and money spent on moving urban populations from one place to another [1].

It is well known that urban planning strategy is one of the most important tasks for sustainable urban development and environmental comfort. Most urban problems, such as traffic, environmental pollution, socio-cultural and safety issues, can be reduced by choosing the best location for urban development objects. Creating convenient and accessible conditions for residents to access retail facilities is one of the main tasks that state and local governments should address. As a rule, it is believed that the closer the object (the desired object) is to the user, the better the service is provided. To solve the problem of locating administrative centers, various methods are used in combination with geographic information technologies (GIS).

Cities are areas where people, buildings, infrastructure, and human activities are concentrated. As forms of settlement, their formation has a long history and takes place under different political, economic and social conditions in a particular country or region. The factors that influence urban spatial organization are also the natural environment and construction technology [2, 4].

The above factors turn cities into diverse and complex forms of settlement that are constantly changing. The long and varied process of settlement is reflected in their spaces. These factors also lead to differences in the scale and shape of cities, types of development, and methods of spatial planning. Cities can be analyzed from many perspectives, taking into account the specifics of their appearance and function.

The study of the spatial structure of cities has signs of a relatively complete theoretical justification and wide coverage. This is due to the fact that the process of spatial development of cities is multidimensional and complex, which is manifested in spatial planning, transformation of many functions and expansion of the territory. Therefore, the problem of the spatial structure of cities is of interest to many scientific disciplines, such as geography, urban planning, sociology, demography and economics.

The concept of urban spatial structure is so important that its research is mainly focused on the following levels of analysis [3]:
- Urban form, including spatial planning, appearance and origin of cities;
- Population and spatial structure of cities, including the analysis of population density and distribution by demographic characteristics;
- The social spatial structure of the city refers to the distribution of social groups in the city and living conditions in certain areas of the city;
- Functional and spatial structure of the city, which involves the distribution of various functions in the city and the structure of urban land use.

It is recommended to use a Geographic Information System (GIS) to keep track of governmental objects. GIS is a fast-growing segment of the high-tech market and is used by most large companies, such as Google, Microsoft, NASA, Intergraph, Grass Development Team, ESRI (ArcGIS), Refractions Research, Autodesk, CalComp and others.

These systems can be used not only to store and display objects of government agencies, but also to solve many complex geographical and information tasks: measuring distances between objects, searching for and organizing objects in a given area, and building optimal routes. An example of a GIS that processes various objects in cities is the ArcGIS geographic information system, which has full functionality for processing geographic objects and the semantics of these urban infrastructure objects [5].

2 Method and Theory
Various site characteristics are considered, including views, transportation, access, and other constraints that may affect future development of the site [6]:
  - Location of the territory (description, visibility, structures, communications).
  - The setting and image of the area in the context of the development of the site, including the types and profile of residential, commercial real estate, and public development;
  - Transportation and pedestrian accessibility of the territory (present and future) - in particular, opportunities for changes in transportation routes, parking location, etc..
  - Anticipated uses of the area.
  - Buildings that surround the shopping center.
  - Analysis of existing development, identifying alternative uses.
  - Analysis of known constraints affecting new development in the area (legal, physical, and technical) and overcoming them to maximize the amount of construction on the Site.
  - Plans and vision of the city authorities regarding the future development of the neighborhood. Analysis of permitted uses in accordance with land use regulations.
  - Procedure for demolition and development of the territory.
  - Soil conditions and other technical features of the area.
  - Infrastructure and peculiarities of communications.

Based on the results of the review it is accepted to conduct a spatial analysis regarding the key characteristics of the territory, as well as the factors that may affect the overall concept of development of the territory. Also, as a result of the analysis of all the limitations of the territory, it is necessary to designate a zone for the construction of the shopping center and take into account the following features:
  - Manufacturing needs.
  - Key Zones. In these zones it is necessary to designate zones that can be considered for new construction of offices, retail premises, housing, technopark, other demanded and expedient types of real estate (conference hall, data center, exhibition hall, etc.) taking into account the existing restrictions of the territory (existing sanitary zones and other restrictions from existing surrounding buildings and structures).
    Also to identify buildings in satisfactory condition in the designated area that are suitable for alternative use with minimal investment.

The purpose of this spatial analysis is to determine the potential for possible future uses of the area, including non-standard uses.

The functional uses considered are [7]:
  - Residential of various classes.
  - Administrative and public use - Offices.
  - Public and recreational use: Retail (associated trade, various standard and non-standard formats, entertainment).
  - Warehouse/industrial real estate.
  - Shopping Center.
  - Other (conference hall, data center, exhibition hall, etc.).

For each of the use options, a decision has been made to identify spatial characteristics regarding the need for and appropriateness of this use of the area. The assessment of strengths and weaknesses is considered in the following criteria [8]:
  - Technical characteristics of the territory, including a comparison of the possibilities for reconstruction of the building in a particular functional use and new construction.
  - Geographical characteristics and features of the territory.
  - Characteristics of accessibility of the territory for transportation and pedestrians.
  - Demand from potential users in light of recent market trends and RF aggression.
  - Prospects for development of the territory in the context of the development of these segments from the point of view of the market and the master plan of the territory.
  - Competitive environment.
Requirements for infrastructure and communications.
Possibility to use existing buildings for them with some degree of reconstruction.

After the analysis, the most spatially attractive uses of the territory are identified for further, more detailed consideration. It is also determined which parts of the territory are suitable for one or another type of use.

3 Results

The Master Plan of the territory and the scheme of the optimal existing concept of the study area were taken as input data for the spatial analysis of the territory use. The scheme identifies the following facilities: IT cluster; Offices; existing development; shopping center; medical center; existing production site; technology park.

An additional parking lot and exhibition hall are proposed. According to the existing results of the concept and the proposed data, modeling of the development objects was performed (Fig. 1).

The next stage of the spatial analysis of the territory use was to determine the feasibility of placing development objects on the example of a shopping center. The analysis was carried out on the subject of demand for this territory by the city residents, taking into account transport accessibility and the presence of competitors. The initial scheme for the analysis is presented in Fig. 2.

![Fig. 1. Modeling scheme of development objects](image-url)
The following layers of attribute data of Kharkov city were used to perform the analysis:
- buildings (Fig. 3);
- highways;
- railroads and access roads (Fig. 4).
The overall view with the necessary information for spatial analysis is shown in Fig. 5.

The first step in performing the spatial analysis was to calculate the number of potential visitors to the planned shopping center in the area, taking into account the zoning of the city (Fig. 6 a) and determining the density of residents for each zone (Fig. 6 b, c).
Fig. 6. Modeling of potential visitors of the shopping center on the territory of its location: a) zoning scheme of the territory; b) territory of the shopping center location; c) determining the density of residents for each zone.

After that, the calculation of existing shopping and entertainment infrastructure objects was performed (Fig. 7), as well as the calculation of the number of potential visitors of the planned shopping center by demand points from the attribute data of the initial information (Fig. 8).

Fig. 7. Location of existing retail and entertainment infrastructure facilities
Fig. 8. Calculation of the number of potential visitors to the planned shopping center on the territory of the district by demand points

Predictive characteristics of shopping center functioning in the district were calculated in 2 stages, which determined the potential number of visitors at equal competition (Fig. 9), as well as the predicted number of visitors when the competitiveness of the shopping center increases 2 times, taking into account the demand points (Fig. 10).

Fig. 9. Forecast characteristics of the shopping center functioning in the district (attractiveness level - 1)
Fig. 10. Forecast characteristics of the shopping center functioning in the district (attractiveness level - 2)

Based on the results of the analysis, conclusions and suggestions are obtained:

1. Placement of the shopping center on the territory of the district is such that by its spatial relationship with other elements of infrastructure of the city is able to serve citizens with the time of approach to the planned shopping center 40 minutes and less.

2. The projected number of regular visitors to the planned shopping center is 10945 people, assuming the same level of its attractiveness compared to competitors.

3. Increasing the level of attractiveness of the planned shopping center twice relative to competitors will increase the number of regular customers to 18502 people.

Based on the results of the geospatial analysis, the stages of design and survey works for the preparation of a topographic base M 1:500 of the development area were developed.

The first stage of design and survey works for the topographic base M 1:500 of the future construction territory is the development and coordination of the technical task between the customer and the contractor, which specifies the stages and terms of work execution.

On the basis of work stages the estimated cost of works is developed and agreed upon. After the cost of works is agreed upon, the contractor collects and updates the existing topographic information on the survey object, submits a request to the Department of Architecture for obtaining the original plans for making changes and further coordination of design materials (the original of the terms of reference may be requested).

The second stage - execution of field works. It includes reconnaissance of existing geodetic points of triangulation and height base, determination of coordinate system. Fixing of additional points of satellite geodetic network (GGS) and preliminary drawing of outlets and markers of utilities on the outline. The collected information is processed and applied to the glued topo-foundation of the Department of Architecture.

After that, theodolite moves are built on the territory of the survey object, leveling of fixed points of tacheometry, processing and calculation of accuracy of the moves. Then the tacheometric survey with fixation of standard for the plan M 1:500 objects, as well as verification, determination of coordinates, direction and other parameters of engineering communications is carried out.

The third stage is desk work. It includes processing of geodetic measurement data, systematization, division into layers for approvals and construction of topographic plan M 1:500. At the same time points of GHS conversion into local coordinate system (or any other) are created for further application of the plan in the course of territory redevelopment.
The fourth stage - coordination of the topographic base with district and city services that operate underground communications of the territory with the following services: water supply, sewerage, gas, power supply, communications, railroads, radio networks, roads, etc.

4 Conclusions

The study characterizes the factors that turn cities into diverse and complex forms of settlement that are constantly changing. The long and diverse process of settlement is reflected in their spaces. These factors also lead to differences in the scale and shape of cities, types of development, and methods of spatial planning. The need for a study of the spatial structure of cities, which has the characteristics of a relatively complete theoretical justification and wide coverage, has been established. The process of spatial development of cities is multidimensional and complex, which is manifested in spatial planning, transformation of many functions and expansion of the territory. Therefore, the direction of research on spatial analysis of the selected city territory was determined.

Considered various site characteristics, including views, transportation, access and other constraints that may affect the future development of each shopping center approach. A spatial analysis of the shopping center location is performed. This analysis identifies the transportation accessibility of the shopping center, accessible distances to residential development, service areas, etc. It is also determined which parts of the territory are suitable for one or another type of use.

The results obtained show that the location of the shopping center on the territory is such that by its spatial relationship with other elements of the city's infrastructure is able to serve citizens with an approach time to the planned shopping center of 40 minutes or less.

The projected number of regular visitors to the planned shopping center is 10945 people, provided the same level of its attractiveness compared to competitors.

Increasing the level of attractiveness of the planned shopping center twice relative to its competitors will increase the number of regular shoppers to 18502 people.

Based on the results of the geospatial analysis, the stages of design and survey work were developed to compile a topographic base M 1:500 of the development area.

References