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*Запропоновано концепцію і розроблено альфа-версію геоінформаційної системи для виявлення і розв'язання урбаністичних проблем. Вона пропонується як допоміжний інструмент для управління розвитком пострадянських міст Східної Європи. Від аналогічних систем її відрізняє орієнтація на виявлення проблем і встановлення протиріч на території міста. Описано її структуру, перелік функцій та інформаційне наповнення. В результаті її випробувань на тестових ділянках визначені зони з характерними урбаністичними процесами: джентрифікацією, комерціалізацією і ревіталізацією території міста. Ці дані наведено у картографічній формі*

*Ключові слова: геоінформаційна система, урбаністика, розумне місто, просторова трансформація, міський простір, джентрифікація, комерціалізація, ревіталізація, карта*

*Предложена концепция и разработана альфа-версия геоинформационной системы для выявления и решения урбанистических проблем. Она предлагается как вспомогательный инструмент для управления развитием постсоветских городов Восточной Европы. От аналогичных систем она отличается ориентацией на выявление проблем и определение противоречий на территории города. Описана ее структура, набор функций и информационное наполнение. В результате ее испытаний на тестовых участках определены зоны с характерными урбанистическими процессами: джентрификацией, коммерциализацией и ревитализацией территории города. Эти данные представлено в картографической форме*

*Ключевые слова: геоинформационная система, урбаністика, умный город, пространственная трансформация, городское пространство, джентрификация, коммерциализация, ревитализация, карта*

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# DEVELOPMENT AND USE OF A GEOINFORMATION SYSTEM FOR REVEALING URBAN PROBLEMS

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## 1. Introduction

Transformations in areas of human life activity are a subject matter of Social and Economic Geography studies [1]. These

changes help determine the human impact on the environment and identify problems involved and caused by this impact [2].

Research is more detailed if it deals with a variety (rather than intensity) of factor impact on a territory,

respective transformation, and feedback, which entails an impact of a changed area on the living conditions of the population. Thus, it is interesting to consider changes in an already transformed territory under the influence of the new socioeconomic living conditions for the population [3]. The latter is viewed as an intermediate agent of such transformations. Accordingly, it may be of scientific, commercial and social value to determine the transformation essence and regulation methods to improve the living conditions of the population and to devise proposals for relevant authorities. One way of implementing such research findings is to develop a geographic information system (GIS) through which spatial transformations can be assessed by various criteria. By combining the collected data, including geospatial information, software features, tools, and techniques, it is possible to devise a GIS that can be called, for example, "A Smart City".

**2. Literature review and problem statement**

Studies on using a GIS are distributed across a number of disciplines relatively evenly: these programs are used in many fields of human activity [4]. Most papers relating to geography, such as [5], set out the possibilities of digital technology in processing and presenting spatial information on natural and social phenomena. This topic is quite popular in Ukraine [6-9].

Studies that are devoted to researching urban space transformations by using GIS technology can be classified in terms of theoretical generalization. The first level entails solving applied problems [10], whereas the second level suggests doing research to develop new knowledge: studying changes in urban contours and space [3, 11, 12] and their interactions with the geographic shell [13]. The applied nature of certain studies limits the use of the authors' experience whenever it concerns other areas and different initial conditions. This can be observed in [14], which examines the complexity of public involvement in a pilot project that was implemented for a small town in the U.S.A. Another study [15] is even more localized. It substantiates the relevance of choosing the city of Milwaukee (U.S.A.) to evaluate the effectiveness of using a GIS by community organizations in administering the city.

It is noteworthy that there are new ways of viewing, understanding, planning and designing an urban area (at the third level of generalization). This is because they cover the epistemology and theory of urban mapping [16]. In [17], there is an attempt to rethink the urban core concept of a "region" in terms of spatial epistemology. The studies that are excessively theorized also make it difficult to adapt the results to solve the complex problem of managing urban development by using GIS technology.

Gaps in research on transformations of urban space by using a GIS are identified by visual and statistical methods.

Phrases that characterize a particular line of research were used to form queries to the scientometric database Scopus. Fig. 1 shows the inverse dependence of the font size of the phrases on the number of publications on the respective subject matter (the number is specified in the brackets).

Urban processes in an urban environment have appeared to be a narrow-focus topic, which is explored by the authors of [18–19]. However, the GIS in the studies of these processes is used by a very limited number (10–20) of researchers, who are cited, in particular, in [20–22]. Thus, the devised GIS is intended to be included into analyzing urban processes.

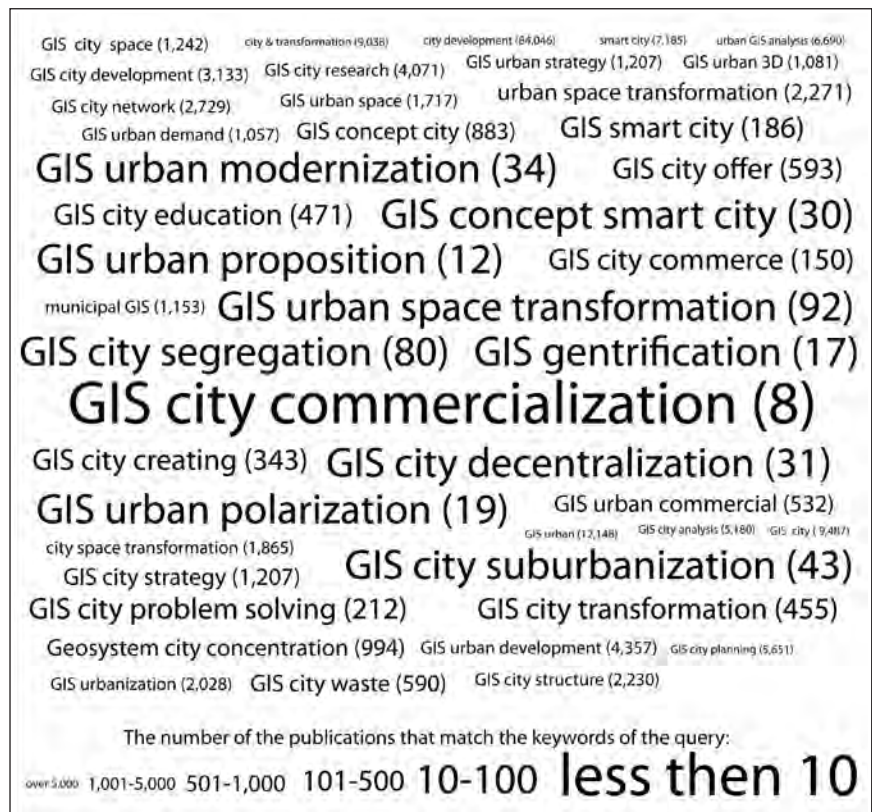


Fig. 1. Identification of gaps in research

In addition to the specified research gap, the analysis of previous studies has found that all of them focused on the development or use of a GIS for a specific purpose. It remains essential to create a geosystem that would be designed to identify problems so that the collected data could be used to reveal (primarily) a problem and to apply the GIS itself to devising a proposal for its solving. Such studies are few [23, 24].

For example, the purpose of urban objects changes due to the population efforts to adapt the environment to the people's needs. Thus, the problem is the disparity between the urban space and the population needs. The latter can be determined by analyzing spatial transformations by using a GIS. For example, a large number of public service facilities in residential buildings reflect not only gaps in the service infrastructure of the industrial city but also point to the need to have one's own business. Individual entrepreneurship is just a complex form of earning income. Accordingly, vast abundance of small businesses can mean lack of jobs and salary shortage to comply with the expectations and qualifications of the population. Centrally created conditions for businesses can improve the living standard and the

employment balance of the population. This concerns creating a tool for determining the functional direction of the local administration.

Research on spatial transformations was the initial phase of developing the GIS. This topic is fairly well explored by scientists from industrialized countries [25, 26]. The studies predominantly consider the placement of communications, parking lots, transportation management, and the like. All research is applied. Theoretical studies that could be useful are practically absent.

**3. The purpose and objectives of the study**

The purpose of this study is to develop an alpha version of a geographic information system that would differ from the existing analogue by the focus on problem searching rather than problem solving.

To achieve this purpose, it is necessary to do the following tasks:

- to identify the target audience, its needs, and the commercialization way as well as to model work with this product;
- to develop the overall structure of the GIS to implement its functions and information content, as well as to determine to form of presenting the work results and their characteristics;
- to supply the GIS with test data and to test the system.

**4. Methods and software to use in the study**

The target users, the GIS structure and the presentation of the results were established on the basis of studying related previous publications [7–9, 14, 17], surveying the target audience, considering similar products, questioning the population of the test areas in diverse cities, and using the method of a “black box”. The questionnaires made it possible to assess the perception of certain categories of the local population of the spatial transformations and the respondents’ willingness to contribute to the urban regulation. The survey was carried out at more than 40 sites of 12 test cities; the results were collected on the basis of 772 questionnaire responses. The survey revealed that the questionnaire limited the respondents’ ideas. Moreover, most of them could not exactly articulate the requirements for their environment without relying on their own experience (Fig. 2).

In addition, it became clear that it is inappropriate to modernize a territory without considering the needs of the population that lives on it. Such type of data cannot be obtained from the questionnaire responses on education since the level of the latter does not characterize the business competence of the population. Thus, there is a risk of a wrong approach even in the stage of designing the GIS: some investment may remain unjustified if it is made into some kind of a communication system that may prove to be unnecessary.

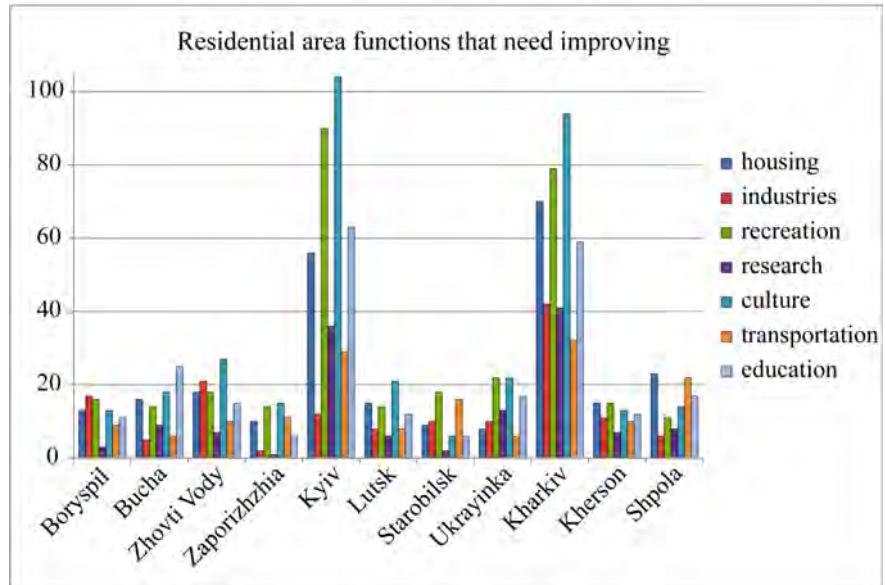


Fig. 2. Results of surveying the local population. The vertical axis represents the number of the respondents who believe that a specific function of their district (city) is underdeveloped

Therefore, a decision was made that the GIS developers and users themselves should be responsible for the formulation of requirements for the environment. To get an idea of these categories (the population needs and the possibilities of using the relevant territory), it is necessary to supplement and analyze the data collected during the survey. Such work can be done only indirectly, by comparing the results of the survey and the environmental transformation.

The method of the “black box” was used to develop the GIS concept that would produce easily understood results and have a user friendly interface. This required establishing a set of competences of the potential users. The latter were offered to formulate the concept of a tool for solving problems of urban planning. The resulting information was compared with knowledge of the GIS developers. This made it possible to determine the requirements for the methods of processing data and presenting results.

The system of symbols for the GIS maps was based on the traditional approach because the classical form allowed focusing on the work results.

To develop the GIS “from scratch”, the research sector did not provide enough resources. So the typical approach to small working groups was used to take a basic platform (or an instrumental GIS) and to complete it for the desired result. The open QGIS system was used as a basic software platform for the development of the GIS. The modules and scripts for the basic version of the QGIS environment were written in Python. Some plug-ins of the public domain were downloaded from the Internet. Those plug-ins included, in particular, Form Value Relation, which is used to monitor completeness of spatial data collection, and Ru-Geocode. The latter was applied to establish the geographic coordinates of urban space objects that had only the mailing address. The QGIS was also downloaded to a tablet to collect data on spatial transformations. The questionnaires were processed and some graphics were developed in a spreadsheet LibreOffice. The graphics were processed in the raster editor GIMP.

### 5. Presentation of research results

At the initial stage, it was found that the need for a specific geographic information system depended on economic growth. For Ukraine, such a GIS may be costly and unjustified in terms of the effort spent. In addition, according to the authors, the essence of the concept of a “smart city” does not consist in the number and novelty of communication devices and technologies, but it is a relative factor. The main thing is their rational placement. The factual material for developing the theory can be collected on the basis of stochastic transformations of urban space, which are, actually, disordered population attempts to transform the residential environment. Their theoretical justification can stimulate urban development with a minimum amount of investment, only by arranging the transformations through legislative and policy instruments.

It was at once established that the requirements for such a GIS could be divided into technical and communicational. The technical requirements included standard functions of the GIS, the ability to be downloaded to different computing platforms, and flexibility (the ability to use the same program for input, processing and visualization of data).

The developed system belongs to specialized GISs that are designed to solve a specific range of tasks and aimed at a certain category of users. This involves determining the

exact list of data and the functions of their processing. The suggested GIS can serve as an information platform, designed for input, storage, verification and systematization of geodata on the presence, type, status and functions of urban space objects. The sources of completing it are the following: statistical and geospatial information, field research results, and desktop data collection.

The statistical data that were integrated into the GIS were used to facilitate the application of the GIS, the processing of graphics, and the performance of standard calculations. These data characterized the demographic and functional transformations of 458 cities of Ukraine and included freely accessed information and purchased data for the period from 2002 to 2014 (Fig. 3).

Some of the statistical information that was required for a successful use of the GIS was missing among the available sources, but it was calculated on the basis of data of national and regional centers of statistics. These so-called “original data” included absolute and chain increases of the population, the list of the cities by their type, etc. Statistical indices were supplemented by information that had been obtained through applying cartometry operations to spatial objects. The result produced a mutual consistency of the collected spatial, attributive and statistical data.

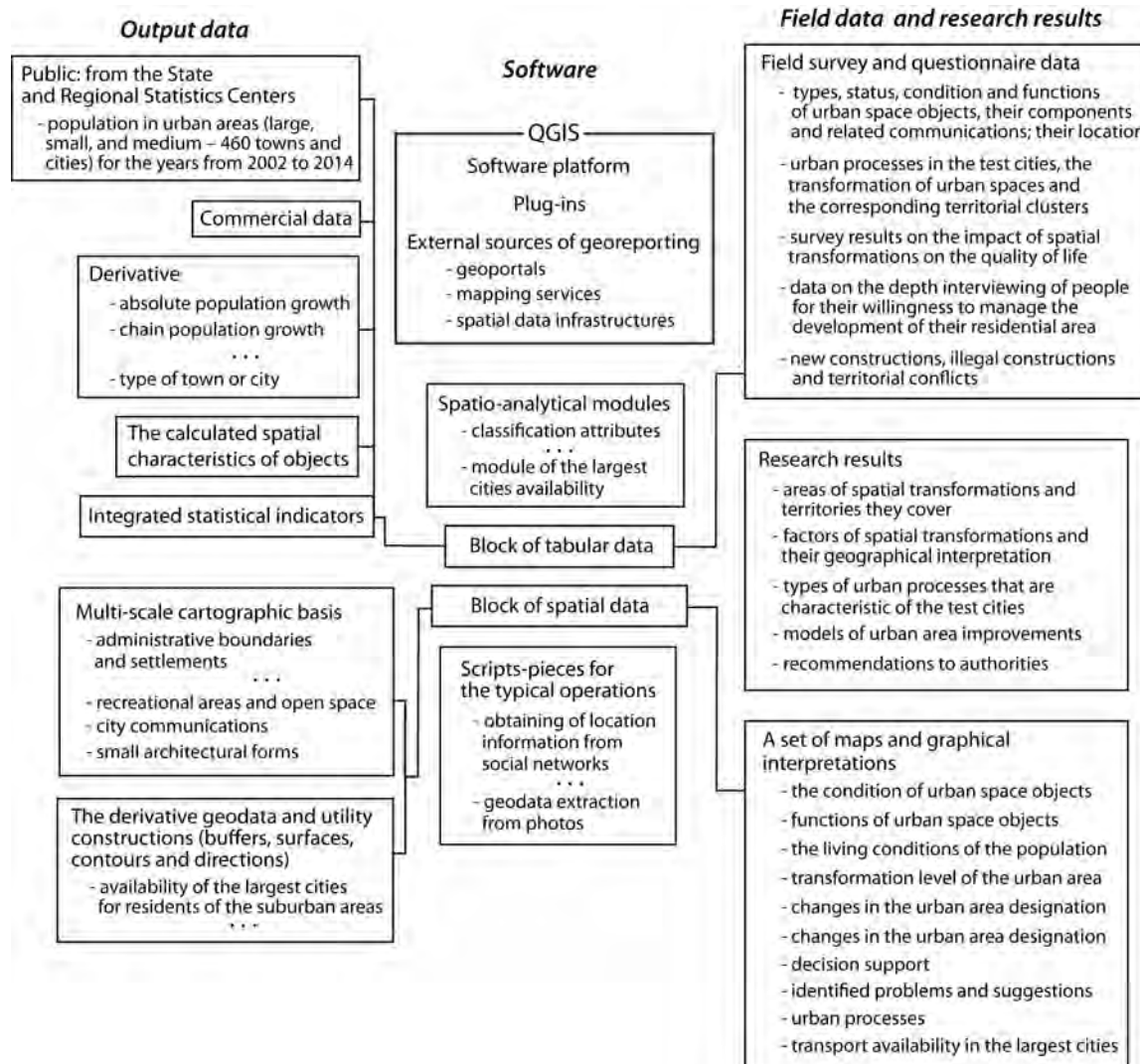


Fig. 3. The overall structure of the GIS to study spatial transformations

The transformations in urban areas were studied on the basis of data collection in 12 test cities (Kyiv, Kharkiv, Lutsk, Zaporizhzhia, Vinnytsia, Kherson, Boryspil Bucha, Shpola, Ukrayinka, Zhovti Vody, and Starobilsk). The test areas ranged from 0.4 sq. km to 7 sq. km. The study took into account the general condition of buildings and structures as well as the condition of their facade, communications, and yard arrangements. The characteristics of the general condition of facilities and communications were supplemented with their level of modernization: the ranking was based on two logical planes – the condition and level of modernization. It allowed developing a compact and capacitive classification. For example, communication systems were subdivided into 6 classes: elite and innovative, new or upgraded, partially upgraded, in need of modernization, and dilapidated. A similar classification was used for housing and public utilities. The data were meant to determine changes in the functions of urban space objects and to establish the principle of outlining transformation zones in the test cities. Additionally, the information was intended to reflect urban processes on the maps for the GIS. For reference, these processes were gentrification, commercialization, segregation, industrialization and deindustrialization, urbanization, suburbanization, counter-urbanization, polarization and revitalization of urban space [18–20].

The GIS creation entails compliance with already established approaches to software development and geodata storage: non-duplication, independence and transferability to different hardware and software platforms.

Non-duplication entails reference to external sources of data. This provision is not limited to hyperlinks to websites but is fundamental in terms of giving the possibility to upload and download the necessary information or the method of processing thereof. Examples are services for the transmission of map images and data, such as the Web Map Service (WMS) and the Web Feature Service (WFS). These functions are already implemented in the QGIS and will be supplemented by references to geoportals where information complements and facilitates reading the content of cartographic interpretations that will be included in the GIS package and will be created by GIS users.

For off-line operation, the GIS will include a multi-scale cartographic platform that was developed to implement previous research on the topic by the research sector. By its maximum detail and content, it will correspond to the political and administrative map of Ukraine with the scale of 1 to 2,500,000. The test areas were additionally marked for the respective buildings, facilities, and infrastructures.

As the developed GIS is designed for users who may have no cartographic education, the spatial data tables within the GIS contain information that displays the geometrics and the relative locations of these objects. For example, all small towns and medium-size cities are supplied with data on the availability of the nearest centers of gravity (10 largest regional centers) in terms of time and value. This greatly facilitates the use of the geosystem.

The creation of the geographic information system entailed taking into account modern approaches to storing and processing location data, including the methods adopted for spatial data of infrastructures [27, 28]. These approaches include topological accuracy and lack of duplication, but the requirements for the GIS are not limited to them. The methods are those of storing, sharing, processing and visualizing data. For example, the condition and functions of

urban space objects are entered by using the QGIS module, which is called the Form Value Relation. It uses a symmetric encryption algorithm for the collected data and prevents their batch entry or import.

Potential problems of urban areas are identified by means of the GIS functions that are logically divided into system (utilitarian), analytical, and spatial (graphic). The first ones can include typical functions of the GIS as a computer program: input, storage, and the like. Analysis entails processing information by using available mathematical and statistical methods as well as attribute queries. The graphic features include creation of auxiliary constructions (such as buffers), implementation of spatial queries, layer blending, and transition between the forms of data presentation: text, spreadsheet, mapping, and scientific graphics. They may also include making finished graphic products – maps and charts as well as cartographic operations with them. The latter may be highly effective for the establishment of common assumptions for problems that, at first glance, have a different nature and origin. On the other hand, technical support of decision making and justification thereof are implemented by using a combination of graphical and analytical program functions (requests and visualization of selected information, extrapolation, modeling, etc.).

The authors have developed a module for obtaining geographical coordinates from photos taken by users and published in social networks. This module makes it possible to determine the places in cities that attract the most intense attention of tourists.

A module with a similar purpose allows users to determine the location of those users who publish such data in certain groups. Usually, these groups are thematic and integrated into local communities, local government, as well as administrations of cities and districts.

The clustering module is designed to detect the dominant features of certain parts of urban space. These areas can be compared with a modern city master plan and identify inconsistencies in the functional mission of the area. This module is also used to highlight urban areas that have some similarities as to the condition of objects. For example, an area of gentrification was discovered in the city of Bucha.

Undoubtedly, the main factors in detecting problems are analytical skills of the users and interpretation of the obtained information.

The geographic information system also includes the results of studies as the starting material for the detection of problems in urban development. These are the results of the field surveys, questionnaires, urban studies, map sets, and graphic interpretations of the work done.

The fieldwork of the studies provided data collection on the following:

- the type, condition, functions and location of urban space objects, their components, and related communication systems (Fig. 4);
- regional clusters, involved into specific urban processes and urban transformations;
- the impact of spatial transformations on the quality of life, revealed through questionnaires;
- the willingness to manage the development of the residential area, discovered by a profound interviewing of people;
- new constructions, illegal buildings, and territorial conflicts.

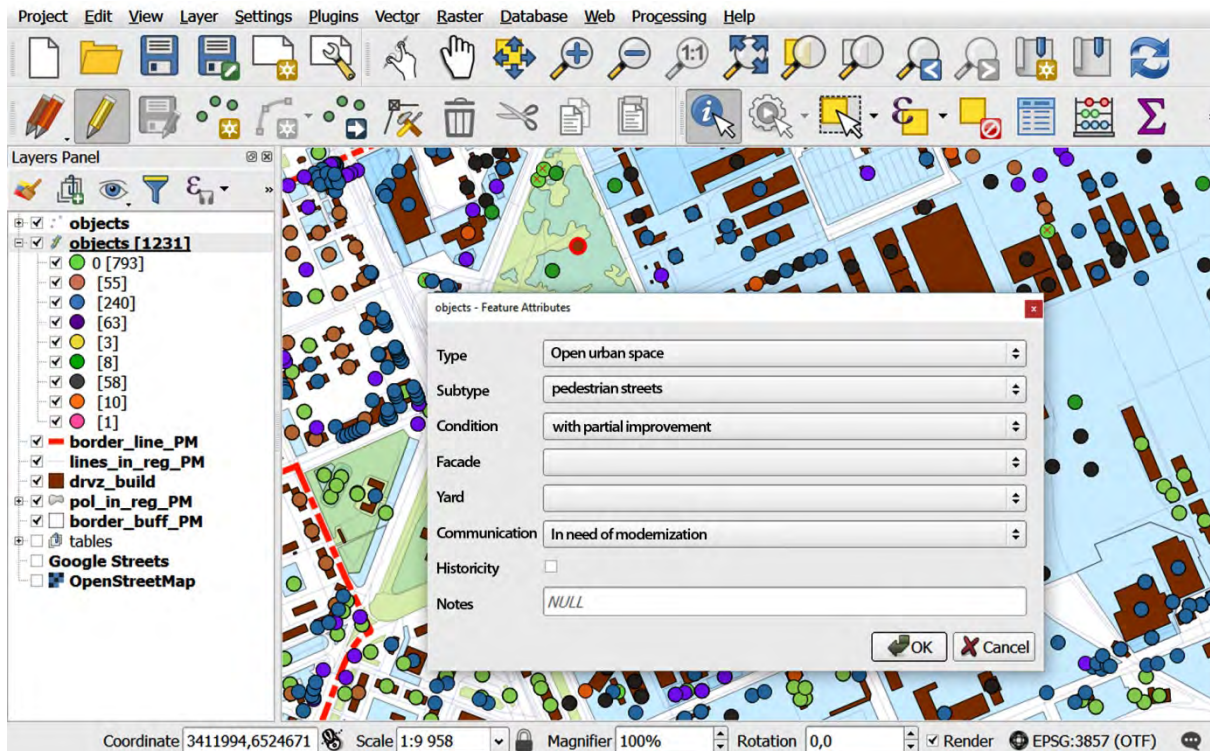


Fig. 4. A snapshot from the screen of the developed geographic information system in the data collection mode. In the center, there is a form to enter information

The GIS structure also includes graphic interpretation of research results on urban processes, namely:

- types of spatial transformations and territories covered by them;
- factors of spatial transformations and their geographical interpretation;
- types of urban processes, characteristic of the test cities;
- models of upgrading urban areas and recommendations to the authorities.

The geosystem is supplemented with maps and charts developed on the following:

- the condition and functions of urban space objects;
- the living conditions of the population;
- the level of transformations in an urban area;
- changes in the function and purpose of an urban area;
- identified problems and proposals;
- urban processes;
- transport accessibility in the biggest cities.

The concept of such a GIS involves not only technical but also “human implementation”, i. e., the communication aspect. This product is aimed at being used by local authorities, local communities, as well as research and research-industrial institutions involved in the development of urban areas. Since the target audience is not cartographically educated, it is taken into account in the rules of obtaining work results. Otherwise, the user can produce “a cartographic chimera” [29].

The designing of the software requires the use of both the theory of knowledge and theory of cartography. That is, in this case, the mapping of urban space should be described in terms of the theory of knowledge (epistemology and ontology [16]) with a focus on urban morphology, differences and overlap between perception and cartographic reflection, as well as logic of spatial relations. The mapping rules imple-

mentation is reduced to sets of ready-made symbols, methods of cartographic representation [30], and some completely prepared thematic maps with legends.

It has to be not only a tool for decision making or, more likely, a means to find something new but mainly for extending and supplementing the mental abilities of a specialist who will work with it. That is why the GIS must be the initial link in the research process, rather than just a tool to visualize the results. It is assumed that the maps’ developer and user can be one and the same person.

The implementation of this GIS is only partially associated with an intuitively understood interface. More attention should be given to obtaining an “intuitive result.” This will be implemented through the following points:

1. A change in presenting information, which is one of the standard GIS functions due to which such programs have become popular. It concerns a shift from text and tabular presentation to graphics – geopictures and scientific graphics. The first includes schematic maps, three-dimensional models and animation maps, whereas the second comprises charts and graphs. This helps detect visually any contradiction in an urban area.

2. Selection of the correct mapping indicators that best convey the purpose of the study. It is not the same as a change in the form of presenting information. Preference is supposed to be given to complex and synthetic maps rather than to series of analytical maps that reflect collected data. Complex maps can be used to identify relations between indicators of similar topics. Synthetic maps can show the effects of interpreting already collected data. In this case, it is necessary to shift from data on the purpose and condition of urban space objects to other categories – for example, to reflect the research object function or its change. Furthermore, it will be possible to identify a change in the purpose of larger units such as city areas, urban processes, and potential

problems. Accordingly, special functions are necessary to define these indicators from already collected data.

3. Selection of intuitive ways and means of presenting images. The means of cartography must be chosen according to the nature of a cartographically registered phenomenon. For example, differences in quantitative values should be reflected as changes in the quantitative characteristics of the expressive means, for example, color saturation, line thickness, etc. Quality indicators are reflected through changes in the color shade or designation form.

Stylization of icon shapes can further increase prominence. The degree of stylization differs for maps of various scales: it is more realistic for a larger scale, whereas simple geometric shapes are used for a small scale.

Color is selected on an associative basis, taking into account traditional approaches. This can be illustrated by light green being used to display objects with a recreational function. Red has traditionally been used to denote industrial sites (Fig. 5).

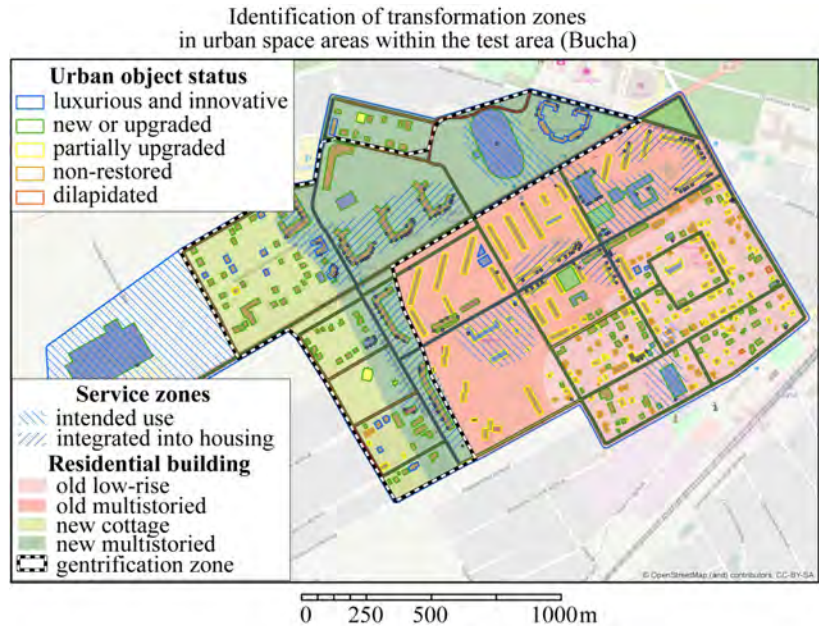


Fig. 6. Results of studying urbanization processes within the test area in the city of Bucha. The functions of the sites are listed in Fig. 5. The highlighted zone denotes gentrification

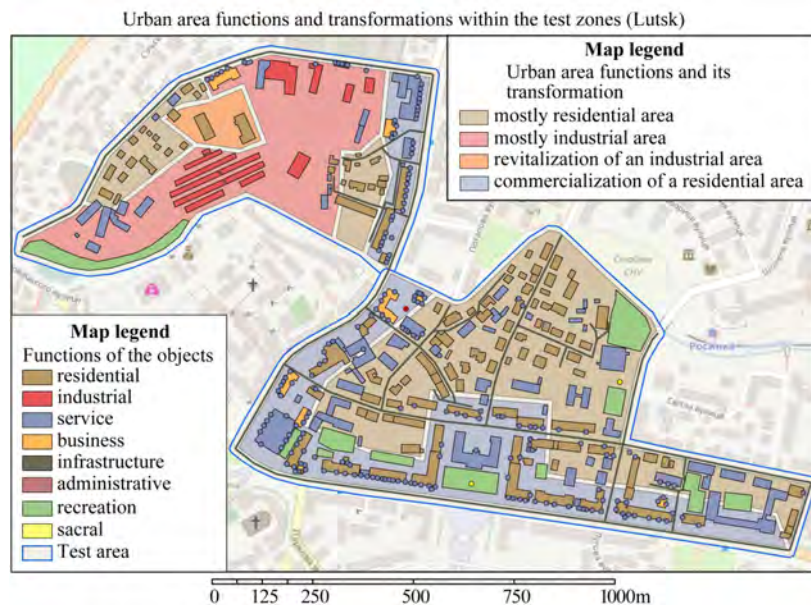


Fig. 5. A map on the GIS operation results. The planar and linear symbols are used to denote objects of the primary function, whereas the dotted notation is used to denote the additional feature shown along the main ones

4. Maximization of the map consistency by using the most informative symbols and integrated means and methods of image reflection. For example, it is necessary to use icons with more graphic variables: the color, thickness and style of the outline, as well as the filling color and the designation shape. The two indicators of mapping distributed over an area are color and shading (Fig. 6). The structure of the latter may denote the nature of a described phenomenon.

5. Consideration of analytical skills of potential users, who prefer to select one option from the already made suggestions.

6. Consideration of cartographic principles in determining the mapping indicators and tools to provide true GIS mapping results in terms of the theory of cartography.

7. The key objective in developing the GIS is efficiency of operating it. Today, there are two approaches for designing software packages on this basis. The first is the adaptation of existing instruments, whereas the second is the creation of a GIS “designed” for a certain problem. However, as mentioned above, the task is outlined vaguely. Therefore, the GIS should be based on a different principle. It is assumed that the system will work not simply to accumulate data and to apply methods of processing them but to provide a specific storage format – not a format of files or software modules but a certain internal structure. The latter should, if possible, be similar to the typical structure of applied human competencies (e. g., the ability to work in a graphics editor or a GIS).

In fact, the capacity of the latter in a given subject area is not a simple accumulation of techniques and data. For example, to use the graphic editor Adobe Illustrator, it is not enough to have studied only the functions and features of the software. The ultimate goal is to learn to recognize and solve problems while using the software. This competence entails connection with other abilities (creative, analytical, and commercial), subject areas, and background experience. The structure and the number of these connections have more influence on the effectiveness of doing tasks than the number of the methods used to develop or process graphics. From all this it follows that a GIS of a new generation can be developed on the basis of determining the structure and competences of the human person and then implementing them in this program. It should be noted that the implementation of this principle requires further detailed studies like [31].

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## 6. Discussion of research results

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Today, problem-oriented software versions are quite numerous, and their market price is gradually decreasing due to competition. It is technically easy, by applying scientific methods and practical tools consistently, to develop a methodology and software or hardware means by which it is possible to solve a given problem with a certain degree of efficiency. Less developed is the scope of identifying, formulating and shaping the needs of urban area residents and administration. The research has revealed that engineering knowledge alone is not enough. Programming skills and knowledge of the subject area in which this GIS is implemented are only the needed basis. To solve this kind of problems, it is necessary to use creativity, non-conventional vision, and analytical competence.

According to the terminology adopted in business, it is called discovery and formation of a market (a new market, rather than the existing market redistribution). That is, a new value is formed for a certain potential consumer, rather than improvements of an existing product are made to solve an existing problem.

This area is more risky because it is unknown whether the proposed solution will be in demand at all, whereas the competitive environment has already been formed and the demand for this type of solution certainly exists. Creating a successful or unsuccessful product obviously depends on the needs of the user.

It was decided to attract potential users (not the population but the administration) by implementing their requirements. The idea to create such a GIS arose from the question asked by a significant number of managers and businessmen: "What can you offer to my company?" The population survey that was made during the year of 2016 in the framework of doing the state-funded research topic "16BP050-02" revealed rather conflicting results. On the one hand, it showed a very low number of people interested in using this GIS. However, among the target audience, the percentage of those interested was much higher. Meanwhile, it was found that such a GIS would produce profit not only from using the program in the on-campus laboratory but also from its sale and installation for the customer.

The state-funded topic "Spatial transformations in Ukraine: models of modernizing and planning urban areas" (16BP050-02) is performed by the research sector "Regional economic issues and policies" at the Taras Shevchenko National University of Kyiv for the Ministry of Education and Science of Ukraine [32, 33]. The first tests by using the developed GIS in cities have made it possible to identify such transformations:

- replacement of an industrial zone with a residential area (revitalization) due to the dilapidation and demolition of industrial enterprises;
- relocation of enterprises from central to peripheral districts, which affects their transport accessibility;
- transference of agricultural land to the residential fund for urban development, which means reducing the value of suburban food-supply systems (urbanization);
- illegal urban construction and extension of the housing area by means of additional buildings;
- spread of numerous objects of small business in the residential part of a city (commercialization, Fig. 5);
- reconstruction and multistoried development in the private sector of a city, with more affluent residents moving to this urban area (gentrification, Fig. 6).

These transformations are caused by problems that are typical of the whole country:

- a sharp decrease in the value of local production due to lack of regulatory mechanisms and the infrastructure for selling the products. A suggestion may be to create conditions for public procurement at the local level at the scale of small producers (within decentralization);
- a lack of balance between the structure of employment and production. The two concepts are interrelated, and they become obvious in the growing role of services in conjunction with a decrease in the average workload of businesses. This leads to a reduction and concealment of population incomes, and in the future it is likely to reduce the purchasing power. A proposal can be made on the basis of using the developed GIS. It is necessary to increase the minimum wages to encourage small-scale and retail sales of industrial goods and local products. This proposal is implemented by creating a national platform for promoting and trading, with a system of guaranteeing purchases and refunds.

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## 7. Conclusions

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1. It has been determined that the market demand for geographic information systems concerns a GIS to identify urban problems. The target audience of GIS users is government bodies as well as municipal communities and administrations. The developed GIS is designed for installing onto the customer computer and for using by the developer to perform research.

2. It has been found that the most valuable factors for developing the GIS are competence of potential users and applicability in different environments (in field data collection, "off-line", and "on-line").

Urban problems are identified and reflected by using techniques that are based on changing the form of presenting data and the methods of spatial analysis (classification of bitmaps, definition of the zones of the maximum concentration of objects, and delimitation of geospatial data clusters). However, the main factor in identifying urban problems remains analytical capabilities of the software users. Changing the shape of displaying information can help discard unnecessary information and reduce the impact of inaccuracies in the collected data. The use of synthetic and complex maps combined with scientific graphics as symbols achieves an "intuitive result" in the mapping processes that take place in the urban space.

3. The testing of the geographic information system has revealed that Ukrainian cities can be described in terms of the following urban processes: industrial revitalization, commercialization of housing, and residential gentrification. Revitalization of industrial areas means a downscaled industrial function in a city. It leads to a shortage of jobs and low wages, which forces people to commercialize residential development. Urban gentrification is a special phenomenon that indicates the city administration efforts aimed at streamlining the urban space.

Further tests of the software package will be carried out after expanding the list of mapped objects, refining and automatizing the technology for data collection, including control systems, as well as identifying new urban processes that have not been investigated.



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*Для автоматизації аналізу станів об'єктів використані правила для представлення знань, а для їх відображення, інтерактивної обробки та перевірки вдосконалені моделі правил у вигляді І/АБО-графа. Запропоновано ІТ з використанням редактора правил для розробки знання-орієнтованих систем контролю, за допомогою якої проводиться автоматизоване перетворення правил в мову продукційного програмування*

*Ключові слова: знанняорієнтована технологія контролю, модель правил контролю, І/АБО-граф, експертні системи контролю*

*Для автоматизации анализа состояний объектов использованы правила для представления знаний, а для их отображения, интерактивной обработки и проверки усовершенствованные модели правил в виде И/ИЛИ-графа. Предложено ИТ с использованием редактора правил для разработки знаниеориентированных систем контроля, с помощью которой проводится автоматизированное преобразование правил в язык продукционного программирования*

*Ключевые слова: знаниеориентированная технология контроля, модель правил контроля, И/ИЛИ-граф, экспертные системы контроля*

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# DEVELOPMENT OF INFORMATION TECHNOLOGY FOR THE GENERATION AND MAINTENANCE OF KNOWLEDGE-ORIENTED CONTROL SYSTEMS

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## 1. Introduction

Present-day requirements to the level of safety for trouble-free operation of objects necessitate improvement of automated control processes. Thus, in addition to monitoring, the control functions include analysis of the object param-

eters to determine its status and provide the decision maker (DM) with processed information.

The paper considers control systems with the following properties:

- limited number of object states;
- parameters can be logical or qualitative;