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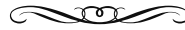
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## THE USE OF GIS TO STUDY ACCESSIBILITY OF THE URBAN ENVIRONMENT (CASE STUDY OF SECONDARY CITIES PROJECT)

Issues of social protection of people with disabilities, the state of introduction of such people into society as well as the accessibility of the environment are considered by many researchers.

**The purpose of the article is** to reveal possibilities of using GIS in the study of urban environment accessibility on the case study of Secondary Cities project, implemented in Kharkiv.

**The main material.** One of the main problems that limits mobility of people with special needs is the lack of information on available community resources and services. The most popular way of solving this problem is to develop separate maps of accessibility and geographic information systems for vulnerable populations.

Secondary Cities project deals with the detailed study of the city infrastructure in terms of its accessibility to vulnerable population. At the preparatory stage, 2 series of workshops were conducted for the participants. Implementation of the project in Kharkiv can be divided into several stages: collection of geospatial data and their initial analysis; development of cartographic products, mobile applications and recommendations for improving accessibility of the urban environment. Data collection is currently ongoing, which is mainly performed with the help of Survey 123 mobile application.

According to the project goal, data have been collected for three general feature categories: «Mobility», «Community Resources and Services», «Public Safety». All the objects, by the level of accessibility, were divided into 3 classes: accessible, limited access, not accessible. In particular, among 419 public establishments of the city center 42% are accessible, 31% have limited accessibility and 27% are not accessible at all. It can be assumed that accessibility of facilities in remote areas of the city is even lower.

**Conclusions.** The most accessible way to receive operative information on the statics and dynamics of social infrastructure for vulnerable population is the use of geoinformation systems. Projects like Secondary Cities should be implemented in other settlements of Ukraine.

**Keywords:** urban environment, environment availability, barrier-free environment, vulnerable population, geographic information systems.

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### ВИКОРИСТАННЯ ГІС-ТЕХНОЛОГІЙ У ДОСЛІДЖЕННІ ДОСТУПНОСТІ МІСЬКОГО СЕРЕДОВИЩА (НА ПРИКЛАДІ ПРОЕКТУ «SECONDARY CITIES»)

Метою статті є розкриття можливостей використання ГІС-технологій у дослідженні доступності міського середовища на прикладі проекту «Secondary Cities». Висвітлено особливості етапів: підготовчого (у рамках якого було проведено дві серії майстер-класів); збору геопросторових даних та первинного їх аналізу; розробки картографічних продуктів, мобільних додатків і рекомендацій щодо покращення доступності та безпеки міського середовища. Представлено результати аналізу даних, зібраних у центральній частині Харкова, та перспективи розвитку проекту «Secondary Cities» у місті.

**Ключові слова:** міське середовище, доступність середовища, безбар'єрне середовище, маломобільні групи населення, геоінформаційні системи.

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### ИСПОЛЬЗОВАНИЕ ГИС-ТЕХНОЛОГИЙ В ИССЛЕДОВАНИИ ДОСТУПНОСТИ ГОРОДСКОЙ СРЕДЫ (НА ПРИМЕРЕ ПРОЕКТА «SECONDARY CITIES»)

Целью статьи является раскрытие возможностей использования ГИС-технологий в исследовании доступности городской среды на примере проекта «Secondary Cities». Освещены особенности этапов: подготовительного (в рамках которого были проведены две серии мастер-классов); сбора геопространственных данных и первичного их анализа; разработки картографических продуктов, мобильных приложений и рекомендаций по улучшению доступности и безопасности городской среды. Приводятся результаты анализа данных, собранных в центральной части Харькова, и перспективы развития проекта «Secondary Cities» в городе.

**Ключевые слова:** городская среда, доступность среды, безбарьерная среда, маломобильные группы населения, геоинформационные системы.

**Introduction.** Vulnerable population is usually defined as people who experience difficulties in self-moving, obtaining services, necessary information or orienting in space. In particular, they include people with disabilities or temporary disability, pregnant women, the elderly, people with strollers, etc.

In today's increasingly tolerant world, more and more attention is paid to ensuring equal rights for every member of the society. In this context, the concept of «accessible urban environment» has emerged, broadly involving equal participation of the disabled people in all spheres of a society's life [9]. Formation of the barrier-free environment is a complex task that requires interdisciplinary cooperation, since all types of transport, places of residence and rest, workplaces and information resources should become available.

After the Second World War most countries of Europe and North America developed transport services for people with special needs, formed an accessible urban environment as well as a tolerant attitude towards this problem. On the contrary, the urban planning policy of the Soviet Union cultivated the idea of servicing enterprises, economy and defence, while the practice of environment «humanizing» was not popular [9].

Only after Ukraine gained its independence, adaptation of urban infrastructure for people with disabilities began. Currently, the goal of architects is to create harmonious, healthy, comfortable living spaces. In this regard, in our country, the study of accessible urban environment for vulnerable population, especially by means of geographic information systems, is becoming increasingly relevant.

**Initial conditions.** Issues of social protection of people with disabilities, integration of such people into the society, as well as the available environment are considered by both Ukrainian and foreign researchers. Currently, a new scientific trend is emerging - the economy of the barrier-free environment, which considers accessibility as a public good and examines its impact on economic development and investment efficiency [4]. Research describing such methodology has been developed [1, 3].

The results of the study [2] demonstrate the importance of projects for the «disabled maps» creation and emphasize their constructive role in urban design rebuilding and overcoming social discrimination.

Recommendations for creating available maps for vulnerable population has been formed: use of different colour icons to indicate the degree of objects accessibility; integrated interaction of maps of settlements with maps of other regions of individual countries; indication of all possible routes for the disabled people from public transport stops to the objects of their interest [1].

The researchers [6] developed a simulation model of the geographic information system for vulnerable population, identified its elements, functional and interaction principles, set the parameters of input and output variables. Structure-functional and logical schemes of the system model have been created. The GeoWheel

system, which contains data on the available social infrastructure objects in the city of Khanty-Mansiysk of the Russian Federation, has been implemented.

Thus, the use of GIS to study the urban environment is a modern trend and requires further theoretical and practical research.

**The purpose** of this article is to reveal possibilities of using GIS in the study of urban environment accessibility on the case study of Secondary Cities project, which is implemented in Kharkiv.

**The main material.** One of the main problems that limit movement of people with special needs is inaccessibility of information on characteristics of social infrastructure objects. The most popular way of solving this problem is to develop separate maps of accessibility and geographic information systems for vulnerable population based on web technologies.

More recently, maps of cities or certain areas, reflecting the results of the survey of sidewalks, buildings entrances, means of visual and audio information as to their accessibility have emerged on the Internet.

In many countries of the world there are interactive, socially-oriented geographic information resources intended for obtaining information on the accessibility of social infrastructure objects for vulnerable population. Examples include: Wheelmap (this German system displays about 250, 000 objects broken down into 12 categories, one of the largest resources of this category in the world); Accessible.net (the French resource allows to search for places by a category on the map); AXSmap (the American project that allows searching for social infrastructure objects, evaluate the accessibility level and exchange information between users of this system and other resources); Affordable Environment (the system is implemented in the Russian Federation as well as the state program with the same name) [5]. Most of these systems also work on Android and Apple iOS mobile devices.

Unfortunately, in Ukraine such social-oriented resources are not widely presented, although the problem of vulnerable population is urgent. According to the State Statistics Service of Ukraine [7], as of 2016, more than 2.6 million people with disabilities lived in the country, that is 61 per 1, 000 people. A certain percentage of these people have difficulty with movement on the land. Calculation is difficult to implement for other categories of vulnerable population since some of the indicators are dynamically changing (people with temporary injuries, pregnant women, etc.). At the same time, experience has shown that even the largest cities of the country are not comfortable for people with disabilities.

Kharkiv, the second largest city of Ukraine, is not an exception. Its weakness is the socio-cultural sphere, which is insufficient to meet the needs of vulnerable social groups. During the creation of Kharkiv City Development Strategy to 2020, there was conducted a survey, which revealed that one of the main problems of the city development is the state of engineering in-

frastructure (11.1 %), unsafe and uncomfortable living conditions (4 %), and imperfect architectural building (1.9 %). According to the same paper, one of the strategic goals of the city development is «modern space and provision of the city with engineering infrastructure», and the vision of Kharkiv city is «a large European green city with a unique architecture, comfortable and safe living conditions of educated people that work in creative branches of the economy» [8]. These goals cannot be implemented without creating the barrier-free environment that would allow all social groups to take an active part in the life of the city.

Secondary Cities project [10], supported by the American Association of Geographers and the US Department of State, deals with the detailed study of the city infrastructure in terms of its accessibility to vulnerable population. Esri company is the partner, so all the project participants have access to ArcGIS software.

In addition to Kharkiv, Secondary Cities project includes the following cities of the world: Cusco (Peru), Medellin (Colombia), Esmeraldas (Ecuador), Santiago de los Caballeros (Dominican Republic), Mekelle (Ethiopia), Port Harcourt (Nigeria), Douala (Cameroon), Denpasar (Indonesia), Pokhara (Nepal).

This project seeks to build partnerships to create relevant geospatial data, to enhance the understanding and management of Kharkiv city through better data and mapping, to build resiliency and develop local capacity in geospatial science-based decision making.

The project executors in the city of Kharkiv are: faculty and students of higher educational institutions (V. N. Karazin Kharkiv National University, O. M. Beketov National University of Urban Economy in Kharkiv, National University of Civil Defence of Ukraine, National Aerospace University «Kharkiv Aviation Institute», Kharkiv National University of Radio Electronics), representatives of commercial and public organizations, volunteers from the local community. Teachers and students of the Department of Physical Geography and Cartography at V. N. Karazin Kharkiv National University have taken active part in the project (7 teachers and 5 students participated in the workshops and more than 60 students of the Department have been directly involved in the data collection).

At the preparatory stage of the project, 2 series of workshops were conducted on the basis of V. N. Karazin Kharkiv National University and O. M. Beketov National University of Urban Economy. During the training, the participants got acquainted with: a general purpose and features of project implementation in other countries; field data collection tools (Field Papers, Survey 123, Mapillary, OSMAnd, GeoForms); ArcGIS Online tools for data visualization and analysis; QGIS analytical tool; the importance of creating meta-data and their uploading rules; general rules for maps design and layout. Through the presentations of the City Information Centre and the non-governmental organization of disabled people Creavita, the participants

deepened their knowledge on the problem of vulnerable population in the city of Kharkiv. During the workshops, the area surrounding the higher educational institutions was divided among the teams of participants in order to practice data collection tools and to work out the skills acquired in the field.

For the project, the following layers of spatial data were provided: borders, hydrography (rivers, water bodies), transport network (bridges, railway stations, tramway lines, metro stations and lines, forest roads, traffic lights, power lines, pedestrian barriers, foot-paths), elevation contours, oil and gas, building use, monuments, street lights, medical facilities, hydrants.

Implementation of Secondary Cities project in Kharkiv can be divided into several stages: collection of geospatial data and their initial analysis; development of cartographic products, mobile applications and recommendations for improving accessibility and safety of the urban environment.

Data collection is still going on, which is mainly performed with the help of Survey 123 mobile application. This application is used for surveys development, field data collection and their uploading to ArcGIS Online or ArcGIS Desktop for further processing and analysis operations. The project curators created 3 surveys («Mobility», «Community Resources and Services», «Public Safety») according to the categories of the objects of interest. All the data collected by volunteers through the mobile application are added to the layers with similar names on the Secondary Cities ArcGIS Online account. Accordingly, it is possible to view and edit online data or download layers to work with them offline.

In addition to the fieldwork, street panoramas from cartographic services on the Internet as well as OpenStreetMap platform have been actively used as a data source to optimize the work.

To make data collection for the project participants easier, the study area of the city of Kharkiv was divided into several zones, assigned to different teams of educational institutions and organizations (Fig. 1).

Data has been collected for three general feature categories: «Mobility» (infrastructural features that contribute to the mobility of vulnerable population in the urban environment), «Community Resources and Services» (resources and services that align with integral needs of identified vulnerable population), «Public Safety» (infrastructure features and community services that contribute to the safety of vulnerable population in the urban environment). All the objects, by the level of accessibility, were divided into 3 classes: *accessible* (no steps at entrance and venue is accessible for people with wheelchairs and strollers), *limited access* (there is one or two small steps on entry, not accessible for wheelchairs users without assistance but accessible for people with strollers), *not accessible* (not wheelchair or stroller-friendly, there is more than one or two small steps on entry). Collected features and attributes are presented in Table, Fig. 2 shows classes of accessibility

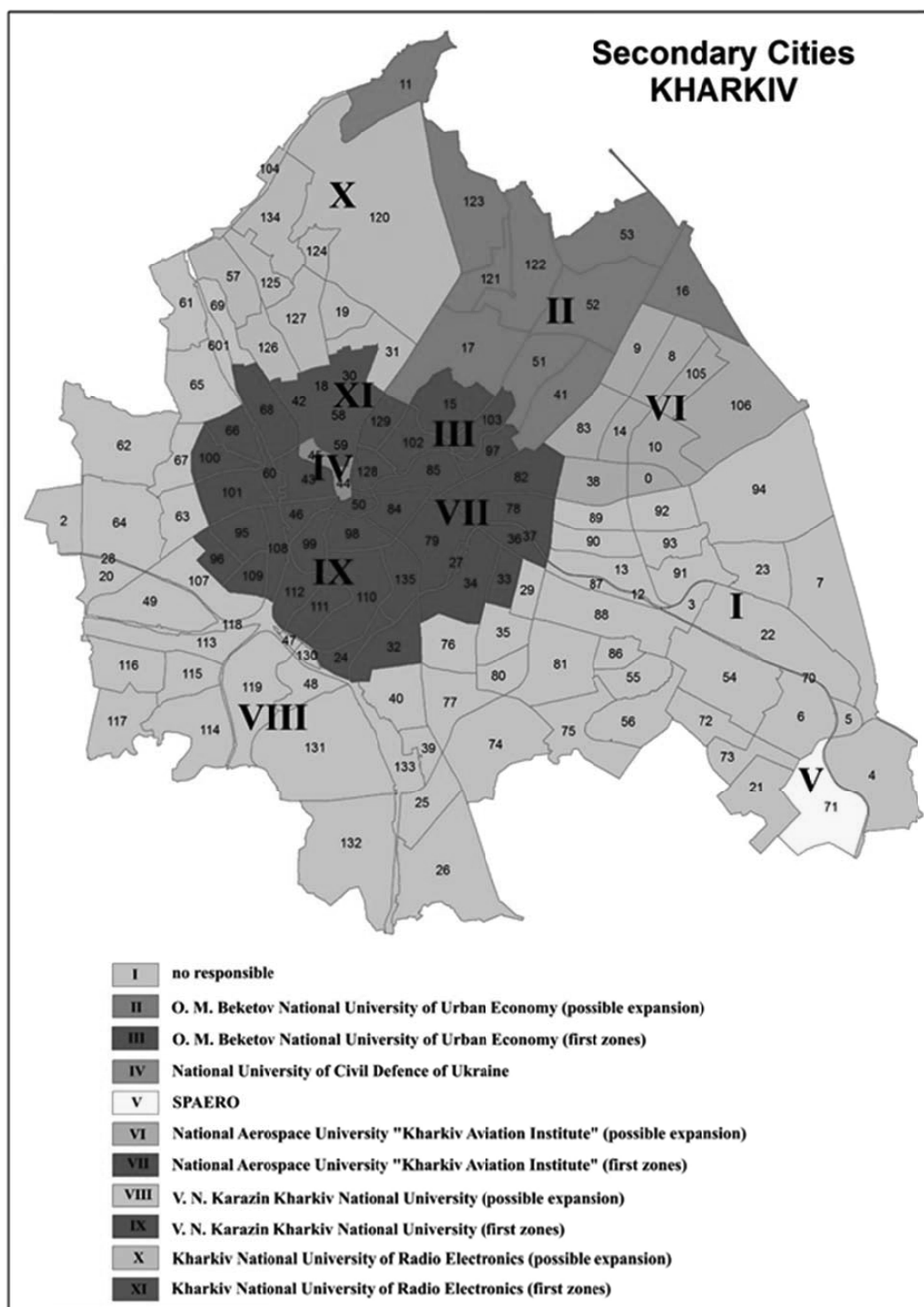


Fig. 1. Responsibility Areas of the Secondary Cities Project's Participants

of the features in the category «Community Resources and Services».

During the data collection, project participants encountered the following main problems:

- study period is summer – the vacation season;
- problems of field data collection from scratch, although a lot of data are already available on the open resources;
- some disadvantages of software tools for data collection;

- insufficient provision of all volunteers by devices for data collection (mobile devices, tablets);
- problems of mobile Internet coverage on the study area (the Internet is required for Survey 123 application).

At present, data is collected on: 2417 features from the category «Mobility» (34 % of data was collected by students of the Department of Physical Geography and Cartography), 1496 features from the category «Community Resources and Services» (28 % – by

Table

Data collection features and attributes

Categories	Features	Attributes
1. Mobility	Street Intersections	Curb cut or ramp: present or absent; name of road the ramp connects access to
	Stairs	Surface material; number of stairs; handrail: present or absent
	Subway Station Entrances	Name of the underground station
2. Community Resources and Services	Healthcare Facilities	Type of healthcare facility; type of healthcare specialists; name and street address
	Housing Resources	Type of housing resource; name and street address
	Childcare Resources	Type of childcare resource; name and street address
	Employment Resources	Type of employment resource; name and street address
	Social Service Organizations and General Community Services	Type of social service or general community service; name and street address
3. Public Safety	Streetlights	The location; if the light currently works; type of urban infrastructure feature this light provides coverage for
	Lamp posts	The location; if the light currently works; type of urban infrastructure feature this lamp post provides coverage for
	Evacuation gathering place	Type of evacuation gathering place

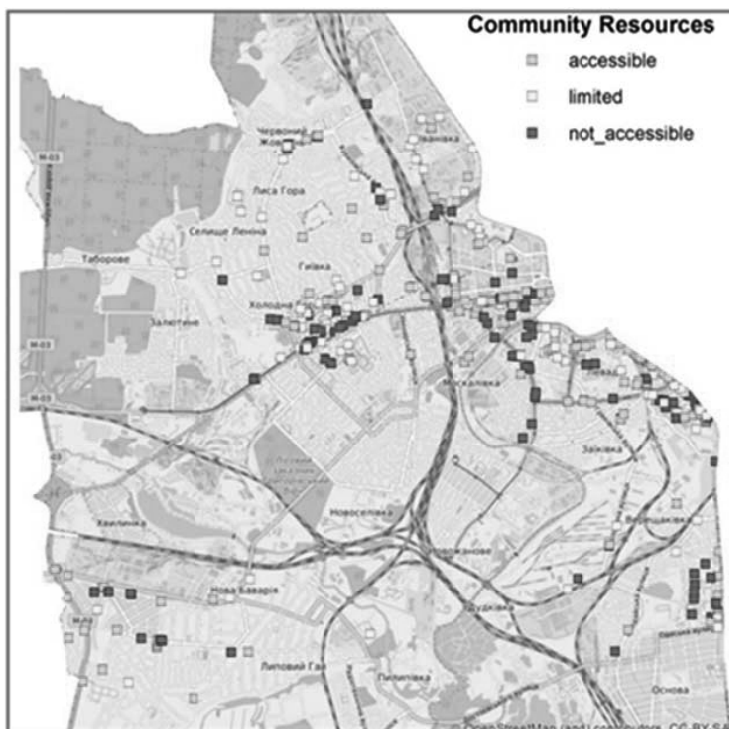


Fig. 2. Classes of accessibility of the features from the category «Community Resources and Services»

by the team of V. N. Karazin Kharkiv National University, 42 % are accessible, 31 % have limited accessibility and 27 % are not accessible as shown in Fig. 3. It is clear that even in the centre of the city, a person with disability can independently get to only one third of all public institutions, that is, the urban space is not comfortable at all. It can be assumed that the accessibility of facilities in remote areas of the city is even lower.

Prospects for the development of Secondary Cities project in Kharkiv are: collecting data with the help of more volunteers; further involvement of students of higher educational institutions through the introduction of new tasks in the GIS courses, training practices and individual study; presentation of project results in the media and in the scientific circles; development of other relevant thematic projects using the same data collecting methods:

- creation of mobile applications for people with hearing and/or vision impairment;
- detection of unsafe areas of the city at night;
- assessment of routes' quality.

After completing the data collection on the whole area of the city, it is expedient to put it in public. Exchange of the data and information, interaction between scientists, NGO representatives and

students of the Department), 18039 features from the category «Public safety» (46 % – by students of the Department). These data allowed us to pre-evaluate which percentage of social institutions could be considered accessible for all population groups.

In particular, among 419 public establishments of the city centre, information on which has been collected

community members are the principles on which the Secondary Cities project is based. So, all the findings will be made available to the general public. In part, it has been started as the data collected in the central part of the city is available on GeoNode – a web-based platform for developing geospatial information systems and spatial data infrastructures.

The collected data and the results of their analysis can be visualized on an interactive map of the availability of Kharkiv city urban space for vulnerable population. Creating an intelligent, user-friendly and at the same time informative map will attract the attention of the authorities, businesses and residents of the city to the level of social infrastructure comfort. The interactive map will allow scientists to visually assess the condition of the living environment for people with special needs, and, based on the analysis, develop measures to improve the situation. Such recommendations will be useful in creating a new development strategy for Kharkiv city and emergency response plans. The idea to develop a free mobile application that will allow planning travel routes for disabled people looks promising.

An extremely important aspect is the dissemination of information about the availability of an interactive map or a mobile application among the target audience – people with disabilities. This issue requires the assistance of non-governmental organizations and the media. Advertising on the Internet might also work.

The field data collection methodology described in the study can also be used to determine the urban space accessibility level of other cities and towns of Ukraine. In future, it is reasonable to create the all-Ukrainian GIS intended for obtaining information on the accessibility of social institutions for vulnerable population. Among the functional requirements there are: targeting different categories of citizens with special needs; a detailed description of the accessibility degree of an object; advanced search functionality; ability to add new features and their attributes; ability to add objects' descriptions, photos and other necessary information.

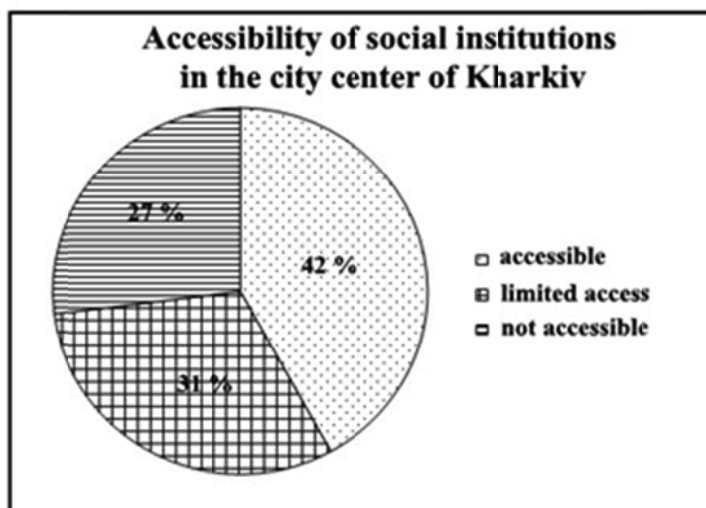


Fig. 3. Accessibility of social institutions in the city centre of Kharkiv

**Conclusions.** As a result of the conducted research, the following conclusions can be made:

- the method of data collecting, processing and visualization used by Secondary Cities project and the Department of Physical Geography and Cartography of the V. N. Karazin Kharkiv National University should be introduced in other cities and towns of Ukraine, especially those where geoinformational and cartographic training of students at higher education institutions is available;
- the most accessible way to receive operative information on the statics and dynamics of social infrastructure for vulnerable populations is to use geoinformation systems and visualization results in mobile applications;
- the subject of cartographic web applications for vulnerable population in different settlements should be unified and developed for all groups of people with special needs;
- projects similar to the Secondary Cities should be implemented not only in cities but also in other settlements of Ukraine.

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