



Real Estate Market Monitoring Technologies in the Digital City

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Abstract—The authors of the article set a goal – to determine the dependence of the value of private houses in the structure of the municipal economy from the certain market factors. To achieve this goal, it is proposed to use a geographic information portal. The authors analyzed and compared trends in determining the factors influencing the value of private house ownership. The research was conducted on the example of private houses in Kharkiv. As a result of the computer geospatial analysis, visual materials, that greatly simplify the analysis process, have been developed. In general, the use of geoportal data on the territory of the city is allowed to determine the factors influencing the value of private houses, the average exposure time, the average auction, and the average cost of 4 groups of the city districts. The results of the study will have a great impact on the sustainable development not only of the Kharkiv city, but also of any city in the country. The research was conducted using geographic information systems, which is promising at the present stage of the development of digital cities. In the course of the research, the value of private houses was determined, depending on the location of each investigated real estate segment using/ with the help of a digital geoportal model. An example of the analysis of the private house market in the city of Kharkiv, on the basis of geoinformation technologies, is given. The classification of the private house market in Ukraine is also proposed and the cost of private houses by area and, depending on the location in the future digital city, system is calculated. Conclusions were drawn on the development trends of the private house market in the municipal economy. Prospects for the development of the private house market for the sustainable urban development in Ukraine are shown. Further research in this area may be related to the improvement of methods of geostatistical analysis of data and methods of forecasting the value of private houses, depending on the location and average exposure time.

Keywords—*real estate market, private house, geoportal, municipal economy, geographic information system, sustainable development, digital city*

I. PROBLEM STATEMENT

Today, in the structure of a smart city, there are trends in the real estate market and its renewal, along with a very strongly developing private house market. The biggest problem in conducting analysis in this market segment is up-to-date and reliable information. It is especially difficult to

conduct research in Ukraine for this reason. The use of geographic information systems (GIS) allows the collection of information on the value of private houses and analysis of the real estate market, even in conditions of insufficient information due to the ease of updating and updating. That is, GIS can now be used as a decision-making and support system.

To conduct the study, data obtained from the geoinformation portal of the company (hereinafter the geoportal) “Uvekon” and the real estate agency “Meter” were collected and analyzed. Uvecon's geoportal is a tool used to create a GIS map based on a geoinformation system database. This geoportal provides an opportunity to view information about the value of a real estate not only in cities, but also in their individual districts and neighborhoods. The processing of digital data for calculations was carried out for the period of 2021 at the rate of UAH 27.3 per \$ 1.

This is a very useful and important criteria for conducting research on the modern digital city. A promising area of the research is the study of the entire real estate market (both apartments and private houses) with the help of GIS.

Thus, the relevance of scientific developments in this field becomes clear. The purpose of this article is to find and process large amounts of information related to the geolocation of objects within the modern city, to identify private sectors on the example of Kharkiv, to analyze and calculate the value of private houses.

II. ANALYSIS OF RECENT RESEARCH AND PUBLICATIONS

Various aspects of the problem of private house market research are reflected in numerous publications of both domestic and foreign researchers. One of the current trends is the problem of researching the private house market in the future infrastructure of the digital city [1]. It is important to study the factors that affect the market value of private houses in the sustainable urban development. Home ownership is a segment of the real estate market, it consists of land, housing, buildings and structures, other movable and immovable things that are located on the land.

For the whole real estate market, which exists in the structure of the digital city, various market and non-market

factors are of great importance [2]. The state of the ecological environment in the modern structure of sustainable development of the city is another important factor when choosing a potential buyer of his own residential building with a land plot.

But the analysis of recent studies shows that information on the real estate market is not enough, such as, difficult and limited access [3]. Particular attention in the structure of the modern digital city should be paid to the study of the private house market. A similar trend is observed both in Europe and around the world [4]. The problem of researching the development of the real estate market of the digital city with the help of GIS is now one of the most relevant trends in urban planning [5, 6].

Researchers such as Herman Donner, Kent Eriksson, Zisen Meng, Pochwatka P, Lin Y, Shipulin V. D., Mamonov K. A., Shalayev V. M., Voronin V. O., Guselnikov A. S., Lyantse E. V., Riltseva V. N. are engaged in the research of these problems [7 – 15].

World practice shows that in the modern world it is best to approach the solution of various problems, and especially the study of the market of private houses through the analysis and consideration of even small aspects. The tools and instruments of geographic information systems have great potential for solving such problems.

III. THE PURPOSE AND TASKS OF THE ARTICLE

The purpose of the article is to study the dependence of the value of private houses in the structure of the urban economy on the market factors identified by the authors with the help of GIS.

To achieve this goal, the following tasks are set in the article:

- 1) Classify private houses and determine the classes for which to conduct research.
- 2) Investigate available GIS and digital databases that can be used to conduct analysis.
- 3) Investigate the factors influencing the household market in the structure of the modern digital city and the dependence of the value of private houses on location.
- 4) Analyze the market of private houses on the basis of information from the geoportal of the company “Uvekon”, the database of the real estate agency “Meter” and calculate the average, minimum and maximum value of private houses in the proposed classes.
- 5) Determine the value of private houses depending on the location of each studied segment of real estate using a digital model of the geoportal. Calculate the cost of private houses by area and depending on location. Analyze the

household market in Kharkiv on the basis of GIS technologies

6) Investigate discrepancies in data obtained using GIS and digital database. Develop an example of visual materials for the household market in Kharkiv.

7) Identify prospects for the development of private houses in the future digital city system. Make conclusions based on the prospects of the household development market for sustainable urban development in Ukraine.

IV. OUTLINE OF THE BASIC MATERIAL

A. *Factors influencing the household market in the structure of the modern digital city. Classification of private houses.*

The authors conducted a study, which determined the classification of private houses by class, and studied the factors influencing the household market in the structure of the modern digital city. In the course of studying this issue, the dependence of the value of the household on the location and the size of the total area was determined.

The three classes of the real estate that are most in demand and the number of proposals for analysis were identified. Thus, the classification of private houses was determined for further study:

- household up to 100 m²;
- household from 100 to 300 m²;
- private houses from 300 to 600 m².

The division of the real estate into classes was carried out by area, this is an important parameter, which is the first thing buyers pay attention to. It is in the location, where the research was conducted, that the value of private houses is close to this indicator. Classification of private houses by class was carried out, taking into account the expert opinion of the real estate experts [16 – 18]. At the same time, information was collected and analyzed in the enlarged districts of Kharkiv, where there is a share of private houses with approximately the same demand and market value. According to these indicators, the location of private houses was grouped by the following areas:

- 1) Center.
- 2) Areas adjacent to the center.
- 3) Sleeping areas.
- 4) Outskirts (remote areas).

It has also been suggested that different market and non-market factors are important for the entire real estate market that exists in the digital city structure [19]. This is clearly shown in Figure 1, which shows the model of integration of home ownership in a smart garden.

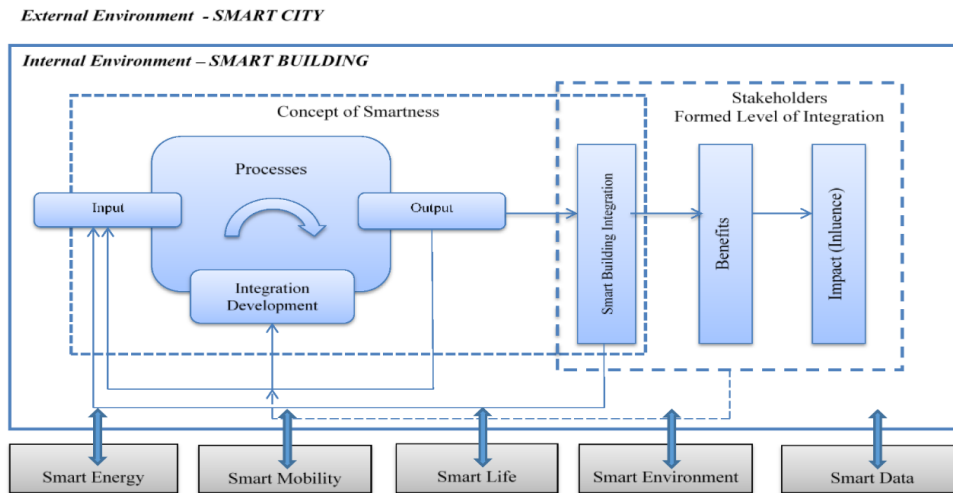


Fig. 1. Type of model of home integration in a smart city

Thus, thanks to the authors' use of the professional opinion of the experts, the classification of private houses, according to the demand by area and the classification of private houses by formed groups, depending on the location, was carried out. The developed classification is proposed to be applied not only in the city of Kharkiv, but also in Ukraine and all over the world.

B. Market size and structure

To analyze the household market, the researchers took propositions of private houses, which are put up for sale and fully completed. Analytics and information collection were performed in 2021. Most of the surveyed houses belong to the housing stock, which was built before 1995. The volume of the market and the structure of private houses was determined on the basis of collected and analyzed materials obtained from the geoportal “Uvecon” [20] and the database of the real estate agency “Meter” [21].

Thus, the available GIS and digital databases were identified, with the help of which it is possible to solve the set task. The built-in geoinformation system of the Uvecon geoportal allows to conduct extremely important and detailed research of the real estate market. A fragment of the GIS map from this geoportal, which was used for further research, is shown in Figure 2.

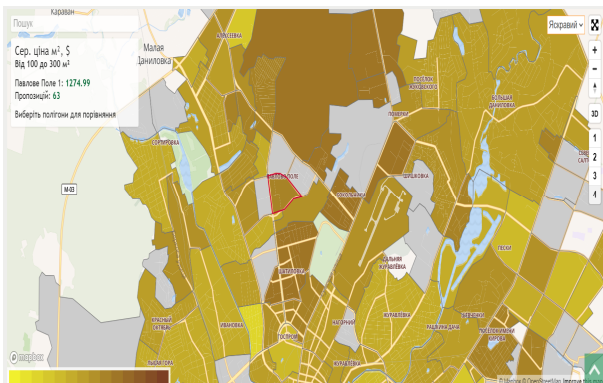


Fig. 2. A fragment of the GIS map used for research

Real estate market research was conducted in two directions. The first is a GIS market research of private houses. The second area of research is the study of the private hous market, using a digital database provided by the real estate agency.

As a result, the authors obtained the results of the research according to the GIS map from the geoportal “Uvekon” for each of the districts of Kharkiv.

Another area of the research in the private hous market – according to the database of real estate agency “Meter”. The authors obtained research results for each of the districts of Kharkiv.

During the whole 2021 year, the total number of offers on the private hous market according to the Uvecon geoportal was 18, 218, which are cumulative data from which private houses were sold and put up for sale during the year. That is, all quantitative data on private houses put up for sale and sold throughout the year.

To find out the number of offers that were on the market at the time of the research, the digital database of the real estate agency “Meter” was studied. As a result, the number of proposals from private houses was determined – 430 at the time of the study.

It is necessary to explain the very high discrepancies between the data obtained from the research from the two digital sources. Uvecon geoportal provides information about all offers, whether they were sold or not, so this data is very important for analysis to be able to compare with previous years, and to monitor the dynamics of a decline or increase in the number of proposals. According to the real estate agency “Meter” and their data, you can examine a sample of only commercially available private houses.

Thus, we can draw conclusions about the number of private houses sold, as the difference between the supply during the year and the balance of private houses offered at the end of the year. According to the real estate agency “Meter”, they are equal to 430. Therefore, we can conclude that during one year it was sold approximately 17,778 private houses.

Examining the dynamics of changes in the value of the real estate market, and comparing data using a GIS map from the geoportal “Uvecon”, we can see that the number of offers of private houses in 2021 were decreased by 10% compared to 2020. Analysis of the number of proposals is shown in Tables I and II.

TABLE I. THE TOTAL NUMBER OF PROPOSALS BY DISTRICT IN KHARKOV ACCORDING TO THE GEOPORTAL “UVEKON”

№	District	Up to 100 m ² , ave. price \$	From 100 to 300 m ² , ave. price \$	From 300 to 600 m ² , ave. price \$
1	Center	244	327	116
2	Adjacent districts	456	314	31
3	Sleeping districts	4907	4592	943
4	Outskirt	3472	2376	440
The total number of		9079	7609	1530
Min		244	314	31
Max		4907	459	943

TABLE II. THE TOTAL NUMBER OF PROPOSALS BY DISTRICT IN KHARKOV, ACCORDING TO REAL ESTATE AGENCY “METER”

№	District	Up to 100 m ² , ave. price \$	From 100 to 300 m ² , ave. price \$	From 300 to 600 m ² , ave. price \$
1	Center	6	26	8
2	Adjacent districts	4	20	1
3	Sleeping districts	34	192	15
4	Outskirt	17	102	15
The total number of		61	340	39
Min		4	20	1
Max		34	192	15

More clearly, the ratio of the number of proposals in the districts of Kharkiv according to the geoportal “Uvekon” in percentages is presented in the form of a diagram in Figure 3.

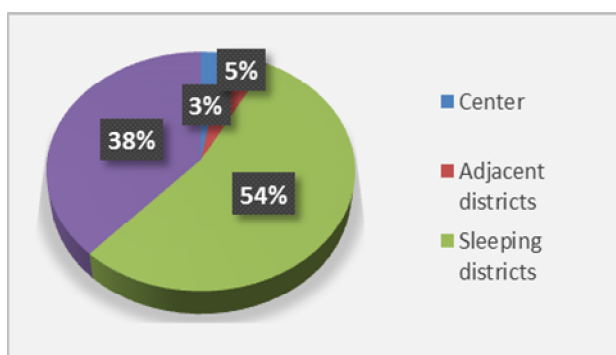


Fig. 3. The ratio of the number of proposals for the sale of private houses in the areas of Kharkov according to the geoportal “Uvekon”

Visualization of the ratio of the number of proposals in the areas of Kharkov, according to real estate agency “Meter” is somewhat different (Fig. 4).

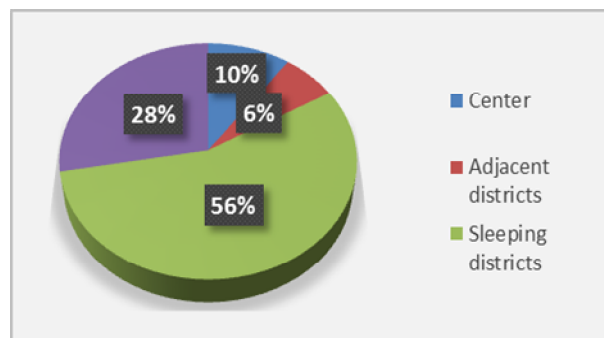


Fig. 4. The ratio of the number of proposals for the sale of private houses in the areas of Kharkov, according to real estate agency “Meter”

The authors analyzed the obtained diagrams and made conclusions about the similarity of the obtained results regardless of the source of information – this can be seen from the diagrams in Figures 2 and 3. Thus, the study grouped by district to analyze the household market of proposals on the information from the geoportal “Uvekon” and the real estate agency “Meter”, the ratio of the number of proposals with the distance from the city center.

C. Determining the value of private houses

The value of private houses is influenced by a number of factors:

- year of construction;
- planning;
- quality and environmental friendliness of building materials;
- size of the land plot and its relief;
- availability of communications;
- distance from metro stations and public transport stops;
- availability of stadiums, sports grounds, swimming pools and other health infrastructure near;
- availability of preschool, school and institutions of children's and youth creativity;
- availability near shops, pharmacies and other catering and trade establishments.

Depending on how many factors will affect the quality of home ownership, its exposure period will depend. The average term of exposition of private houses in the city of Kharkiv is from 18 to 22 months. Average price reduction and bargaining for homes for sale is 20 – 25%. If a house is for sale for more than 22 months, the average reduction in price and bargaining will be 30 – 35%. The average bid from the effective display to the deal is 5 – 10%. The average cost of one square meter was calculated for each of the selected classes of private houses.

According to the geoportal “Uvekon” it is determined that the minimum cost per 1 m² is:

- up to 100 m² – \$ 527;
- from 100 to 300 m² – \$ 703;
- from 300 to 600 m² – \$ 625.

And the maximum cost of home ownership per 1 m² in turn is:

- up to 100 m² – \$ 1263;
- from 100 to 300 m² – \$ 1284;
- from 300 to 600 m² – \$ 1129.

General information on the cost of 1 m² in the city of Kharkiv according to the geoportals “Uvekon” is given in the Table III.

TABLE III. THE AVERAGE PRICE PER 1 M² IN THE DISTRICTS OF KHARKIV ACCORDING TO THE GEOPORTAL “UVEKON”

№	District	Up to 100 m ² , ave. price \$	From 100 to 300 m ² , ave. price \$	From 300 to 600 m ² , ave. price \$
1	Center	1263	1284	1129
2	Adjacent districts	587	636	0
3	Sleeping districts	541	781	713
4	Outskirt	527	703	625
<i>Average price</i>		<i>730</i>	<i>851</i>	<i>617</i>
<i>Min</i>		<i>527</i>	<i>703</i>	<i>625</i>
<i>Max</i>		<i>1263</i>	<i>1284</i>	<i>1129</i>

For further analysis and more convenient work, tabular data were presented in the form of a diagram (Fig. 5), where the change in the average cost of private houses per 1 m² with a distance from the city center is clearly seen.

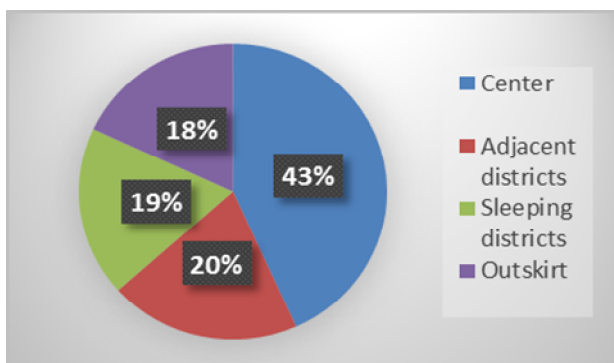


Fig. 5. The average price per 1 m² in the districts of Kharkiv according to the geoportals “Uvekon”

According to the real estate agency “Meter” it is determined that the minimum cost per 1 m² is:

- up to 100 m² – \$ 526;
- from 100 to 300 m² – \$ 939;
- from 300 to 600 m² – \$ 707.

And the maximum cost of home ownership per 1 m² in turn is:

- up to 100 m² – \$ 1113;
- from 100 to 300 m² – \$ 1225;
- from 300 to 600 m² – \$ 1309.

General information on the cost per 1 m² in Kharkov, according to real estate agency “Meter” is given in the Table IV.

TABLE IV. THE AVERAGE PRICE PER 1 M² BY DISTRICT IN KHARKIV, ACCORDING TO THE AGENCY “METER”

№	District	Up to 100 m ² , ave. price \$	From 100 to 300 m ² , ave. price \$	From 300 to 600 m ² , ave. price \$
1	Center	1113	1225	1309
2	Adjacent districts	993	919	457
3	Sleeping districts	706	838	744
4	Outskirt	526	775	319
<i>Average price</i>		<i>835</i>	<i>939</i>	<i>707</i>
<i>Min</i>		<i>526</i>	<i>775</i>	<i>319</i>
<i>Max</i>		<i>1113</i>	<i>1225</i>	<i>1309</i>

From the diagram (Fig. 6) we can see that the difference between the data of the geoportals “Uvekon” and the data of the agency “Meter” is not large, within the error limit.

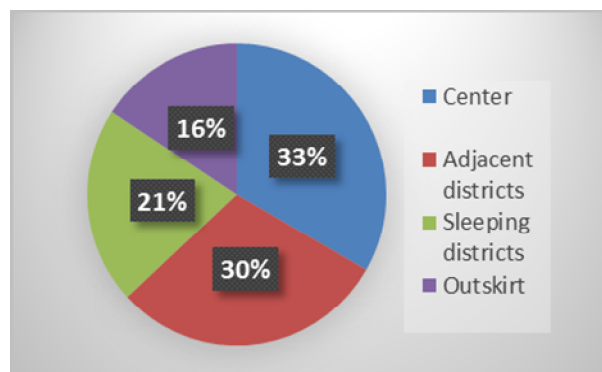


Fig. 6. The average price per 1 m² in the areas of Kharkov, according to real estate agency “Meter”

Further study and analysis of statistical data allows us to investigate the dependence of real estate value on location using different sources of information.

These data show that today the role of digital space in cities is growing. This will affect the traditional role of buildings in the digital city system [22]. Positioning private houses with the help of digital technologies, the ability to quickly update information – all this can be done quickly and accurately with the help of GIS technology. GIS location can drastically change real estate research practices within a digital city.

V. RESULTS

- 1) The authors of the article classified a private house by area and demand and formed three classes of private houses.
- 2) The authors of the article determined the grouping of private houses by location (4 groups) and by market value.
- 3) As a result of the conducted researches the factors of influence on the cost of home ownership were determined, the average term of exposure was determined, the average auction from the effective display to the agreement was determined, the average price for 4 groups of districts was determined.
- 4) The authors solved the task of finding information on geolocations, private sectors within the districts of the city of Kharkiv to conduct analysis and determine the value of the household market.
- 5) Real estate market research was conducted in two directions. The first is a GIS market research of private

houses. The second area of research is household market research using digital database processing.

6) The authors determined the value of private houses depending on the location of each investigated segment of real estate using a geoinformation model of the geoportal.

7) The cost of private houses by area and location was calculated.

VI. CONCLUSIONS

As a result of the analyzed data from the two sources of information, the division of private houses into classes was proposed to further facilitate the identification of factors influencing the value of private houses. The authors proved that the use of GIS to analyze and determine the value of the private houses market will allow with the minimum time to perform the entire cycle of work to determine the prospects for private houses development in the future digital city system.

Conclusions are made on trends and prospects for the development of the private houses market in the municipal economy. Forecasts for the development of the private houses market for sustainable urban development in Ukraine are shown.

Further research in this area may be related to improving the methodology of geostatistical analysis of data and methods of forecasting the value of private houses, depending on the location and average exposure time.

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