Estimation of Transport and Functional Convenience of Assessment Areas During the Regulatory Monetary Valuation of Land Plots In Cities

Iryna Koshkalda[1,*], Liudmyla Bezuhla[2], Olena Trehub[3], Kseniia Bliumska-Danko[4] and Liudmyla Bondarenko[5]

[1]*Department of Land Administration and Cadastre, State Biotechnological University, Kharkiv, Ukraine.*
[2]*Department of Tourism and Enterprise Economics, Dnipro University of Technology, Dnipro, Ukraine.*
[3]*Department of Land Administration and Cadastre, State Biotechnological University, Ukraine.*
[4]*Researcher of Center in Economics and Management, Universitè Paris-Saclay, France.*
[5]*Department of Tourism and Enterprise Economics, Dnipro University of Technology, Dnipro, Ukraine.*

Abstract: Normative monetary valuation of land is used to calculate the amount of land tax, state duty on mines, inheritance and donation of land according to the law, rent for land of state and communal ownership, losses of agricultural and forestry production, as well as developing indicators and mechanisms of economic incentives for the rational use and protection of land. The method of this indicator calculating was changed at the legislative level in 2021, but it is not perfect, as it does not contain a clear algorithm for consideration of all factors, including transport and functional convenience, on land value indicators in cities. There are no recommendations on the selection of evaluation factors, no the list of indicators, any procedure for calculating and interpreting the results and their application in calculating the normative monetary valuation of land, which became the basis for this study. The purpose of the study is to improve the approach to assessing and consideration the factors of transport and functional convenience during the regulatory monetary valuation of land in cities.

Keywords: Monetary valuation, land valuation, Land plots valuation, Land value, Transport and functional convenience estimation, Normative monetary valuation.

INTRODUCTION

Normative monetary valuation of land is a capitalized rental income from the land, calculated according to established and approved standards [1]. The existing method of calculating the normative monetary valuation of land is based on rent [2]. Land rent is the income that can be obtained from land as a factor of production depending on the quality and location of the land [1]. The process of rent formation within the city usually takes place in a fairly large and internally heterogeneous area, characterized by a complex combination of natural and anthropogenic landscapes, differences in functional and planning qualities, different levels of profitability from land use, which leads to heterogeneity of rent-forming factors. This necessitates land valuation structuring of the city and conducting an economic assessment of each assessment unit. There is a debate about the level of transport accessibility and functional diversity impact on land value indicators in the scientific community. In particular, Louis Lategan, Juaneé Cilliers, Zinea Huston and others [3] believe that real estate prices (including land) are rising as the distance to public green spaces decreases, as evidenced by studies using municipal estimates and international market prices. A.R. Rakhmatulloh , I. Buchori , W. Pradoto [4], note that the value of commercial and non-commercial land is primarily affected by the distance to the city center and employment centers. At the same time, the value of non-commercial real estate is also influenced by the accessibility of roads and public facilities. José Maria Codosero Rodas , José Manuel Naranjo Gómez emphasize that the value of land increases in proportion to the pace of urbanization (building) of the city in their research [5].

Literary sources analysis [5-9] showed that the most significant factor influencing the differentiation of the urban land value within the assessment units is the accessibility to the center of the settlement, places of labor concentration, public service centers, public recreation. Currently, there is no methodological justification for the process of assessing the availability of these factors in the territory of valuation units during the land normative monetary valuation in cities, which identified the problems of the study.

METHODOLOGY

Empirical level methods were used in the research process: description, observation, measurement, comparison, generalization. Specific scientific methods are also used: cartographic method, zoning method, mathematical and geoinformation modeling, statistical, ranking and grouping.

*Address correspondence to this author at Doctor of Economic Sciences, Professor, Head of the Department of Land Administration and Cadastre, State Biotechnological University, Kharkiv, Ukraine
E-mail: irinavit1506@gmail.com

RESULTS AND DISCUSSION

According to the current legal framework [2], the normative monetary value of land plots is calculated in the following order:

NMV = S x Nri x Cm1 x Cm2 x Cm3 x Cm4 x Cp x Cpp x Cni (1)

where: S — land area, square meters;

Nri — norm of capitalized rental income per unit area in accordance with Annex 1 of the Methodology [2];

Cm1 — coefficient that takes into account the location of the territorial community within the zone of large cities influence;

Cm2 — coefficient that takes into account the recreational value of settlements;

Cm3 — coefficient that takes into account the location of the territorial community within the zones of radiation pollution;

Cm4 — coefficient that characterizes the zonal factors of the land location;

Cp — coefficient that takes into account the land purpose according to the State Land Cadastre;

Cpp — coefficient that takes into account the peculiarities of land use within the category of land for the main purpose;

Cni — product of indexation coefficients of normative monetary valuation of lands for the period from standard approval of the capitalized rental income to the date of valuation.

Formula 1 shows that a set of rent-generating factors of different levels is taken into account in the process of calculating the normative monetary valuation of land: from regional to local. The analysis showed that the only coefficient for which there are no clearly defined indicators, or the order of calculation, is the coefficient Cm4 - a coefficient that characterizes the zonal factors of the land location. It should be noted that the Cm4 coefficient has several features:

1. It is determined not for all categories of land, but only for land for housing and public buildings, land for recreational purposes, land for industry, transport, communications, energy, defense and other purposes, as well as for land that is not classified as land by main purpose.
2. Differentiated by assessment areas, which are established on the basis of economic assessment of the territory.

In our opinion, assessment areas are territorially and functionally defined formations within which the assessment of land properties is carried out within the jurisdiction of a village, settlement, city council or within the territory of a territorial community.

Analysis of the legal framework, literature sources, as well as documentation on the normative monetary valuation of land settlements, gives us the opportunity to formulate the features of the assessment areas as elements of the assessment of the settlement. Assessment areas in the city:

- have mostly the same functional and planning qualities;
- limited by natural (sea coast, rivers, canals, streams, beams, streams, etc.); anthropogenic (roads, streets and alleys, settlements, road structures, forest belts, canals, historical and cultural, industrial, recreational areas, etc.); administrative (boundaries of territories of villages, settlements, cities, village, settlement, city councils, territorial communities); cadastral (cadastral quarters) boundaries;
- stand out as closed landfills, the boundaries of which do not intersect;
- the boundaries of assessment areas may not cross the boundaries of villages, settlements, cities, villages, townships, city councils, territorial communities, administrative districts in cities;
- the boundaries of the assessment areas may not disrupt the planning network of the settlement;
- subjects to allocation into separate assessment areas: lanes of the main railway (except for stations and station areas); land under opencast mining, quarries, mines and related structures; diversion lanes of main oil, gas and product pipelines; lanes of 220 kV and higher electric lines;
- the square of the assessment area may not exceed 1000 hectares, must be compared with the neighborhood of multi-storey buildings, a quarter (group of quarters) of homestead buildings.

A fragment of the city division into assessment districts is shown in Fig. (**1**).

According to point 10 of the Methodology [2], to calculate the coefficient that characterizes the zonal factors of the land location (Cm4), it is necessary to conduct an economic assessment of the assessment areas territory, taking into account such groups of factors:

- heterogeneity of functional and planning qualities of the territory;
- accessibility to the center of the settlement, places of labor activity concentration, public service centers, public recreation;
- level of engineering support and landscaping (availability and possibility of connecting real estate to water, electricity, gas, heating and sewerage networks);
- level of public services development (availability of basic social infrastructure facilities (schools, kindergartens, health care facilities, other social infrastructure facilities);
- ecological quality of the territory (level of air and soil pollution, acoustic and electromagnetic pollution, area of sanitary protection zones, as well as area of public green spaces, water areas and recreation areas);
- complexity of physical, geographical and geomorphological conditions (presence of ravines, steep slopes, flooding, etc.);

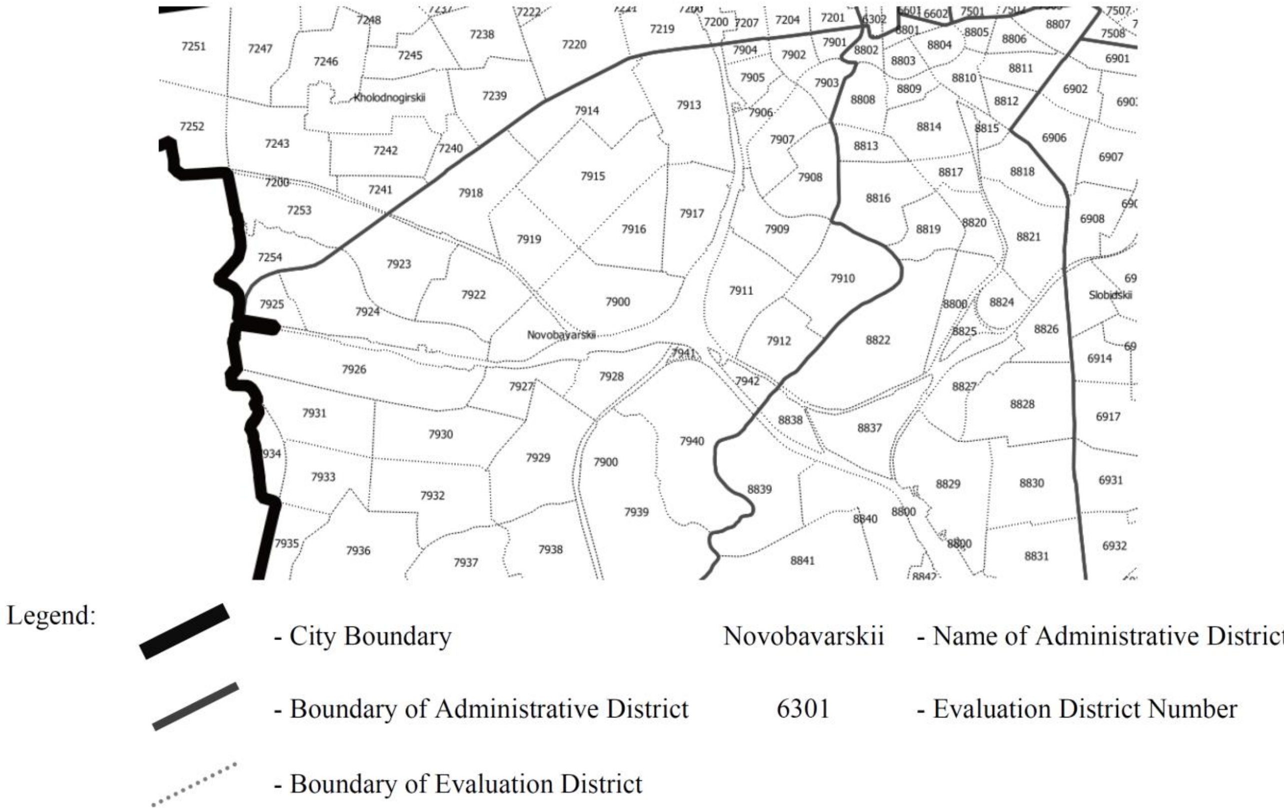

Fig. (1). A fragment of the evaluation zoning of the Kharkiv city territory.

Source: formed by the authors.

- attractiveness of the environment (variety of work places, availability of historical, cultural and natural monuments, etc.).

The weighting factor is set for each group of assessment factors, the value of which depends on the geographical and urban features of the territory of the village, town, city council or the territory of the territorial community as the assessment object. The sum of the weighted coefficients of the group of evaluation factors is equal to 1.

The coefficient that characterizes the zonal factors of the land plot location (Cm4) is determined by the results of geoinformation modeling. For village, settlement, city councils and territorial communities with a population of less than 50 thousand people, the coefficient characterizing the zonal factors of land location (Cm4) can be determined for each assessment area based on the score of economic value criteria given in Annex 6 of the Methodology [2]. The coefficient value that characterizes the zonal factors of the land plot location (Cm4) for the assessment area is calculated as the ratio of the sum of scores of this assessment area to the average sum of scores of assessment areas of the territorial community.

As we can see, for settlements with a population of 50 thousand people, the procedure for conducting economic assessment of assessment areas and calculation of the Cm4 coefficient is not legally defined. Therefore, to take into account the maximum number of rent-generating factors, we offer to assess each assessment area by weighing individual indices that reflect the value of urban land: transport and functional convenience of the territory (S_i); engineering and infrastructural arrangement of the territory (U_i); ecological quality of the territory (E_i); social attractiveness of the environment (C_i). Due to the established restrictions for the purpose of the article, we will offer measures to improve the calculation of the transport and functional convenience index of the territory (S_i). The offered procedure for calculating the coefficients Cm4 and S_i is shown in Table **1**.

When assessing the transport and functional convenience of the assessment areas (S_i), it should be kept in mind that the value of any assessment area is determined primarily by the convenience of its location in relation to other assessment areas of the city and functional "load" areas of the city. The main city functions are: housing, cultural, recreational and employment of the population. The location of the area relative to the facilities that provide these functions determines the level of convenience of its location in the city. This level is determined by two factors: on the one hand, it depends on the time spent on moving people from one area to facilities located in other areas, on the other, it is determined by the presence of these facilities in the area [4, 10-12].

- Assessment area	P_i	square meters	Estimated for each assessment area

Transport and functional convenience of the assessment areas territory of the city is expressed by an integrated indicator S_i, which combines the action of various factors, including the availability of the assessment area to: the gravity center (B_i); recreation facilities (G_i); training and educational centers (N_i); city center (Z_i). The choice and number of these indicators is determined by the available information base, features of the planning structure and functional zoning of the settlement.

Table 1. The Procedure for Calculating the Cm4 Coefficient and the Index of Transport and Functional Convenience of the Territory.

Indicator	Denotation	Unit of Measurement	Source or Order of Calculation	Formula Number
Coefficient that characterizes the zonal factors of the land location	Cm4	coefficient	$Cm4= S_i \times W_{Si} + U_i \times W_{Ui} + E_i \times W_{Ei} + C_i \times W_{Ci}$	2
- transport and functional convenience index of the territory	Si	coefficient	Estimated for each assessment area	
- engineering and infrastructural arrangement index of the territory	Ui	coefficient		
- index of environment social attractiveness	Ci	coefficient		
-index of territory ecological condition	Ei	Coefficient		
- the weight of the corresponding index	W(S;U;E;C)i	coefficient	Based on the specialists` opinion who perform land valuation works	
Index of the territory transport and functional convenience	S_i	coefficient	$S_i = B_i \times W_B + G_i \times W_G + N_i \times W_N + Z_i \times W_z$	3
- accessibility index of the i-th assessment area to the center of gravity	B_i	coefficient	$B_i = S_{Bi} / S_{Bcep}$	4
- accessibility index of the i-th assessment area to recreation facilities	G_i	coefficient	$G_i = S_{Gi} / S_{Gcep}$	5
- accessibility index of the i-th assessment district to training and educational centers	N_i	coefficient	$N_i = S_{Ni} / S_{Ncep}$	6
- accessibility index of the i-th assessment area to the city center	Z_i	coefficient	$Z_i = S_{Zi} / S_{Zcep}$	7
- the weight of corresponding index	$W_{(B;G;N;Z)i}$	coefficient	Based on the specialists` opinion who perform land valuation works	
- the average value of the relevant factor availability in the i-th assessment area	$S_{(B;G;N;Z)i}$	coefficient	Estimated for each assessment area	
- the weighted average of the relevant factor availability in the city	$S_{(B;G;N;Z)cep}$	coefficient	$S_{(B;G;N;Z)cep} = [\sum S_{(B;G;N;Z)i} \times P_i] / \sum P_i$	8

Source: formed by the authors.

The assessment of the transport and functional convenience is offered to perform by creating integrated spatial models of these accessibility factors with their subsequent imposition on the assessment areas territory of the city. To calculate the accessibility index of the i-th assessment area to the gravity center (B_i), we have identified centers of mass gravity, in relation to which the coefficients of time expenditure influence have been determined. A total of 86 centers of gravity were identified in the city, their location and radius of gravity (Table **2**) were characterized and mapping was performed (Fig. **2**).

In the mathematical expression of the convenience level of the location of the assessment area, there is a need for the interconnection of these determinants. An objective assessment of the location elements of the territorial structure relative to the gravity centers is the "location potential". Special attention should be paid to the calculation of time expenditures (t_{ij}) on movement between assessment areas. They are

Table 2. Fragment of the Gravity Centers Characteristics in the city.

No of Center	Location	Characteristics of Gravity Center	Gravity Radius, m
1	City center	Theaters, cinemas, museums, libraries, children's and youth art house, swimming pools, stadiums, sports complexes, zoo, cultural parks, supermarkets, shopping malls, food shops and non-food shops, market, restaurants, cafes, bars, universities, hospitals, clinics, pharmacies, homes, hotels, offices, parking lots, banks, office buildings, schools and preschools, exit from the underground, public transport stop along Independence Square, Nauky Avenue, Sumskaya Street.	2500
2	Crossroad of Nauky avenue and Cultury street (Naukova underground station)	Libraries, universities, clinics, pharmacies, food shops and non-food shops, supermarket, shopping center, cafes, restaurants, swimming pool, banks, parking lots, schools and preschools, exit from the underground, public transport stops along Nauky Avenue and Cultury street	1000-1500

Source: formed by the authors.

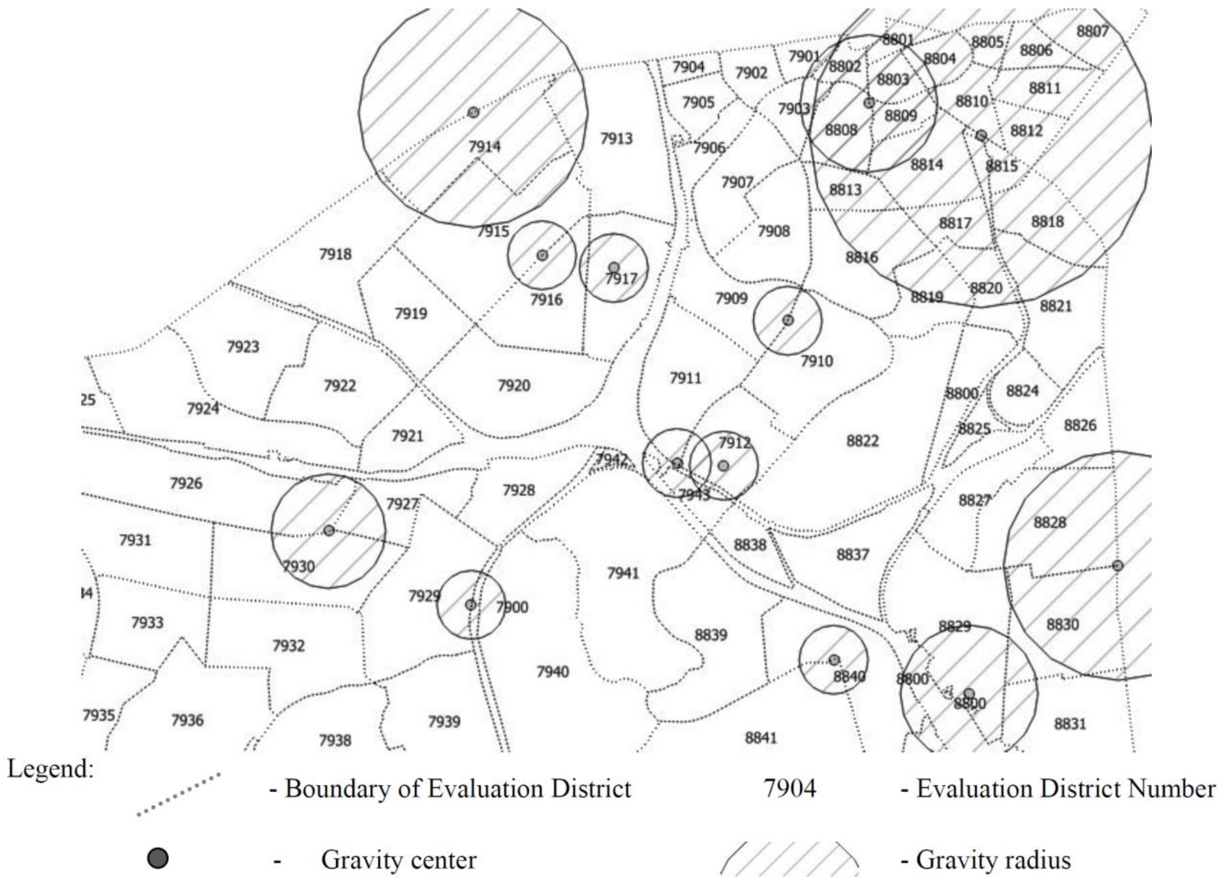

Fig. (2). Fragment of the gravity centers location in the city.
Source: formed by the authors.

carried out on the basis of creating a matrix of time spent according to the method based on the representation of the city transport network in the form of a connected graph, the vertices of which are the intersections of highways, exit points from the assessment areas to the main and route network, which are the characteristics of highways or routes (speed, class, direction, etc.). The edges of the graph are the connections between these vertices [13, 14].

When conducting a normative monetary valuation of urban lands, we recommend displaying graphs of road networks in the form of a separate digital map (layer). The road network graph contains two main types of objects such as arcs and nodes. The arcs are divided into two types - two-way and one-way traffic and are built, as a rule, along the axial lines of streets, roads and road structures, observing the topology at the connection points. Nodes can connect two arcs that have different characteristics, or connect several arcs at intersections. It should be noted that if the roads physically pass over one section of the terrain, but at different levels (tunnel, overpass, etc.), then the node is missing at the point of roads intersection on the map of the graph [13].

Table 3. The Matrix Fragment of the Shortest Distances between the Assessment Areas and the Gravity Centers of the City.

Assessment Area Number	Number of Gravity Center							
	1	2	3	4	5	6	7…	…86
7904	456,1655	1195,5110	1410,6785	1602,9199	1758,3795	1817,4984	1852,9161	17457,1416
8803	298,3430	524,7731	679,2014	753,2335	910,9268	920,8707	1286,6885	15752,3663
7902	823,1399	890,0606	920,7514	1056,8305	1287,9955	1330,6364	1409,8716	16925,2826
7901	406,1306	695,7770	724,3950	827,9527	858,3826	968,5593	1173,4396	16546,9938
8802	232,6059	383,2406	667,7353	682,7051	854,3194	936,0358	1332,5652	16184,4449
8804	679,0705	732,5608	763,1084	783,3059	817,5738	899,1498	1341,4138	15446,9322
8806	703,9280	887,6690	1049,4638	1114,5765	1276,7518	1372,2929	1440,7072	14708,3601
8807	304,7594	598,9925	1003,4961	1176,6853	1335,3891	1433,7852	1647,0133	14334,8365
7923	1772,2420	2089,4746	2725,8370	2863,6034	3005,0635	3304,1644	3915,5401	20584,5888
7919	1250,7901	1812,1773	1835,5704	2030,8167	2347,0203	2595,6090	2659,3401	19200,8226
8820	1331,9085	1421,0779	1658,4972	1705,1013	1756,2594	1912,0187	2320,3838	14383,2776
8821	1123,9609	1443,8384	1486,5090	1624,0732	2194,5467	2240,1211	2329,9034	13753,7946
7909	526,3056	1061,3727	1460,7171	1513,2412	1695,5669	2081,6609	2475,8544	16504,6026
7916	389,9876	648,7202	1751,4808	1823,7252	2111,0802	2119,3794	2719,3733	18072,2248
7917	116,6966	723,0332	1494,6013	1678,8044	1859,2271	1941,5964	2340,5117	17477,6265
… n=512								

Source: formed by the authors.

The eccentricity of the vertex should be taken into account, i.e. the distance from the vertex to the farthest from it. The radius of the graph is the smallest of the eccentricities of all vertices, the center of the graph is the vertex whose eccentricity is equal to the radius. In other words, the center of the road network in the city is the least distant from other peaks (nodes) intersection. Radius is the maximum distance from this node to the farthest. The degree of the vertex is also taken into account, i.e. the number of edges that join it. In the graphs of road networks, the degree is in the range from 2 to 4. This is due to economic efficiency: it is difficult and economically impractical to build an intersection with a large number of adjacent roads. Therefore, the graph of the road network should be represented as a weighted graph, where the nodes within the settlement are the vertices of the graph, roads are the edges of the graph, the distances between nodes are the weights of the edges, the number of roads adjacent to the node is the degree of the vertex [13, 14].

To determine the weighted average time spent on movement between the assessment areas, both information on the speed of pedestrian traffic, passenger and mass passenger transport on the relevant sections and lines, and the scale of probability of separation of flows between individual and public transport are used, as well as the coefficient of transport utilization, which depends on the length of movement and conditions of transport service. Many algorithms can be used to calculate the weighted average time spent, for example, the Dijkstra's algorithm [15]. This algorithm allows to define the shortest path from one vertex of the graph to another and is universal, which allows to use it in graphs of any design.

When calculating the transport and functional convenience of the assessment areas of the city, we built weighted non-orientational graphs with positive weight values of the edges of the graph. The shortest distance matrix was constructed to calculate accessibility between each assessment area and the gravity center (Table **3**), the columns of the matrix correspond to the gravity centers of the city, the rows correspond to the assessment areas. Columns and rows correspond to the vertices of the graph. The eccentricity of a vertex is the distance between this vertex and the farthest from it. The radius of the graph is the smallest of the eccentricities of all vertices. The center of the graph is a vertex whose eccentricity is equal to the radius. Vertex degree is the number of edges that join the vertex. In the studied city, the graphs have a low degree of vertices, i.e. the city is dominated by scattered graphs.

For example, in order to determine the accessibility index of the assessment area 7904 to the centers of gravity, the shortest distances from this assessment area to each of the 86 gravity centers were determined in the matrix (Table **3**). As a result, it was found that the average value of accessibility to the gravity centers in the assessed area 7904 is S_{B7904} = 7248,1324.

Similarly, this indicator was determined for the remaining 511 assessment areas. Next, according to formula 8 (Table **1**)

Table 4. Statistical Analysis of Accessibility Indices of City Assessment Areas.

Indicator	Access to Gravity Centers (Bi)	Access to Recreation Facilities (Gi)	Access to Training and Educational Centers (Ni)	Access to the City Center (Zi)
Average value	1,1415	1,2362	1,2127	1,8817
Standard deviation	0,2644	0,3917	0,3555	1,4739
Minimum value	0,6063	0,5033	0,5301	0,4339
Maximum value	1,6130	1,9228	1,8344	6,6854

Source: formed by the authors.

the weighted average of the accessibility to the gravity centers was calculated on average in the city: S_{Bav} = 8999,4458. The next step is to compare the accessibility index of the assessment area to the centers of gravity (S_{B7904}) with a weighted average of the city (S_{Bav}) according to formula 4 (table 1). At this stage, it should be kept in mind that the higher the accessibility factor to the center of gravity, the greater the value of land, respectively, if the estimated area of accessibility is less than the city average, its value should be greater than one, so when calculating the accessibility index of the i-th assessment area to the center of gravity (B_i) the inverse value is used, i.e.: B_{7904} = S_{B7904}/S_{Bav} = 7248,1324/8999,4458 = 0,80539. Condition check – the relation of accessibility index to the centers of gravity in the area is lower than the city average, therefore: B_{7904} = 1/0,80539 = 1,2416.

Similarly, the accessibility index of assessment areas to recreation facilities (G_i), accessibility index of assessment areas to training and educational centers (N_i) and the accessibility index of assessment areas to the city center (Z_i) was calculated. For the assessment area 7904 the mentioned indices are: G_i = 1,7697; N_i = 1,5549; Z_i = 3,6820.

The calculation of the transport and functional convenience index of the territory is carried out by weighing individual factors. Analysis of the of the normative monetary valuation lands results of Ukrainian cities in previous years allowed to determine the weights (W) for each criterion for assessing transport and functional convenience: accessibility to gravity centers (W_B=0.1), to recreation facilities (W_G=0.15), to training and educational centers (W_N=0.15) and to the city center (W_Z=0.6). In our opinion, the issue of determining weights is debatable and needs to be improved and scientifically substantiated, which is the basis for further research. For the assessment area 7904 the index of transport and functional convenience of the territory will be:

$$S_{7904} = B_{7904} \times W_B + G_{7904} \times W_G + N_{7904} \times W_N + Z_{7904} \times W_Z = 1.2416 \times 0.1 + 1.7697 \times 0.15 + 1.5549 \times 0.15 + 3.6820 \times 0{,}6 = 2.8320$$

Similar calculations were performed on the remaining 511 assessment districts of the city, which allowed us to perform a statistical analysis of the data (Table **4**).

Thus, on average in the city, the assessment areas in terms of accessibility to centers of gravity, recreation facilities, training and educational centers do not deviate significantly from the average value - the standard deviation for them is in the range from 0.2644 to 0.3917, and the average value is greater than 1, i.e. the estimation areas are evenly spaced from the centers of gravity, but this distance is less than the city average. This is also evidenced by the values of maximum and minimum availability factors. Considering the index of accessibility to the city center, an increase in the standard deviation and a significant difference between the minimum (0.4339) and maximum (6.6854) value should be noted. On the one hand, this is due to the presence of remote areas to the city center, and on the other hand, it indicates the need to clarify the impact weight of this rent-forming factor on the value of urban land.

The existing methodology for calculating the coefficient that characterizes the zonal factors of the land location (Cm4), for the assessment area does not involve the use of geographic information technology, but is calculated as the ratio of the sum of scores of this assessment area to the average amount of scores of city assessment areas. This methodology is convenient to apply to small and medium-sized settlements, for large settlements it involves significant time spent on surveys of respondents (experts), analysis and interpretation of data. The use of modern geographic information technologies allows to simplify, automate, speed up and reduce the cost of this process. At this stage, a comparison of existing and new indicators of the transport and functional convenience index of the assessment areas (S_i) of a city was conducted, clarifying that we have improved the calculation of accessibility indices (Bi;Gi;Ni;Zi), but weighted coefficients ($W_{(B;G;N;Z)i}$) remained unchanged (Table **3**).

Comparing existing and new indices of transport and functional convenience of the territory assessment areas (S_i) of the city, it should be noted that the existing minimum value is 0.5496, and the new minimum value is 0.4760. The maximum existing value of the index is 5.2588, and the new - 4.7087, which indicates a decrease in the variability of transport and functional convenience index and a more detailed consideration of transport and functional rent-generating factors available in the settlement. This is also evidenced by the Standard Deviation value. Thus, the existing standard deviation of the index (S_i) is 0.0556, and the new one is 0.0442, i.e., the new indicators deviate less from the average value of the index.

The calculations make it possible to display the value of transport and functional convenience index of the assessment areas (S_i) on the territory of a separate administrative district (Fig. **4**) and the city as a whole in a separate layer of the

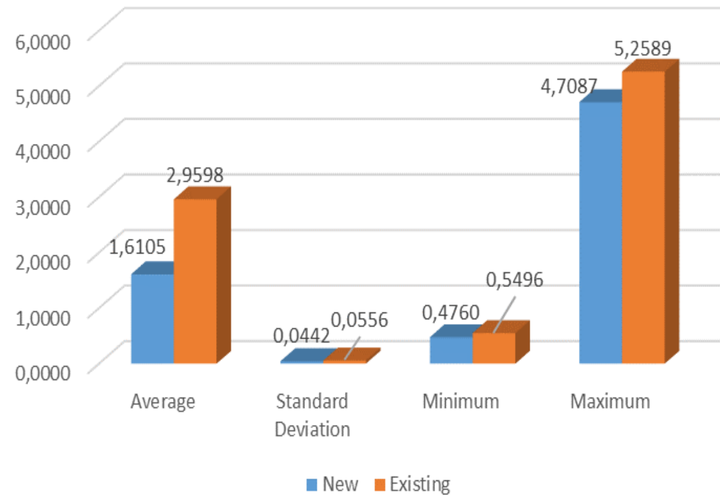

Fig. (3). Statistical analysis of transport and functional convenience index of the assessment areas territory (S_i) according to existing and new indicators.

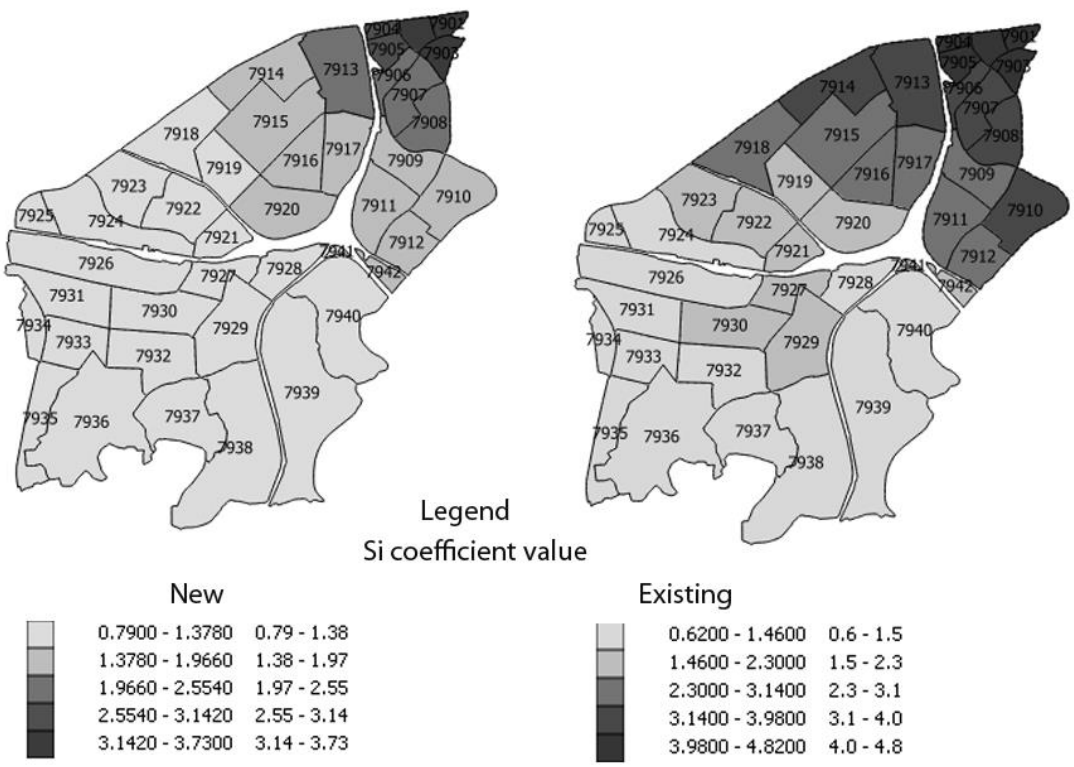

Fig. (4). Fragment of assessment districts grouping of the city according to the index of transport and functional convenience (S_i). Source: formed by the authors.

model. The layer of transport and functional convenience was imposed on the assessment districts of the city, which allowed to group the assessment districts into 5 groups at equal intervals and compare them with each other. The assessment areas were grouped using "The Graduated Sign" module of the QGIS software.

In order to apply the index of transport and functional convenience of the assessment areas (S_i) when calculating the normative monetary valuation of land, it is necessary to calculate the coefficient characterizing the zonal factors of land location (Cm4) by weighing individual indices that reflect the value of urban lands: the index of transport and functional convenience of the territory (Si); index of engineering and infrastructural arrangement of the territory (Ui); index of ecological quality (ecological condition) of the territory (Ei); index of environment social attractiveness (Ci).

To calculate the weighing (calibration) coefficients, the results of normative monetary valuation of the city territory of previous years, the results of normative monetary valuation of other cities of Ukraine and expert estimates of weight values were analyzed, resulting in the following weight (W) coefficients: $W_{Si} = 0{,}45$; $W_{Ui} = 0{,}22$; $W_{Ei} = 0{,}15$; $W_{Ci} = 0{,}18$.

Table 5. Statistical Analysis of the Residential Land Value of 1m2 within the Assessed Areas of the City in Existing and Project Indicators, UAH/m^2.

Index		Existing		New
Minimum		339,8300		310,7359
Maximum		2444,4934		2274,0144
Average		1298,8965		915,8021
Standard Deviation		513,995		442,022
Statistical grouping				
Intervals	Frequency (Existing frequency)	% all observations (of all observations)	Frequency	% all observations
76,74<NMV<=602,91	49	9,57	104	20,31
602,91<NMV<=1129,08	155	30,27	270	52,73
1129,08<NMV<=1655,25	167	32,62	76	14,84
1655,25<NMV<=2181,41	118	23,05	47	9,18
2181,41<NMV<=2707,58	23	4,49	15	2,93
Total	512	100	512	100

Calculation of Cm4 coefficient is performed according to formula 2 (Table **1**).

It is offered to calculate the impact of changes in the index of transport and functional convenience of the territory on the coefficient that characterizes the zonal factors of the land plot location (Cm4) of the assessment area. Only one indicator will be changed (S_i), other indicators are remained unchanged. For the assessment area 7904 existing ($Cm4_{7904ex}$) and new ($Cm4_{7904new}$) indices are:

Cm47904ex = 4,4149×0,45+ 1,8845×0,22+ 0,3968×0,15+ 1,4902×0,18 = 2,7291

$Cm4_{7904new}$ = 2,8320×0,45+ 1,8845×0,22+ 0,3968×0,15+ 1,4902×0,18 = 2,0167

Therefore, the ratio of the new Cm4 to the existing one is 0.73. In general, in the settlement of 512 assessment districts in 320 assessment units, the ratio of the existing Cm4 to the new one is close to 1, the average value is $Cm4_{ex}/Cm4_{new}$ =0,72, minimal is 0.37, maximum is 1.66; standard deviation is 0.17. Grouping the obtained data at equal intervals allowed us to draw the following conclusions: in the city as a whole, 189 assessment areas have a ratio of $Cm4_{ex}/Cm4_{new}$ from 0,3 to 0,65; 296 assessment areas 0,65< $Cm4_{ex}/Cm4_{new}$ <=1,0; 26 assessment areas 1,0< $Cm4_{ex}/Cm4_{new}$<=1,35; and 1 assessment area 1.35< $Cm4_{ex}/Cm4_{new}$ <=1,7.

At the next stage of the study we calculated the normative monetary value of 1m2 of land for housing in terms of assessed areas of the city in the order shown in Table **1**, taking into account existing and new indicators of the coefficient Cm4. Here is an example of the NMV calculation of 1m2 of land with an area of 1m2 in the assessment area 7904. Indicator of the land area (S) take the level of 1m2. The norm of capitalized rental income (Nri) for residential and public buildings, according to Annex 1 of the Methodology [2] is 639 UAH/m2 (population in the studied city is 149 thousand people). Coefficient that takes into account the location of the territorial community within the zone of large cities influence (Cm1) = 1 (Annex 3 of the Methodology [2]). Coefficient that takes into account the recreational value of settlements (Cm2 = 1) (Annex 4 of the Methodology [2]). Coefficient that takes into account the location of the territorial community within the zones of radiation pollution (Cm3 = 1) (Annex 5 of the Methodology [2]). Coefficient that characterizes the zonal factors of the land location: existing: $Cm4_{7904ex}$= 2,7291; new: $Cm4_{7904new}$ = 2,0167. The coefficient that takes into account the purpose of the land in accordance with the State Land Cadastre (Cp) for residential lands, in accordance with Annex 8 of the Methodology [2], is equal to 1. The coefficient, which takes into account the peculiarities of land use within the category of land by main purpose (Cpp), for residential lands in accordance with paragraphs 12-17 and Annexes 9-14 of the Methodology [2], is equal to 1. The product of indexation coefficients of regulatory monetary valuation lands for the period from the approval of the standard of capitalized rental income to the date of the assessment (Cni) at the time of the assessment is 1.0.

Thus, the monetary value of 1 m^2 of residential land in the assessment area 7904 (NMV_{7904}) according to existing and new indicators is:

$NMV_{7904\ ex}$ = 1м^2×639 UAH/m^2×1×1×1×2,7291×1×1×1 = 1743,8949 UAH

$NMV_{7904new}$ = 1м^2×639 UAH/m^2×1×1×1×2,0167×1×1×1 = 1288,6713 UAH

Thus, according to new indicators, the normative monetary value of residential land is reduced by 455.2236 UAH for 1 m^2.

Next, we calculated the normative monetary valuation of land for each assessment area of the city, taking into account the existing and new coefficient Cm4, statistical analysis of the obtained indicators is given in Table **5**.

CONCLUSION

As a result of the study, the goal of improving the approach to assessing and considering the factors of transport and functional convenience during the regulatory monetary valuation of land in cities was achieved. The modern method of normative monetary valuation of lands is analyzed, the author's definition of the concept "valuation area" is formulated, the scientifically substantiated system of indicators for estimation of transport-functional convenience of estimation areas, algorithms of their calculation and application of the received results in normative monetary valuation of land plots is defined. On the one hand, the study allowed to consider all indicators that may affect the value of urban land and improve the approach to results interpretation - to take them into account when conducting regulatory monetary valuation of urban land as a whole, individual areas and land assessment. On the other hand, the algorithm that involves the use of GIS allows to form a database of spatial factors of transport and functional convenience of the city, which is the basis for further creation of a series of maps and geographic information model of regulatory monetary valuation. The matrices and geoinformation models obtained as a result of the research allow to use them not only in land valuation, but also in other spheres.

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