ГЕОДЕЗІЯ ТА ЗЕМЛЕУСТРІЙ. ТОПОГРАФО-ГЕОДЕЗИЧНЕ І КАРТОГРАФІЧНЕ ЗАБЕЗПЕЧЕННЯ ЗЕМЛЕВПОРЯДКУВАННЯ

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THE PRACTICE OF THE CALCULATION OF LAND PLOT PHYSICAL AREA

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Abstract. *The issue of physical area calculation has been scrutinized in the article. The research rationale is predefined by the influence of the accuracy of land plot area determination on the economic, environmental, and social components of land tenure. The issue of physical characteristics of a land plot at the determination of its area has been singled out in the article. The goal of the research is the substantiation of the use of land plot physical area calculation methodology in the current social and economic environment. The notion of land plot physical area has been provided. The trends of the application of land plot physical area determination methodology have been systemized. The methodology of land plot physical area determination by means of marking out polygons and determining the average slope has been used. The calculations of land plot area considering the relief at various quantities of the division of a triangle side have been made. Comparison with the calculation of area without considering the relief has been performed. The regression analysis of the dependence of physical area change with the change of the quantity of triangle side divisions has been carried out. The calculation of the relief complexity index for the determination of land plot physical area has been presented. This calculation confirms the economic viability of the determination of a land plot physical area by the suggested methodology at land improvement and agrotechnical activities. The result can be used for various works connected to the spatial aspects of land use and in the following scientific researches.*

Keywords: *physical area, land plot, land plot area, relief, mathematical modelling.*

Introduction.

Accurate data on land plot area is important at land resources management [1] and for the actual sustainable development [2]. Land plot area accurateness influences the effectiveness of land use and conservation measures, rational land tenure economic encouragement, land distributive justice, land title assurance, etc.

The determination of the physical area of land plots with a complicated configuration and relief is one of the most important aspects. According to researches [3] the area of a land plot without considering its physical characteristics can differ up to 20 per cent of its actual area. The calculation of the land plot physical area with the provision of sufficient substantiation has a prospect of application in various branches.

The researches of a number of Ukrainian and foreign scientists were dedicated to the issues of the determination of a land plot area accurateness: V.D. Baranovskyi, Yu.H. Batrakov, V.I. Balandin, M. Ya. Bryn, M.H. Viduiev, S.P. Voitenko, V.N. Hanshyn, A.I. Danylovych, O.L. Dorozhynskyi, B.N. Diakov, R.M. Litnarovych, A.V. Maslov, Yu.K. Neumyvakin, A.L. Ostrovskyi, M.I. Perskyi, U.D. Samratov, V.M. Serdiukov, A.V. Yuskevych, A.H. Yunusov et al.

The goal of the research is the employment substantiation of the methodology of land plot physical area calculation.

Research methods and materials.

Physical area is the area of earth surface within the land plot considering the ground roughness (slopes, ravines, clifts, etc.). The geodetic area of a land plot is defined by the coordinates of its boundaries rotation angles. Mathematically, it is the area of the projection of the land plot boundaries on the projection subspace in the Gauss-Krüger geodetic reference system.

The analytical determination of the area of a polygonal plot P is calculated by rectangular plane coordinates x, and by Gauss-Krüger formulas [4]:

$$P = \frac{1}{2}\sum_{1}^{n} y_k\left(x_{r-1} - x_{k+1}\right); \quad (1)$$

$$P = \frac{1}{2}\sum_{1}^{n} x_k y_{k+1} - \sum_{1}^{n} x_{k+1} y_k; \quad (2)$$

$$P = \frac{1}{2}\sum_{1}^{n} \left(x_k + x_{k+1}\right)\left(y_{k+1} - y_k\right); \quad (3)$$

$$P = \frac{1}{2}\sum_{1}^{n} X_k\left(y_{k+1} - y_{k-1}\right), \quad (4)$$

where P is the area of a land plot;

x, y are the geodetic coordinates of landmarks;

n is the total quantity of the boundaries landmarks;

k is the number of a landmark.

These formulas define the fixed geodetic plot area, i.e. the projection of its boundaries on the topographic subspace in the Gauss-Krüger projection.

It has been suggested to improve the modelling of the physical surface relief and increase the physical area calculation accurateness by using the methodology which predefines the marking of polygons and the determination of the average slope [5]. Land plot area P is calculated as the total of areas of triangles m, which are the constituents of a land plot with complicated relief and configuration in accordance with the methodology [3]:

$$P = \sum_{j=1}^{m} P_j .$$

The developed surface physical area determination methodology allows resolving a wide range of application tasks in many branches, the main list of which is presented in Fig. 1.

At current conditions, works connected to the definition of land plot area

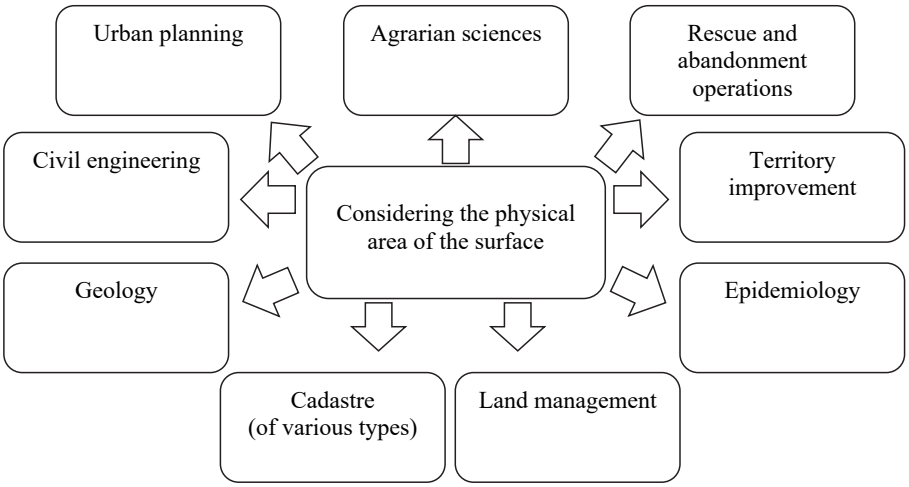

Fig.1. The directions of the practical application of the defined surface physical area

considering the terrain physical surface are of great importance at the resolving of urban planning tasks, development of recreation facilities, location surveys, road construction, crop rotation planning, farm operations, defining the erosion, snow, mud and rock avalanche tow in mountains, prediction of landslides,

Table.1. **Land plot area determination**

Triangle side division quantity	Plot area without considering the relief	Plot area considering the relief	Relief complicatedness index	Area change, %	Triangle side length
1	846668	848414	0.99	0.2	34.300
2	846668	852533	0.98	0.6	14.710
3	846668	863755	0.96	2.0	11.430
4	846668	869787	0.94	2.7	8.575
5	846668	873298	0.94	3.1	6.860
6	846668	880094	0.92	3.9	5.717
7	846668	884570	0.91	4.4	4.900
8	846668	885816	0.91	4.6	4.288
9	846668	888944	0.91	4.9	3.811
10	846668	891342	0.90	5.2	3.430
15	846668	900064	0.89	6.3	2.287
20	846668	907870	0.88	7.2	1.715
25	846668	914403	0.87	8.0	1.372
30	846668	920711	0.86	8.7	1.143
33	846668	956730	0.82	11.3	0.260

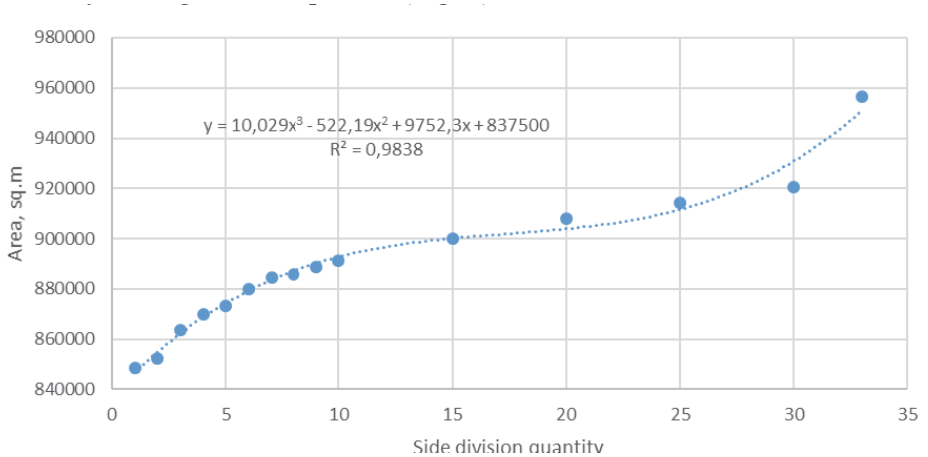

Fig.2. Polygon area calculation, scale 1:500

maintenance of resorts in mountain and hill terrains, construction site vertical planning, linear structure landscape engineering, etc. [5]. The examples of the implementation of the developed methodology in agricultural sciences and territory improvement have been presented in this study.

Using the methodology [5], let us scrutinize an example of the area determination of a land plot with complicated configuration and relief. Calculation for a land plot in M 1:500 map scale is presented in Table.1.

Data provided in Table.1, demonstrates how the area considering the relief is changed depending on the side division quantity. This area is being increased with the increasing side division quantity due to more precise consideration of the relief. Dependence of the change of physical area with the change of side division quantity is reflected by the regression equation (Fig. 2).

It is possible to draw a conclusion from the diagram, that the application [3] stopped on the 33th division, land plot area in the 1:500 scale is 956730 m2.

Relief complicatedness index also depends on the quantity of divisions. It is demonstrated on Fig. 3. The change of the calculated area and its ratio to geodetic land plot area at 33 divisions of sides is 0.82. The very index value characterizes the complicatedness of the relief of this polygon in accordance with the methodology.

A conclusion can be drawn from the calculations, that at one polygon side division, the area considering the relief differs from that calculated without considering the relief by 0.2%. It is the evidence that the triangles, with the help of which the physical area is calculated, revise the relief. With increasing the quantity of divisions, land plot area is changed at every side division. Let us scrutinize data in Table.1, where the length of a square side is reflected. We can draw a conclusion that in this case, for 1:500 scale, the area at 33th side division, when the triangle side, in which the polygon is distributed, is 0.26 m, is considered to be the most accurate result for the calculation of the final area. The final physical area of the polygon at 33th side division differs from area without considering the relief by 11.3%.

It has been revealed that it is reasonable to use the scale test for polygons with rugged relief.

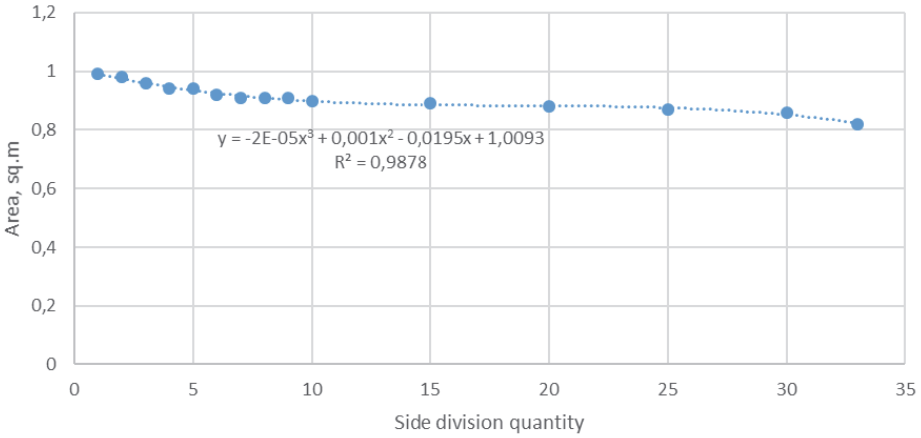

Fig.3. Defining the polygon relief complicatedness index, scale 1:500

Research results.

The methodology of land plot area determination considering the relief was implemented by an agricultural enterprise and a landscape design company [5].

Taking into consideration the physical surface at the calculation of costs for the cleaning of the territory is an example of this methodology in the context of the economic substantiation of territory improvement. Calculation is presented in the Table.2.

The developed algorithm makes it possible to reflect the actual situation on the territory improvement and calculate costs according to physical area.

The implementation of the developed methodology in landscape design is presented in Table.3.

The implementation of physical area calculation methodology at fertilizer distribution on agricultural land plots is presented in Table. 4.

Table. 2. **Territory improvement costs calculation**

Cleaning costs, 1 m²/UAH	7.30
Total land plot area according to the title, m²	3500
Calculated area considering the relief, m²	3760
Difference, m²	160
Difference, UAH	1168

Table.3. **Territory improvement optimisation with the implementation of land plot physical area calculation methodology**

Value of one m2 of roll lawn, UAH	42
Total land plot area according to the title, ares	35
Built-up territory, ares	13.2
Calculated area considering the relief, ares	37.6
Difference, ares	1.6
Value, UAH	13600

Table.4. **Agriculture optimisation with the implementation of land plot physical area calculation methodology**

Value of 1 ton of fertilizer, UAH	3000
Total land plot area according to the title, ha	20
Calculated area considering the relief, ha	20.7
Difference, ha	0.7
Difference, UAH	2100

Conclusions and prospects.

The developed methodology helps to improve the modelling of the physical surface relief and increase the land plot physical area calculation accurateness. The directions of land plot physical area application have been systematised. This study confirms the economic viability of the determination of a land plot physical area by the suggested methodology at land improvement and agrotechnical activities. The results of the research uphold the effectiveness of the implementation of the methodology at the resolving of various tasks connected to land use spatial aspects.

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ПРАКТИКА РОЗРАХУНКІВ ФІЗИЧНОЇ ПЛОЩІ ЗЕМЕЛЬНИХ ДІЛЯНОК

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Анотація. *У статті розглядається питання розрахунку фізичної площі земельних ділянок. Актуальність дослідження обумовлена впливом точності визначення площ земельних ділянок на економічну, екологічну, соціальну складову землекористування. У статті виокремлено проблему врахування фізичних характеристик земельних ділянок при визначенні їх площі. Мета дослідження полягає в обґрунтуванні застосування методики розрахунку фізичної площі земельних ділянок в сучасних соціально-економічних умовах. Наведене поняття фізичної площі земельних ділянок, систематизовано напрямки застосування методики визначення фізичної площі земельних ділянок. Використана методика визначення фізичної площі земельної ділянки шляхом розмічування полігонів та визначення середнього ухилу. Проведені розрахунки площі земельної ділянки із врахування рельєфу при різних кількостях поділу сторони трикутника. Виконано порівняння із розрахунками площі без вра-*

хування рельєфу. Здійснений регресійний аналіз залежності зміни фізичної площі зі зміною кількості розбиття сторін трикутників. Наведені розрахунки коефіцієнту складності рельєфу для визначення фізичної площі земельної ділянки; розрахунки, які підтверджують економічну доцільність визначення фізичної площі земельної ділянки за запропонованою методикою при проведенні благоустрою території та при агротехнічних роботах. Отримані результати можуть бути використані в різних видах робіт, пов`язаних із просторовими аспектами використанням земель, в наступних наукових дослідженнях.

Ключові слова: *фізична поверхня, земельна ділянка, площа земельної ділянки, рельєф, математичне моделювання.*

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ПРАКТИКА РАСЧЕТОВ ФИЗИЧЕСКОЙ ПЛОЩАДИ ЗЕМЕЛЬНЫХ УЧАСТКОВ

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Аннотация. *В статье рассматривается вопрос расчета физической площади земельных участков. Актуальность исследования обусловлена влиянием точности определения площадей земельных участков на экономическую, экологическую, социальную составляющую землепользования. В статье выделена проблема учета физических характеристик земельных участков при определении их площади. Цель исследования состоит в обосновании применения методики расчета физической площади земельных участков в современных социально-экономических условиях. Приведено понятие физической площади земельных участков, систематизированы направления применения методики определения физической площади земельных участков. Использована методика определения физической площади земельного участка путем разметки полигонов и определения среднего уклона. Произведены расчеты площади земельного участка с учетом рельефа при разных количествах разделения стороны треугольника. Произведено сравнение с расчетами площади без учета рельефа. Осуществлен регрессионный анализ зависимости изменения физической площади с изменением количества разбиений сторон треугольников. Представлены расчеты коэффициента сложности рельефа для определения физической площади земельного участка; расчеты, подтверждающие экономическую целесообразность определения физической площади земельного участка по предложенной методике при проведении благоустройства территории и при агротехнических работах. Полученные результаты могут быть использованы в разных видах работ, связанных с пространственными аспектами использования земель, в последующих научных исследованиях.*

Ключевые слова: *физическая поверхность, земельный участок, площадь земельного участка, рельеф, математическое моделирование.*