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ORIGINAL ARTICLE

Unreliability of cadastral data on parcel area and its effect on sustainable real estate valuation

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Abstract

Appropriate and sustainable management of land is required to the preserve spatial order and the appropriate use of resources. To make quality decisions in space, as well as to actively manage a resource, it is crucial to be able to use, among others, credible, up-to-date spatial details, including the cadastral data. The question is, however, whether the data inscribed in the cadastre correspond to reality. Among others, the problem of considerable differences between recorded, cadastral and geodetic area (reflecting actual circumstances) of the parcels can be commonly observed, influencing the procedure of real estate appraisal. This research examines the scale of the problem of unreliability of cadastral data regarding the area of parcels. Based on the example of a middle-sized city, analyses of the scale of the problem and an investigation of the types of properties most commonly involved were conducted. Moreover, an analysis of legal acts in force and those already expired, as well as the literature on the subject was performed to determine the permissible differences in the area between relevant records. The influence of the unreliable cadastral data on the procedure of appraisal of real estates was also investigated.

Key words: cadastral area, real estate value, differences in area, geodetic area, cadastral data

1 Introduction

Appropriate and efficient management of real estate enables the sustainable use of resources and preservation of the spatial order. It requires the availability of data from many different sources in order to obtain as complete information about a given property as is available.

Busko and Apollo (2023) point out that only reliable, standardized and up-to-date cadastral data constitute a suitable basis for efficient and productive processes of land management including taxation, agricultural subsidies, and land valuation. As emphasised by Roić et al. (2021), inaccurate records negatively influence the quality of decision-making, while improved spatial records would result in increased consumer trust and confidence.

Busko et al. (2022) state that each country has its individual definitions of the cadastre (land and building register) and the register of ownership. Although in Poland the designation of real estate in the land and mortgage register is not subject to a presumption of truthfulness, nor is it protected by the warranty of public credibility of land and mortgage registers, it has a significant impact on real estate transactions. Meanwhile, the Finnish land register is characterized by full negative or positive faith and credit, so that a third party can trust the rights inscribed in the register (Krigsholm et al., 2017). The authors mention that the cadastre is not considered as representing the same level of reliability because of defects resulting from differences in practices of recording easements, rights of use and restrictions. According to Bajtala et al. (2017), following the current regulations, also in the Slovak Republic parcel area records do not constitute legally-binding information.

The problem of reliability of cadastral data on the parcels seems especially important considering that the cadastre is the basis for the designation of real estate in mortgage registers, and it also informs the process of their valuation. Meanwhile, following Sisman et al. (2023), real estate valuation constitutes an objective field of study based on scientific foundations that should consider social justice. Ostapchuk et al. (2021) point out that there are several factors the value of land resources depends on, related to the market value of properties or the sustainable value defied by Walacik et al. (2020). The factors include, among others: land allocation, zoning, land use planning, infrastructure development, relationship between demand and supply on the given market, environmental regulations, the properties of soils, its productivity, the value-added premium, the surrounding area, inflation, benchmark land prices. Yildiz et al. (2022) highlight that among different parcel attributes, data concerning its area have the greatest impact on financial systems. Even though researchers all over the world make efforts to solve the problem by proposing new algorithms, such as one for theremote measurement of a building's usable floor area – Janowski et al. (2021), a noticeable problem of unreliability of data – especially considerable differences between cadastral (registered) and geodetic area (reflecting the actual circumstances) of parcels can be commonly observed. As indicated by Yildiz et al. (2022), court cases from Continental Europe have showed that, in case of differences between the area inscribed in the official registers and the factual (geometric) area, the parties sustaining losses may be entitled to a compensation. The Authors point out that the Republic of Turkey has been found responsible for financial losses resulting from errors in the recorded area information.

The authors claim that reliable cadastral data are the basis for effective real estate management, including increasing the certainty of results in the real estate valuation process. This publication showcases the scale of the problem of unreliability of the cadastral data concerning the area of parcels on the basis of examples from the city of Kielce, Poland. Analyses were aimed at recognizing among which attempt to identify the types of property where the problem is most common, hence the study includes a breakdown by land use group and their purpose. Moreover, an analysis of the legal acts in force and those already expired is made for the purpose of determining the permissible difference in area followed by research conducted to discern the impact of unreliable cadastral data regarding the area of parcels on real estate valuation. A comparison was made between the differences in property values determined for the same property after taking into account the geodetic and cadastral area of the parcels.

2 Literature review

2.1 Area of a parcel in valuation of real estate

The real estate market plays an important role in economy (Bryx, 2006). Despite the fact that it is not fully transparent and organized, it still enables real estate trading. The unique nature of the real estate market stems from the fact that one of the key attributes of a property is the permanence of its location in a specific area on the earth's surface. This feature entails a number of other distinctive characteristics of the real estate market Piasecka (2017). The more individual features of a property, the lower is the market activity and the more complex is the process of objectivization of the assessment of real estate (Foryś and Gaca, 2020; Kucharska-Stasiak, 2013).

According to Kocur-Bera (2016), in Poland, the factors the value of land resources depends on can be divided: relatively permanent, exogenous (such as transport and retail networks, demographic relationships, urban development, etc.), and anthropogenic, endogenous (for example, the size and shape of plots, the use of land, location.). As pointed out by Dąbrowski and Latos (2015), the most important component of land valuation is the appropriate selection and identification of the characteristics, as well as the determination of their importance – which have the greatest impact on the value of a property, together with establishing the purpose of land use. Planning decisions regarding the use of undeveloped land also influence its market value. This strong dependence and impact of planning decisions on land use, as well as the value of land real estate, are mentioned by, among others, Krajewska et al. (2014) and Friedmann (2004). Another important indispensable factor in the valuation of real estate, regardless of its type, is the quality of the data from the cadastre (Hopfer, 1994), primarily data identifying the real estate in space, so as to ensure safe real estate trading. The range of data from the cadastre is wide and one of the types of information referred to by the appraiser in the prepared opinion is the description of the surface of the plot. The size of the plot has an informative value and it also constitutes a market feature commonly taken into account in the valuation process (Kononova and Zatolokina, 2020; Matko, 2008). As Ritter et al. (2020) notes, the complex relationship between land price and plot size cannot be captured by a simple functional formula, since it is affected by several factors. Finally, the plot surface is also a reference unit, which directly affects the valuation (area multiplied by unit price, e.g., 1 m^2 of land), regardless whether the land is intended for residential, service or agricultural purposes. As Gilbertson (2001) notes, regardless of the level of property market development, the client bears the cost of the calculations. The uncertainty of the input data puts the result of the exercise at risk of failure from the very beginning. The degree of the uncertainties varies according to the level of market activity. The more active a market, the more credence is given to the input information (French and Gabrielli, 2004). Therefore, it is crucial that the data regarding the surface that the appraiser obtains from the cadastre are correct.

2.2 Reliability of the cadastral data on the area of parcels

As mentioned above, the source of spatial information regarding land in Poland, including its location, boundaries, area, or land use, is the cadastre. The cadastral survey, consisting of digital databases includes information concerning identifiers of cadastral parcels, numerical description of boundaries, and data on their area. In addition to the cadastral area, the cadastral register also shows the areas of the state's territorial subdivisions as recorded in the state register of boundaries and the areas of the country's territorial subdivisions, referred to as "geodetic areas", as well as the differences between the above-mentioned areas. As a rule, the geodetic area, as accepted as the correct one, is calculated based on the coordinates of the parcel's boundary points (with precision of up to 0.0001 ha). In Poland the rules concerning both the determination of boundaries and the area of parcels as well as accuracy requirements are equal regardless of the land use they represent. The geodetic situational measurement of field details of the first group, which covers the boundary points, determines the position of the detail in relation to the points of the horizontal geodetic or survey control, with an accuracy of not less than 0.10 m. In turn, as highlighted by Hanus et al. (2020), the quality of data on the area of a parcel is most commonly determined by the mean errors of the boundary point position, as well as based on the origin of the information about their coordinates. The authors point out that the cadastral data could have been collected in different periods by various methods, so that the database can contain data of differentiated quality. Benduch (2016) concludes that the accuracy of analytical determination of the parcel area is also affected by the geometry of a parcel and the number of parcel boundary bend points. Doskocz (2011) points out that the size of the geometric figure is also important in this regard, and the decrease in the accuracy of the area calculation is caused by the increase in the elongation of the surface object. Furthermore, Kocur-Bera (2019) indicates that the existing differences could also be attributed to insufficient updates of the data inscribed in the cadastre.

All changes to cadastral data in Poland, including changes to the area of a plot, are introduced as an ongoing update or modernization (periodical update) of the record and are conducted by the bodies responsible for its maintenance. According to the current technical standards (2020), the area of a plot that is different from the cadastral one can be shown in the surveying documentation only if the analysis of the resource materials and the results of the measurement showed that the course of all the boundaries of that parcel was established in administrative or judicial proceedings or in accordance with the provisions issued under Article 26 paragraph 2 of the Law (1989). Thus, in the current legislation, the requirements placed on the geodetic-legal documentation of the parcel of land, the area of which will be updated, have been made much more complex. There is no possibility to update the area inscribed on the cadastre unless all the boundaries are established. In the current legislation there is no formula for the permissible difference of area; however, over the years, the regulations concerning the issue and the relevant recommended calculation formulas have been changed. Table 1 shows examples of the guidelines for calculating the area in Poland according to the legal acts in force and those already expired.

Table 1. The content of the legal acts in force and those already expired on the permissible difference of area

ORDINANCE OF THE MINISTER OF DEVELOPMENT **of 18 August 2020 on technical standards for performing geodetic situational and altitude measurements**, as well as the development and transfer of the results of such measurements to the state geodetic and cartographic resource *(provision in force)*
§ 41. 1. Showing in the documents, resulting from the surveying work, the area of a registered parcel of land other than that disclosed in the cadastre may take place if the analysis of the resource materials and the results of the measurement show that the course of all the boundaries of the parcel has been established in administrative or judicial proceedings or in accordance with the provisions issued pursuant to Article 26 paragraph 2 of the law.
ORDINANCE OF THE MINISTER OF DEVELOPMENT **of 9 November 2011 on technical standards for performing geodetic situational and altitude measurements**, as well as the development and transfer of the results of such measurements to the state geodetic and cartographic resource *(regulation not in force)*
§ 68. 1. The working database shall disclose the area of the cadastral parcel calculated based on the measurement results if: 1) the measurement of the boundary points of this parcel was performed with greater accuracy than the measurement being the source of cadastral data obtained from the national geodetic and cartographic resource (PZGiK); 2) there is no evidence in the PZGiK materials indicating that the measurement being the source of cadastral data was preceded by the determination of the position of the boundary points. 2. If the circumstances referred to in paragraph (1) do not occur, the area of the cadastral parcel calculated on the basis of measurement shall be disclosed in the working database, if the difference between the area calculated and the area of the cadastral parcel disclosed in the land and buildings register exceeds the value calculated according to the formula: $$dP_{max} = m_p \sqrt{\frac{\sum_{i=1}^{n} d_{i-1,i+1}^2}{8}}$$ in which: m_p - denotes the average error in the position of the boundary point, $d_{i-1,i+1}^2$ – the shortest diagonal opposite the point with the number i.
REGULATION OF THE MINISTER OF REGIONAL DEVELOPMENT AND CONSTRUCTION **of 29 March 2001 on land and building registration** *(regulation not in force)*
§ 82. 1. When performing a comprehensive modernization of the registry, established before the entry into force of the Ordinance, existing materials and data of the national geodetic and cartographic resource are used to prepare a numerical description of the boundaries of the parcels, even if they do not meet the requirements of the applicable technical standards. 4. In the event that the cadastral data, determining the location of the break points of the boundary lines of the parcels, adopted during the comprehensive modernization of the records, do not meet the requirements of the applicable technical standards, in the modernized records the area fields of the evidentiary parcels are adopted on the basis of the existing records.
INSTRUCTION G-5 REGISTRY OF LAND AND BUILDINGS *(regulation not in force)*
§102. 1. The area of registered parcels in the process of modernization of the cadastre (P_{geod} – geodetic area) are compared with the corresponding registration data (P_{ew} – cadastral area) and the area deviation is calculated according to the formula: $$dP_1 = P_{geod} - P_{ew}$$ 4. In the record keeping operation, the following is disclosed: 1) the cadastral area, when the value of dP_1, referred to in paragraph 1 does not exceed the value of dP_{max}, calculated according to the formula: $$dP_{max} = 0.001 \cdot P + 0.2 \cdot \sqrt{P}$$ in which P means the area of the geodetic surface expressed in m^2, 2) the geodetic area, when the value of dP_1 referred to in paragraph 1 exceeds the value of dP_{max}.

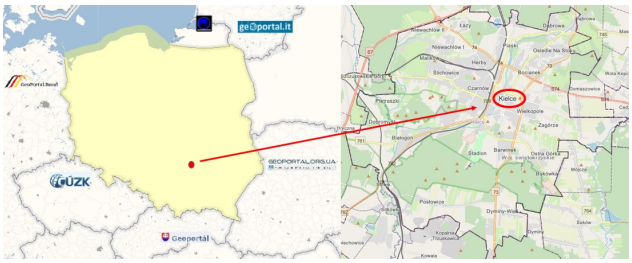

Figure 1. Study area – city of Kielce; (Source: Own elaboration based on www.geoportal.gov.pl and www.bdl.lasy.gov.pl)

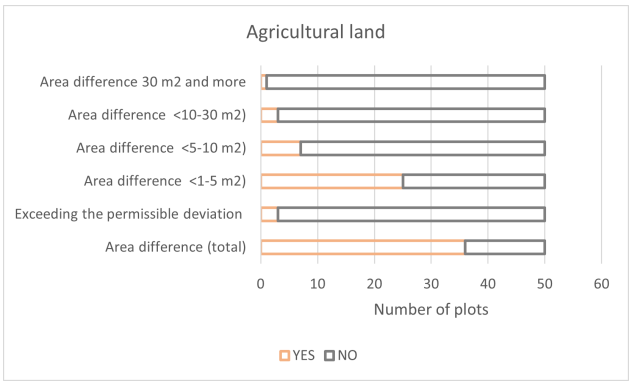

Figure 2. Distribution of plots classified as agricultural land for which differences in the cadastral and geodetic area were recorded

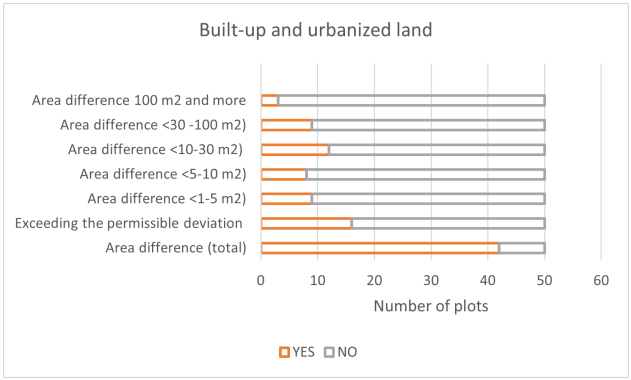

Figure 3. Distribution of plots classified as built-up and urbanized land for which differences in the cadastral and geodetic area were recorded

3 Study area, methods and materials

3.1 Study area

The study area (Figure 1) encompasses is the city of Kielce, situated in the south-east of Poland, and with the population of 183 885 inhabitants (as of 31.12.2022) (GUS, 2023),. It is the capital of the Świętokrzyskie Voivodeship and its centre in terms of economy, education, communication and culture. It is characterized by a diverse terrain form and dense urban development.

According to summary statement from 2019 (GUGiK), the Kielce land area is approximately 1 171 236 ha, containing approximately 338 205 ha of forest and wooded and shrub land (28.88%), 765 736 ha (65.38%) of agricultural land, 57 033 ha (4.87%) of urbanized land, 8800 ha (0.75%) of land under water, 377 ha (0.03%) of ecological land, and 1085 ha (0.09%) of other land. The choice of Kielce as the study area follows from the availability of relevant data offered by a number of important databases – parts of the spatial information infrastructure (geoportal). Generally, as pointed out by Szopińska et al. (2022), and Ogryzek et al. (2020), the open access to geospatial data was provided in Poland in 2011 and since then the resources have been successively expanded. On the basis of the content of the geoportal maintained for the city of Kielce, it was possible, among others, to single out parcels located within the limits of the city to acquire information regarding their cadastral and geodetic area, land use, purpose of land, as well as the tenure structure (affiliation with a registration group). In addition, among the analysed parcels, 100 were selected for the purpose of comparing the cadastral area and the geodetic area, and thus the value of the property. Crucially, as this study and the authors' professional experience confirm, the data obtained from the above-mentioned district are typical and can be used to formulate general conclusions.

3.2 Research methodology

The research was carried out in three stages: In the first stage, the authors identified the scale of the problem of unreliability of the cadastral data concerning the area of parcels. These parcels were divided into groups according to the type of use of land, to allow for observe relevant differences between the those groups . Among the parcels located within the limits of the city, selected following Geoportal Kielce, 50 parcels were chosen for each land use category. A comparison of cadastral area (officially registered in the cadastre) and geodetic area (calculated on the basis of coordinates with a projection correction) was conducted, and the permissible difference of area was determined. Comparisons were based on the permissible difference in area dP_{max}, calculated according to the formula: $dP_{max} = 0.001 \cdot P + 0.2 \cdot \sqrt{P}$ (where P is the geodetic area expressed in m^2). In the second phase, analyses were carried out focussing, in particular, on agricultural land and built-up and urbanized land. The purpose in the local spatial development plans and study of conditions and directions of land development were verified. The following were listed: (i) areas of high-intensity development with metropolitan services (HID), (ii) areas of all-city metropolitan services located outside the downtown zone (ACMS), (iii) areas of production and warehouse development and technical services (PWDTS), (iv) areas of single-family residential development (SFRD), and (v) areas of development of recreation, sports and leisure services with accompanying greenery (RD). In the third stage, the value of land plots was estimated taking into account two types of area: registered and surveyed. The prices of 1 m^2 of land depending on the intended use were adopted on the basis of an analysis of the real estate market of the city of Kielce and the transaction prices recorded in the last two years. Generalized average prices of 1 m^2 of land for the types of designation indicated above were adopted, respectively: (i) HID – PLN 2 000/m^2, (ii) ACMS – PLN 1 000/m^2, (iii) PWDTS – PLN 500/m^2, (iv) SFRD – PLN 350/m^2, (v) RD – PLN 200/m^2. In the case of developed and urbanized land, the value of structures and other components of the property was not factored in. Finally, the impact of the differences in the above-mentioned registered areas on the value of the plots of land was recognized.

4 Results

The research has shown that the records of cadastral area of parcels, being the basis for numerous processes in the field of land management, are, in many cases, unreliable and diverge from the geodetic area calculated on the strength of coordinates of boundary points. Considering the division into agricultural land and built-up and urbanized land, Figures 2 and 3, respectively, show the distribution of parcels for which differences in registered and surveyed area were recorded, and indicate the distribution of parcels for which the area difference exceeded the permissible deviation.

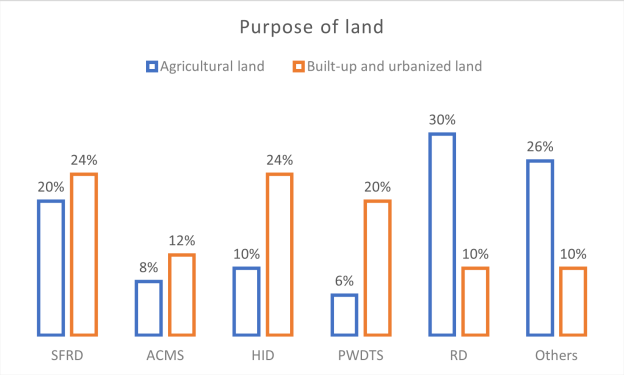

Figure 4. Purpose of land by analyzed land use groups

Within the group of agricultural land, the difference in registered and surveyed area was observed for 72% of the analysed plots however, the resulting deviations were surprisingly small (only 6% exceeded the permissible deviation). For 50% of the plots, the difference was in the range of 1 m^2 to 5 m^2, and for 14% of the plots – in the range of 5 m^2 to 10 m^2. In contrast, in the group of built-up and urbanized land, the differences between the recorded and surveyed were shown for as many as 84% of the analysed plots, and these differences were already much larger. For 24% of the plots, the difference was between 10 m^2 and 30 m^2, for 36% of the plots, i.e., 18% each, between 1 m^2 and 5 m^2 and 30 m^2 and 100 m^2, respectively, while for 16% of the plots, the difference was between 5 m^2 and 10 m^2. The permissible deviation was exceeded for as many as 32% of the plots in this category.

The distribution of the analysed plots according to the purpose of land determined for the purpose of approximate estimation of the value of real estate divided into agricultural land and built-up and urbanized land is shown in Figure 4.

The analysis showed that among agricultural land, the largest share of the analysed plots – 30% – were intended for the development of recreation (RD), sports and leisure services with accompanying greenery. Of these, nearly 87% were characterized by a difference in the recorded and geodetic area of 1 m^2 or more. A significant share of the land was also intended for single-family residential development (SFRD) (20% of the analysed plots), 60% of which showed a difference in analysed plot areas.

In the category of built-up and urbanized land, the largest number of parcels were designated for high-intensity development with metropolitan services (HID) and for single-family residential development (SFRD) – 24% each, of which, in each group 75% of the parcels showed a difference in recorded and geodetic area of 1 m^2 or more. Similarly, in the case of land intended for production and warehouse development and technical services (PWDTS) (20% of the analysed plots) and for all-city metropolitan services located outside the downtown zone (ACMS) (12% of the analysed plots), 90% and 83% of them, respectively, showed significant inconsistencies in the recorded area.

When determining the value of land, real estate appraisers take as binding areas those shown in the real estate cadastre, i.e., recorded areas. Thus, the indicated problem of differences in areas means that the estimated values of real estate are prone to error due to erroneous initial data. The calculated differences in the value of land parcels as products of the value of 1 m^2 of land with a given purpose of land and the cadastral area (V1) and geodetic area (V2), respectively, proved to be considerably low. In the analysed research sample, the differences did not exceed 10 per cent. In absolute terms, however, they showed to be quite significant. The highest differences were in the case of land intended for high-intensity development with all-city services, which is the most expensive land. An example of the value differences is provided in Table 2.

5 Discussion

In real estate appraisal, a valuer may be aware of the unreliability of cadastral data regarding the land area. However, they may still accept these data as credible in the calculations of the market value. The data will also be the basis for the description of the property in the case of its turnover (sale). A direct reference to data from the real estate cadastre in Polish conditions follows from the Law (1997). As Jasińska (2014) notes, due diligence practices may provide detailed information regarding land to help the buyer avoid financial risk, which may adversely affect the price of the property and the terms of the transaction. However, in the vast majority of cases, such an analysis is not performed for financial reasons. In parallel, verification of data quality by surveyors is not a common practice. Instead, they focus solely on the geodetic aspect.

The reasons for the discrepancies are various, and include legislative changes and changes in mandatory technical standards, technological progress – new opportunities, changes in accuracy and methodological requirements, measurement units used, spatial reference systems, measurement instruments. Serious errors in spatial data are not isolated, which, in the era of development of modern measurement technologies and GIS, can be successfully verified, and cases that require correction – updated on an ongoing basis.

As highlighted by Dawidowicz and Źróbek (2018), in an era when information constitutes the primary strategic resource, a growing need for comprehensive spatial information can be observed, including cadastral data, necessitating ongoing modernisation of cadastral systems. Mika (2017) states that the scope of the objective and subjective data recorded therein should guarantee the reliability of such records. Meanwhile, as repeatedly confirmed in the relevant literature in Poland and internationally (Cienciała et al., 2021; Kocur-Bera, 2020; Noga et al., 2017; Noszczyk and Hernik, 2019; Przewięźlikowska, 2020; Thompson, 2015), numerous inconsistencies can be observed when comparing data on real estates recorded in cadastre, considering the relevant current circumstances and developments.

There are several reasons of the problem: The parcel boundaries records maintained in the Polish cadastre, being the basis for determining the area, are characterized by varied accuracy and a large percentage of boundary points do not meet the current requirements. The problem is particularly evident among properties owned by public entities, including forest properties discussed in this paper. Kocur-Bera (2019) states that the archival materials used in the process of building the Polish cadastre were not sufficiently accurate. Regarding the reasons of discrepancies between the area revealed in the cadastre and the one resulting from the cadastral map, Benduch (2016) specifies, among others, deviations being the result of the methods used in the process of their determination on traditional maps (graphic method, planimetric method, etc.), as well as the scale of the maps. Bajtala et al. (2017) notes that these could be attributed to frequent changes in technological maintenance of the cadastre. In addition, over the years, in the field of boundary surveying, changes in the mandatory technical standards and accuracy requirements have been observed, as well as technological advancements bringing new opportunities and improved achievable precision. As mentioned in Bieda et al. (2014), the inaccuracy of data revealed in the cadastre also resulted from rounding up the area of parcels within rural cadastral units (to 100 m^2) that was relevant to former provisions. As pointed out by Bielecka (2010), all decisions are often made based on uncertain information, but it is crucial that the decision-maker is fully aware of this. Meanwhile, in the decision-making process, evaluating the accuracy and reliability of the data is crucial.

Assessment of the quality of spatial data in the boundaries records of the parcels was conducted, among others, by Hanus et al. (2020). The research of two cadastral districts located in the Małopolska Province, Poland (for 28 773 and 99 082 sections of the

Table 2. Differences in the value of land parcels for high-intensity development with all-city services

Number of cadastral unit	Plot number	Land use	Cadastral area [m²]	Geodetic area [m²]	Area difference [m²]	V1 [PLN]	V2 [PLN]	Absolute	
								Value difference [%]	Value difference [PLN]
9	1118/2	B	7113	7092	-21	14,226,000	14,184,000	0.30%	42,000
9	1153/20	B	13800	13546	-254	27,600,000	27,092,220	1.84%	507,780
10	802/2	B	3917	3887	-30	7,834,000	7,774,660	0.76%	59,340
10	1035/2	B	10285	10273	-12	20,570,000	20,545,980	0.12%	24,020
11	275/139	B	17695	17765	70	35,390,000	35,530,620	0.40%	140,620
15	277	B	828	842	14	1,656,000	1,683,620	1.67%	27,620
17	164/5	B	2940	2928	-12	5,880,000	5,856,440	0.40%	23,560
17	158/2	B	2516	2523	7	5,032,000	5,046,240	0.28%	14,240
17	260/5	Ba	13443	13483	40	26,886,000	26,965,320	0.30%	79,320

boundary lines of the parcels, respectively) showed that especially in one of them the boundaries failed to meet the requirements and the sources of the data were unreliable. The authors noticed that the standardized quality coefficient reached the lowest values within forest and woodlot areas and concluded that it would be impossible and unreasonable to cover such areas with a guarantee of consistency between the factual circumstances and the cadastral data. In turn, Roić et al. (2021) performed an analysis of inconsistencies indicated by area differences that exceeded tolerances. The investigation included 610 cadastral parcels from three cadastral municipalities in Croatia. The authors classified the typical origins of the inconsistencies, limiting the classification to four sources (by their origin and source of inconsistency) and successfully resolved them according to the proposed methodology. Kocur-Bera and Frąszczak (2021) conducted research of the coherence between data regarding the area of a parcel and land use recorded in cadastral documents and arising from the situation in the field. The study covered more than 4000 parcels in 14 villages in the Łódzkie Province (Poland). The coherence index showed that the differences ranged from 30% to 80%.

Additionally, in other countries, the issue of inscribing divergent data on the area of parcels is also present. In the process of determination of the area of parcels in Ukraine, the area of the physical surface (of the land surface with consideration of its topography) and the area of the horizontal section of the land parcel depiction are calculated in the accepted projection (normally in the transverse Mercator map projection) (Hubar et al., 2021). In the current documentation certifying the rights, the geodetic area is specified by measuring, based on the cartographic and topographic materials. Roić et al. (2021) propose that to improve the quality of cadastral data achieving full integrity cadastral resurveys should be performed, though they are costly and, frequently, time consuming. The updating of the data and the complete modernization of the cadastre, facilitated using modern technology, may be a possible solution as well. Chekole et al. (2020) emphasise that to improve the cadastral system organization, responsible authorities should pay attention, among others, to the design of strategy and policy, quality of leadership, as well as provision of partnership and resources. Meanwhile, Bajtala et al. (2017) propose a determination of a quality attribute for the parcel area records, the 'reliability of the parcel area' which would increase the technical and legal certainty of the rights to properties.

6 Conclusions

Commonly observed differences between cadastral and geodetic area of parcels constitute a significant problem in land management, including appraisal of properties. In the analysed region, the difference in area concerned a significant number of surveyed parcels (among agricultural land – 72%, in the case of built-up and urbanized land – 84%). Exceeded permissible deviation was shown for 6% and 32% of the plots, respectively. The problem of area differences was the most significant in land intended for high-intensity development with metropolitan services and for single-family residential development, where 75% of the parcels were characterized by differences in recorded and geodetic area. The problem is significant because these are capital-intensive lands, frequently subject to real estate transactions. Differences in areas showed differences in values of a few percent at most. In absolute terms, the differences reached up to several hundred thousand zlotys (a maximum of about PLN 500,000).

To avoid the difficulties in establishing the actual (geodetic) area and updating frequently outdated, unreliable information, a suitable strategy and policy need to be elaborated and implemented, including the rules for the calculation of the permissible deviation. Only reliable and up-to-date cadastral data provide a suitable basis for efficient and productive processes of land management including real estate appraisal.

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