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ORIGINAL ARTICLE

The concept of estimating usable floor area of buildings based on cadastral data

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Abstract

Usable floor area is one of the most important spatial attributes of buildings and premises. It is used, for example, to determine the basis for their taxation. Unfortunately, the question of proper determination of usable floor area in Poland has remained problematic for many years, which is closely related to the occurrence of various definitions of usable floor area in the currently binding legal acts. Consequently, usable floor area is not a universal attribute. This means that in certain cases significant discrepancies may occur between the usable floor area of the same structure, determined for different purposes. In addition, despite attempts made to unify the principles for the performance of surveys of building structures and their parts, this requirement still can not be recognized as fully met. Therefore, there is no doubt that the problem of reliability and availability of data defining the usable floor area of buildings is becoming even more important in view of the introduction of the 'ad valorem' tax, which has been planned for years. For this reason, this paper proposes a universal, multi-variant method of estimating usable floor area based on geometric and descriptive data of buildings contained in the cadastre. The Authors, taking into account the applicable legal regulations, have considered the possibilities of practical implementation of individual variants of this specific method. They have carried out empirical tests of effectiveness of the proposed approach. They have also defined tasks for which this method of determining the usable floor area of buildings would be particularly useful.

Key words: real estate cadastre, building, usable floor area, base for property tax, 'ad valorem' tax

1 Introduction

The problem of proper determination of the usable floor area of buildings and their parts has existed and remained up-to-date for many years. The discrepancy between the definitions of usable floor area, contained in the cadastral and real estate tax regulations, has been repeatedly pointed out in the Polish subject literature (Benduch and Butryn, 2017; Buśko, 2015). The use of the rules for surveying building structures contained in the Polish architectural and construction standards have also been discussed by Korzeniewski (2008), Budzyński (2012), Pokorska and Kysiak (2012), Zbroś (2016), Benduch and Butryn (2018).

Unclear and imprecise legal regulations, also with regard to entering the usable floor area of buildings into the real estate cadastre, result in this information being relatively rarely entered. For this reason, meeting the demand set forth in art. 21 of the Geodetic and Cartographic Law (Act, 1989) of using the data of the register of land and buildings for the purposes of tax and obligation assessment is not fully possible at the moment. The Act on taxes and local fees (Act, 1991) explicitly indicates that usable floor area expressed in square meters forms the base for taxation of buildings with real estate tax. Although the data of the real estate cadastre was not directly referred to, in the case-law of administrative courts (II FSK 3099/12), (II FSK 3108/12) the view was established that this data is absolutely binding for the tax authority. In practice, however, the usable floor area of a building is usually declared by taxpayers. Unfortunately, the information obtained in this way, also due to the lack of precise regulations with respect to qualification

Table 1. Cadastral data of buildings regarding usable floor area since the Regulation on the register of lands and buildings entered into force. Source: own study based on Regulation (2001), Regulation (2013)

2001.06.02 – 2013.12.31	2013.12.31 –
• Total usable floor area, expressed in square meters: i. of all premises in a building, ii. of rooms belonging to premises.	• Usable floor area of a building, based on: i. surveys, ii. information contained in the construction design. • Total usable floor area: i. of premises constituting separate real estate, ii. of non-separate premises, iii. of rooms belonging to premises.

of premises and surveys of usable floor area, is often unreliable. The method of calculating usable floor area is therefore inconsistent, which should be changed in the future, especially in the context of the planned introduction of the 'ad valorem' tax in Poland based on the cadastral value of the real estate. In the current wording of the Act on real estate management (Act, 1997), the cadastral value of individual land components, including buildings, is determined as the product of their area entered into the real estate cadastre and the unit value demonstrated in the taxation tables. Therefore, due to the frequently encountered problem of the lack of relevant data defining the usable floor area of buildings in the database of the real estate cadastre, the performance of general taxation in the manner indicated in the regulations would be seriously hindered.

The objective of this research paper is an attempt to develop a universal and uniform method of estimating the usable floor area of buildings based on available cadastral data. The authors specify the tasks for which such floor area could be particularly useful. They carry out practical verification of the effectiveness of the proposed approach. They provide different variants of calculations and point to their limitations. Finally, they compare the usable floor area of buildings determined by means of surveys with the area estimated using the subject method developed by the Authors.

2 Usable floor area of a building in the real estate cadastre

The usable floor area of a building was introduced as one of the building's record data as late as on 31 December 2013, which is after the amendment to the Regulation on the register of land and buildings of 29 November 2013 (Regulation, 2013) had come into force. Previously, only the total usable floor area of all independent premises in the building and rooms belonging to these premises had been recorded in the real estate cadastre. Although many years have passed since that change, the legislator has not introduced a formal definition of the usable floor area of a building, still referring only to the definition of the usable floor area of premises included in the Act on the protection of tenants' rights, municipal housing resources and amendment to the Civil Code (Act, 2001). In practice, it is usually assumed that this definition is binding also for buildings.

Table 1 presents the manner in which the cadastral data of buildings regarding usable floor area has been changing over the last several years.

It is worth noting that the amendment to the provisions on the real estate cadastre of 2015 (Regulation, 2015b) did not bring any changes in this respect. While analysing the information contained in Table 1, it is easy to notice that currently we are dealing with the usable floor area of a building based on surveys and information contained in the construction design. This does not mean, however, that both of these values are subjected to simultaneous record. According to the information contained in §71 section 2 and in Appendix 1a (Regulation, 2001), the usable floor area of a building determined based on a construction design may be entered only if such a design exists and usable floor area determined from surveys is not known. Thus, the legislator implies that the leading information on the usable floor area of a building is the result of performed surveys. It is important that the surveys for entering usable floor area into the real estate cadastre should be carried out by a person with appropriate architectural and construction qualifications. Therefore, at the moment, the surveyor can not define the usable floor area of a building on their own. This issue is the subject of broad discussion and polemic in the professional environment. As discussed by Benduch et al. (2017b), the entry into force of the Act of 20 July 2017 on National Property Resources (Act, 2017) may become a kind of a gate for performing surveys of usable floor area by an authorized surveyor. Either way, the usable floor area of a building is relatively rarely recorded, especially for buildings that were erected many years ago.

§71 section 1 (Regulation, 2001) is of particular importance in this respect, according to which the data on the usable floor area of buildings determined based on surveys, can be entered into the database of the register of land and buildings in the following ways:

- ex officio, if such information is contained in relevant documents delivered to the authority maintaining the cadastre, such as copies of final court decisions, copies of notarial deeds or copies of final administrative decisions,
- at the request of a proper record entity who will submit relevant documentation, understood as the governor's certificate of residential premises meeting the requirements of being a separate unit, together with attached projections of individual storeys of the building on which the premises are located together with their auxiliary rooms.

It can therefore be presumed that the legislator meant to record the usable floor area of buildings calculated from surveys primarily in the case of buildings being subject to court, administrative and market turnover proceedings, as well as in the case of buildings in which residential premises have been separated, because this follows directly from the literal meaning of the quoted provision of law. Besides, one problem remains: what principles governed the performance of the survey of usable floor area and whether these principles were in line with those specified in the Act on the protection of tenants' rights, municipal housing resources and amendment to the Civil Code (Act, 2001).

3 Necessary changes in recording usable floor area

Although the Geodetic and Cartographic Law (Act, 1989) imposes the obligation to use cadastral data for the purpose of determining the tax base for real estate on the tax authorities, meeting this demand for buildings, especially in the light of current considerations, remains problematic. Local town councils and district offices, which are real property tax collectors, use the information about the usable floor area of buildings entered into the property tax register, which were declared by taxpayers. For various reasons, the level of reliability of these data is often average, as demonstrated e.g. by Benduch and Butryn (2017). It is worth mentioning that tax authorities do not have adequate means or possibilities to verify declarations made by individual entities. It is unreasonable to assume that such information would constitute in future a proper basis for determining the cadastral value of land components in the process of general taxation, especially that art. 167 of the Act on real estate management (Act, 1997) directly points to the need of using the data on the surface area of individual structures which are contained in the real estate cadastre.

An important problem is also the discrepancy between the definitions of usable floor area in the Act on the protection of tenants' rights, municipal housing resources and amendment to the Civil Code (Act, 2001) and the Act on taxes and local fees (Act, 1991). The consequence are differences regarding rooms qualified for calculations, which may significantly affect the final result of the survey. This problem seems to remain unnoticed by administrative courts, which in their case-law clearly point to the need to use the data of the register of land and buildings as the basis for property taxation (I SA/Op 775/14, I SA/Sz 60/15, I SA/Łd 512/15). As it was discussed by Benduch (2017) based on the judgement of the Supreme Administrative Court of 26 September 2014 (II FSK 3099/12), the cadastral data of buildings and premises constituting a separate subject of property, relating to their location, purpose, utility functions and usable floor area, are the data which are mandatory for the tax authority, which is not entitled to correct these data themselves during the tax proceedings. In the event of a discrepancy between the actual status and this contained in official documents, the data contained in the real estate cadastre must be properly updated. The tax authority has no grounds to question valid decisions issued by other authorities, just as it has no right to challenge official documents (Etel, 2013). In accordance with the judgement of the Provincial Administrative Court in Olsztyn of 23 December 2015 (I SA/Ol 644/15), the taxpayer is obliged to ensure that the records in the land and building register comply with the actual status regarding the properties held by them, if such differences occur. Nevertheless, the data on the usable floor area of buildings collected for the purpose of their being entered into the real estate cadastre should be consistent with the definition contained in the Act on the protection of tenants' rights, municipal housing resources and amendment to the Civil Code (Act, 2001). Thus, the use of these data as a tax base in some cases will be impossible. This is just one of the common problems regarding integration of the cadastral data with the data included in other public registers, and the use of these data for statutory tasks (Buśko, 2017).

According to the Authors, the most practical solution to this problem would be the adoption of a uniform definition of usable floor area, binding regardless of the needs. Another approach that has already been mentioned by Benduch and Butryn (2017) is the introduction of additional subcategories of the term 'usable floor area' in order to eliminate the polysemy of this concept. The proposed sub-category could be a 'taxation area', treated as a new attribute entered into the real estate cadastre. This area would be used as the basis for property taxation binding for tax authorities. Also, in the case of the introduction of the 'ad valorem' tax in Poland, compliance with the provisions of the Geodetic and Cartographic Law (Act, 1989) and the Act on real estate management (Act, 1997) could be achieved. It is also important to distinguish and clearly separate the definition of the usable floor area of buildings from the usable floor area of premises, as attributes of separate structures with different characteristics. There is no doubt, however, that any changes in this respect would require amendment of at least several acts and secondary legislation, and their actual implementation would be a long-term and costly process.

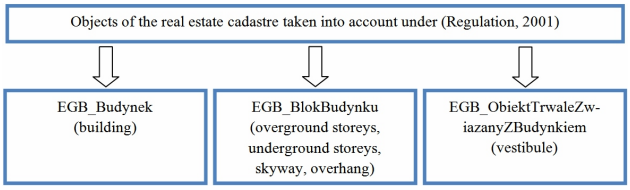


Figure 1. Objects of the real estate cadastre taken into account in the implementation of all the variants of the proposed method

At the moment, the consequence of the ambiguity of the analysed concept is that it is impossible to recognize the data on usable floor area entered into the register of land and buildings as multi-purpose one. What is more, the lack of unambiguous and transparent principles for the performance of surveys and determination of usable floor area means that this process is subjected to a large dose of subjectivity. On the other hand, further findings based on the results of activities carried out in a subjective manner, will be burdened with uncertainty. This applies e.g. to tax base for buildings which, in the context of the planned introduction of the 'ad valorem' tax in Poland, is even more important.

4 Proposed variants of estimating usable floor area

Based on the previous analyses, it can be concluded that the proper step towards improving the quality of information on the usable floor area of buildings in the real estate cadastre would be the implementation of a universal method for determining this area, which would allow for the calculations to be made as objectively and uniformly as possible throughout the country. According to the authors, the criteria of objectivity and uniformity should be adopted as decisive when determining the usable floor area of buildings, especially when this information is to be used for tax assessment. An important requirement is also a quick completion of the missing data in accordance with the proposed methodology.

The main assumption of the presented approach to estimating usable floor area developed by the Authors, is the use of the existing cadastral data of a building, including in particular:

i. geometric data of a building, selected blocks and building structures permanently attached to that building,
ii. number of overground and underground storeys of a building,
iii. information on the material used for the construction of external walls of a building,
iv. total number of chambers in a residential building.

Figure 1 illustrates objects of the real estate cadastre which should be taken into account in the implementation of all three variants for estimating the usable floor area of buildings described in Table 2.

A necessary condition to exploit the potential of this method

Table 2. Variants for estimating usable floor area of buildings developed by the Authors

Denotation	Remark	General Formula
Variant I	Simplified approach – using geometry of objects `EGB_Budynek`, `EGB_BlokBudynku`, `EGB_ObiektTrwaleZwiazanyZBudynkiem` as well as the number of overground and underground storeys of a building.	$P_{UI} = P_B \cdot L_{Kn} + P_{BB} + P_{OZ}$
Variant II	General approach – using data from Variant I as well as information on the material used for the construction of external walls of a building.	$P_{UII} = (P_B \cdot L_{Kn} + P_{BB} + P_{OZ}) - P_{SZ}$ $P_{UII} = P_{UI} - P_{SZ}$
Variant III	Detailed approach – using data from Variant II as well information on the number of chambers in a residential building.	$P_{UIII} = (P_B \cdot L_{Kn} + P_{BB} + P_{OZ}) - P_{SZ} - P_{SW}$ $P_{UIII} = P_{UII} - P_{SW}$

efficiently is to deal with a complete set of buildings entered into the modernized real estate cadastre as objects. Depending on the adopted calculation variant, the level of use of the above data may vary. Table 2 presents three closely related variants of the proposed method for estimating the usable floor area of buildings.

Denotations of the individual Formulas contained in Table 2 are as follows:

P_U – estimated usable floor area of a building within a given variant,
P_B – surface area of the object `EGB_Budynek`,
L_{Kn} – number of overground storeys of a building,
P_{BB} – surface area of selected blocks of a building (object `EGB_BlokBudynku`),
P_{OZ} – surface area of selected structures permanently attached to a building (object `EGB_ObiektTrwaleZwiazanyZBudynkiem`),
P_{SZ} – surface area of external walls of a building made of a specific material,
P_{SW} – surface area of internal walls of a residential building, determined based on the number of chambers in a building.

Due to the fact that development area of a building is closely related to the concept of the contour of a building, which objects `EGB_Budynek` and selected objects of `EGB_BlokBudynku` are included into, the presented method does not directly use the record data on a development area. The use of a development area in some cases could lead to erroneous results. In addition, it would impede the practical implementation of the proposed approach to estimating the usable floor area of buildings. The issue of individual objects being included into the contour of a building and the concept of a development area have been discussed in detail by Benduch et al. (2017a), Buśko (2016).

Only those structures depicted in Figure 1, representing a building in the real estate cadastre, will have a usable floor area. A vestibule, as a building structure permanently attached to a building, as discussed by Benduch et al. (2017c), is a small, closed room located at the entrance to the building or apartment, used to stop the inflow of cold air from outside. On the other hand, an overhang, which is a block of a building, should be interpreted as a part of a building with a usable floor area protruding beyond the contour of its basement. An overhang should not be identified with the roof of a building based on pillars. As it was analysed by Benduch et al. (2017c), such structures should be recorded as building blocks other than those listed in Appendix 1a to Regulation on the register of land and buildings (Regulation, 2001).

In the aspect of using the geometry of an overhang as a block of a building for the purpose of estimating usable floor area, it is not important whether a given overhang is supported on a pillar (as opposed to calculating the development area of a building), as illustrated in Figure 2. For the purpose of determining the development area of a building based on the numerical description of its contour, in the case of the building depicted in Figure 2 on the left, only the surface area of the

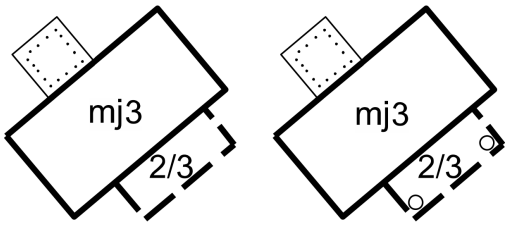


Figure 2. Examples of three-storey buildings with vestibules and overhangs, unsupported and supported on pillars, respectively (Source: own study based on Regulation (2015a))

object `EGB_Budynek` would be included in the calculations. However, in the case of the building on the right, the surface area of the object `EGB_BlokBudynku`, which is an overhang supported on pillars, should also be included. This is one of the reasons why the process of estimating usable floor area based on development area would not always be possible to be implemented properly.

It is also worth clarifying here, that the concept of usable floor area of a building in this Chapter should be treated in a conventional manner. There is no doubt that the surface area determined based on the assumptions of Variant I will not constitute usable floor area within the meaning of applicable provisions of law or construction standards. Only the implementation of Variant II will allow for a direct approximation to the actual usable floor area, unless the buildings in question have additional internal vertical partitions. However, this does not change the fact that it will only be an approximation. That is why we are talking about estimating usable floor area, and not strictly determining it. The authors propose that the surface area obtained irrespective of the adopted variant of calculation, was ultimately referred to as the cadastral area.

4.1 Variant I – simplified approach

Assuming that the individual structures that make up the buildings illustrated in Figure 2 have a geometry with the following surface areas:

- `EGB_Budynek` (Building): 75 m^2,
- `EGB_BlokBudynku` (Overhang): 25 m^2,
- `EGB_ObiektTrwaleZwiazanyZBudynkiem` (Vestibule): 15 m^2,

and in the real estate cadastre, the data on the number of overground and underground storeys of the building has been entered:

- Number of overground storeys: 3,
- Number of underground storeys: 0,

then, the implementation of Variant I of the proposed method for estimating usable floor area would be as follows:

$$P_{UI} = P_B \cdot L_{Kn} + P_{BB} + P_{OZ} = 75.00 \cdot 3 + 25.00 + 15.00 = 265.00 \text{ [m}^2\text{]}$$

Table 3. Assumed thickness of walls depending on the material used for the implementation of Variant II

Material of the ext. walls*	Thickness of walls**	Remark
Brick	0.40 m	Standard thickness of full brick, chequer brick, ceramic block: 0.25 m Standard thickness of insulation layers and façade: 0.15 m
Wood	0.25 m	Standard thickness of solid wooden logs: 0.25 m
Other	0.10 m	Standard thickness of walls covered with trapezoidal sheet with mineral wool filling or walls covered with polyurethane sandwich panels: 0.10 m

*Material of the external walls of a building according to Appendix 1a (Regulation, 2001)
**Thickness of walls assumed for the implementation of Variant II

The above calculation result is true for both buildings presented in Figure 2 which, as previously stated, differ only as far as supports under the overhang are concerned. The consequence of this approach is the inclusion of surface areas of the external and internal walls of the building to the usable floor area. With reference to the nomenclature from the Polish architectural and construction Standard of 2015 (PN-ISO 9836:2015-12, 2015), such surface area can be equated with the total surface area of the building. This does not mean, however, that it could not be used for specific purposes, including those related to real estate taxation. Considering the problems associated with determination of usable floor area of buildings, accepting the results of Variant I as binding would greatly help to unify the manner of recording this information. In addition, it would be possible to eliminate subjective factors accompanying the determination of the usable floor area of a building in a traditional way, such as the classification of rooms included in the calculation and the selection of the methodology of surveys. It should be emphasized that the proposed method also allows for including the surface area of building's underground storeys in the calculation process.

4.2 Variant II – general approach

Assuming that the data on the material used for the construction of external walls of a building are entered into the cadastre, it is possible to use Variant II described in Table 2. According to the proposed Formula, the result obtained during the implementation of Variant I should be reduced by the surface area of the external walls of a building. It is worth remembering, that according to Appendix 1a (Regulation, 2001), in the database of the register of land and buildings, recording three types of construction materials from which the external walls are built is permissible at the moment. These materials are listed in Table 3.

The thickness of external walls demonstrated in Table 3 are the values proposed for the implementation of Variant II of the discussed method for estimating the usable floor area of a building developed by the Authors. It seems, however, that for the purpose of its implementation, a favourable solution would be to extend the list of acceptable values of the attribute `EGB_MaterialScianZewnBudynku`, which would allow to distinguish insulated buildings from non-insulated ones, and thus would contribute to the increased accuracy of calculations. The problem may also arise when a partially wooden and partially brick building is denoted as "Other".

Figure 3 depicts a diagram which illustrates a practical effect of the implementation of Variant II of the proposed method for estimating the usable floor area of a building. The orange colour corresponds to the exterior walls of the building, which should not be taken into account when estimating usable floor area. It is important that the individual objects: `EGB_Budynek`, `EGB_BlokBudynku`, `EGB_ObiektTrwaleZwiazanyZBudynkiem` are analysed separately, in this order, which allows to avoid the problem of redundancy of surfaces of walls, excluded from the calculations at the points of contact of the above-mentioned objects, as marked in Figure 3 with a blue arrow. This is one of the reasons why implementation of the calculations based on a uniform surface-correcting algorithm, as the one used in Variant III (2), was abandoned at this stage.

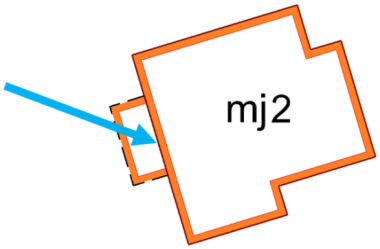


Figure 3. Schematic diagram representing implementation of Variant II of the proposed method for estimating usable floor area of a building

Considering, however, that the modernized register of land and buildings is maintained as a database, from the point of view of information technology, there should be no problems with automatic or semi-automatic calculations. It should be emphasized that the surface of individual structures is determined based on their recorded geometry using Gaussian formulas. For the purpose of the implementation of Variant II, it is possible to use a number of functions based on analytical geometry and coordinate calculus, available in the software used to maintain a real estate cadastre. An example of such a tool is e.g. parallel placement of the selected closed or open area to a given distance, available in the EWMAPA program. The possibilities of geoinformation systems, which in some counties are also used to keep records of land and buildings, are also worth mentioning.

Based on the geometry of a building recorded in the cadastre, the information on the material from which the building's external walls were made (brick), and the assumed wall thickness (0.40 m), in accordance with Table 3, the usable floor area of the building presented in Figure 2 was estimated:

$$P_{UII} = P_{UI} - P_{SZ} = 265.00 - 50.00 = 215.00\ [\mathrm{m}^2]$$

According to the presented methodology, when using Variant II, the following surfaces marked in orange, corresponding to the external walls of the building, were excluded from the calculations: In practice, it does not matter whether, in accordance with Variant II, the usable floor area of a building and attached structures will be determined as a difference between the area calculated during the implementation of Variant I and the surface area of external walls, or whether it will be calculated again for a new geometry:

$$P_{UII} = P_{BII} \cdot L_{Kn} + P_{BBII} + P_{OZII} = 61.50 \cdot 3 + 20.00 + 10.50 = 215.00\ [\mathrm{m}^2]$$

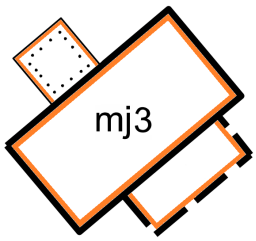


Figure 4. Graphic presentation of areas excluded from calculations using Variant II

where:

P_{BII} – surface area of the object `EGB_Budynek` minus surface area of external walls,

P_{BBII} – surface area of selected blocks of a building (object `EGB_BlokBudynku`), minus surface area of external walls,

P_{OZII} – surface area of selected structures permanently attached to a building (object `EGB_ObiektTrwaleZwiazanyZBudynkiem`), minus surface area of external walls.

The above method of calculation seems more appropriate for the needs of the software. Such surface area can be equated with the internal surface area of a building, referred to in the Regulation on technical conditions which should be met by buildings and their location (Regulation, 2002). Undoubtedly, it is a value closer to usable floor area determined in a traditional way than the area obtained in the implementation of Variant I, referred to as the total area of a building.

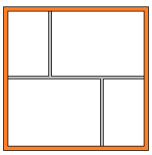
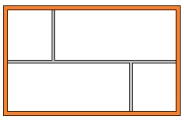
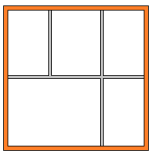
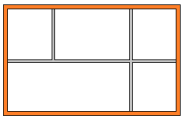
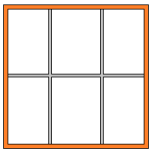
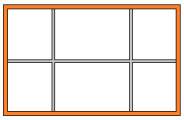
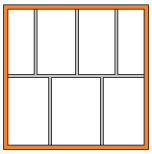
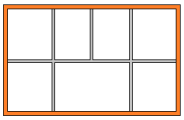
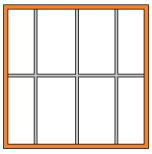
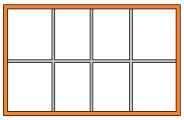
4.3 Variant III – detailed approach

The last of the proposed solutions, which will only apply to residential buildings, though, is the implementation of Variant III described in Table 2. Based on the information on the total number of chambers in a residential building, contained in the cadastre, it is possible to use an algorithm which, after the adoption of certain assumptions, will allow to get close to the results obtained during the survey of usable floor area. Under the provisions of legislation (Regulation, 2001), a chamber is a space in a residential dwelling, separated from other rooms by solid walls reaching from floor to ceiling, with an area of not less than 4 m^2, with direct daylight in the external wall of a building (window or glazed door). Not only rooms are considered to be chambers, but also kitchens that meet the above criteria. However, regardless of the size and lighting, antechambers, halls, bathrooms, toilets, pantries, porches, or storage spaces are not considered chambers.

Considering that, unlike in some Western European countries (Stoter et al., 2013; El-Mekawy et al., 2014), implementation of a 3D cadastre in Poland still remains only in the sphere of theoretical considerations (Karabin, 2013; Bydłosz, 2016), for the purpose of applying the discussed approach, it is necessary to adopt a certain permanent layout of rooms on individual storeys of residential buildings with a specific number of chambers. It should be emphasized that the Authors intended to develop a sufficiently universal method that would allow for simple, automatic and uniform determination of the area similar to the usable floor area of buildings, especially for taxation purposes.

For this reason, an attempt was made to define a function whose explanatory variable would be the inner surface of a single storey of the object `EGB_Budynek` (P_{BII}) and the number of chambers, and the explained variable – the value of the coefficient expressed as a percentage, whose value should be used to reduce the internal surface area of a given storey (P_{BII}) in order to eliminate surface area of the internal walls of a building. In this way, a surface similar to the usable floor area of a single storey of a residential building (P_{BIII}) will be obtained. Thus, the value of the analysed coefficient, which is denoted as W, will reflect the percentage share of the building's interior walls in the surface area of the object `EGB_Budynek` (P_{BII}).

Table 4. Layout of rooms of residential buildings with simple geometry, adopted for calculations

No. of chambers	Geometry: Square	Geometry: Rectangle
2		
3		
4		
5		
6		

According to the presented assumptions, for the purpose of the calculations, an identical layout of rooms of structures with simple geometry was adopted, as demonstrated in Table 4. It was assumed that on each storey of a building there were two rooms that were not considered a chamber, such as antechamber, storage room or bathroom. The thickness of internal walls was predetermined at 0.20 m. Then, based on the simulations carried out on the generated objects, it was observed that the W coefficient can be determined in a strict manner using the following function:

$$W = \frac{1}{X \cdot \sqrt{P_{BII}}} \cdot Z \cdot 100\% \tag{1}$$

where:

W – sought, percentage value of surface coefficient,

X – variable dependent on the shape and surface of the object `EGB_Budynek`,

P_{BII} – surface area of the object `EGB_Budynek` minus the surface area of external walls,

Z – variable dependent on the number of chambers in a residential building.

It was found that the variable X decreased with the elongation of the figure. For a square, it took a value of ca. 2.5, and for a rectangle with a 1:4 ratio of the sides – a value of ca. 2.0. In

Table 5. Adopted fixed values of parameter Z for residential buildings with a predetermined number of chambers

No. of chambers	Const. value of parameter Z
2	0.4250
3	0.5050
4	0.5875
5	0.6700
6	0.7525

addition, the larger the internal surface area of a given storey (P_BII), the smaller value taken by the variable X. On the other hand, the variable Z increased proportionally to the number of chambers in a residential building. The more elongated a structure, the smaller the value of Z. It is worth mentioning that for structures with two chambers, the variable Z will take a value equal to 1, regardless of their shape and surface area. It results from the assumptions accompanying the calculation process, where the result proper for two-chamber buildings was adopted as the basis, which was then adjusted accordingly.

In the light of the presented considerations, strict determination of the value of the W coefficient, in accordance with the presented Formula, would require the determination of X and Z parameters each time. Considering the fact that the presented method is intended to be used for automatic or semi-automatic estimation of the usable floor area of residential buildings, it was decided that the calculation procedure should be simplified. Thus, Formula 1 was modified so that the parameter X would always take a constant value equal to 1:

$$W = \frac{1}{\sqrt{P_{BII}}} \cdot Z \cdot 100\% \tag{2}$$

It was therefore possible to reach the expected situation with the variables being only: the internal surface area of a single storey of a building (P_{BII}) and also the parameter Z depending on the number of chambers in a residential building. It was determined that when fixed, estimated values of the parameter Z presented in Table 5 were adopted, in the vast majority of cases the internal accuracy of the calculation of the usable floor area would be maintained at the level of 1 m^2. It is also possible to determine fixed values of the parameter Z for residential buildings with a larger number of chambers within a single storey. Assuming, however, that the number of overground storeys contained in the cadastre is greater than 1, then the number of chambers will be scattered proportionally to individual storeys. Table 6 demonstrates exemplary calculation of usable floor area using the analysed Variant III: It should be noted that if the rest from the division of the number of chambers in a residential building by the number of overground storeys was zero, then there would be no need to determine two different values of the W coefficient. The resulting difference between the surface areas estimated using Variant II (P_{UII}) and Variant III (P_{UIII}) reflects the surface area of the internal walls of a building on all its storeys, assuming the layout of rooms as demonstrated in Table 4. It was found that the deviation from the result obtained based on the calculations presented in Table 6, relative to the usable floor area of a residential building determined in a strict manner using Formula (1), was at the level of 0.45 m^2.

On the other hand, referring to the example applied to in the presentation of the assumptions of Variant I (Fig. 2) and Variant II (Fig. 4), the usable floor area of the analysed object was estimated. This time, it was assumed that the number of chambers entered into the cadastre in a residential building was equal to 9. With three overground storeys, there was no need to determine two separate values of the W coefficient. The parameter Z (Tab. 5) applicable for three chambers was used.

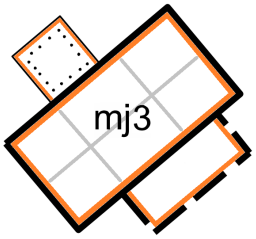


Figure 5. Graphical presentation of areas excluded from calculations using Variant III

Figure 6. Building with overhang unsupported on pillars, requiring adjustment for surface area of internal walls in object `EGB_BlokBudynku`

$$W = \frac{1}{\sqrt{P_{BII}}} \cdot Z \cdot 100\% = \frac{1}{\sqrt{61.50}} \cdot 0.5050 \cdot 100\% = 6.44\%$$

$$P_{BIII} = P_{BII} \cdot (1 - W) = 61.50 \cdot (1 - 0.0644) = 57.54\ [\text{m}^2]$$

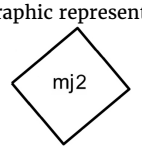
$$P_{UIII} = P_{BIII} \cdot L_{Kn} + P_{BBII} + P_{OZII} =$$

$$= 57.54 \cdot 3 + 20.00 + 10.50 = 203.12\ [\text{m}^2]$$

In this case, the difference between the estimated usable floor area and the area determined strictly, was 0.30 m^2. In the Authors' opinion, such discrepancies are fully acceptable, especially that, due to a number of assumptions adopted at the beginning, the proposed method is to serve as a tool for determining usable floor area in an approximate, but also universal and uniform manner.

It should be emphasized that, according to Fig. 5, it was necessary to add the surface areas of the objects `EGB_BlokBudynku` (P_{BBII}) and `EGB_ObiektTrwaleZwiazanyZBudynkiem` (P_{OZII}) to the final result of the calculations. These surface areas were not further adjusted for the surface of the internal walls, which is due to the geometry and nature of these structures. In practice, however, there may be cases where the adjustment of the surface of an overhang or a vestibule with the use of the W coefficient will be necessary. An example of such a structure is presented in Figure 6. Also, in the case when a part of a building distinguished due to a different number of storeys is considered a building block, it is undoubtedly necessary to consider adjustment of the surface area of this building based on the number of chambers. This is one of the reasons why Variant III of the proposed method for estimating usable floor area should be classified as semi-automatic rather than fully automatic. In some cases, verification by the user is required.

Table 6. Exemplary implementation of usable floor area calculation process with the use of Variant III for a building with an odd number of storeys

Data for implementation of Variant III	Number of chambers: 11 Number of overground storeys: 2 P_{UII} = 150.00 [m^2] P_{BII} = 75.00 [m^2] Z_1 = 0.7525 Z_2 = 0.6700	Cartographic representation 
Calculating coefficients W_1 i W_2 for individual storeys	$W_1 = \frac{1}{\sqrt{P_{BII}}} \cdot Z_1 \cdot 100\% = \frac{1}{\sqrt{75.00}} \cdot 0.7525 \cdot 100\% = 8.69\%$ $W_2 = \frac{1}{\sqrt{P_{BII}}} \cdot Z_2 \cdot 100\% = \frac{1}{\sqrt{75.00}} \cdot 0.6700 \cdot 100\% = 7.74\%$	
Estimating usable floor area of individual storeys of a building	$P_{BIII(storey\_1)} = P_{BII} \cdot (1 - W_1) = 75.00 \cdot (1 - 0.0869) = 68.48$ [m^2] $P_{BIII(storey\_2)} = P_{BII} \cdot (1 - W_2) = 75.00 \cdot (1 - 0.0774) = 69.20$ [m^2]	
Determining usable floor area of a residential building	$P_{UIII} = P_{BIII(storey\_1)} + P_{BIII(storey\_2)} = 68.48 + 69.20 = 137.68$ [m^2]	

5 Empirical verification of adopted assumptions

The presented assumptions and possibilities of the discussed variants to estimate usable floor area of buildings were tested in practice. In order to verify the correctness of the proposed approach, field surveys of two residential buildings and two non-residential buildings of various geometry were performed. In addition, a classical survey of their usable floor area was carried out, applying to the principles contained in the Act on the protection of tenants' rights, municipal housing resources and amendment to the Civil Code (Act, 2001) and in the Polish Standard of 1997 – PN-ISO 9836:1997 (1997). The characteristics of the test structures are presented in Table 7. It is worth noting that none of the analysed buildings had recorded information about their usable floor area in the database of the register of land and buildings. The research results and results of the comparisons are presented in Table 8.

Considering the existing differences and discrepancies between the results of the classical survey of usable floor area and the results of the implementation of the proposed method, it was found that this method had a chance to prove itself in practice. In the case of buildings B (residential building) and C (farm building), there was almost full compliance with the results of the survey. It resulted from the fact that these objects had features identical to those predetermined for the purpose of developing the proposed methodology:

- Thickness of masonry external walls was equal to 0.40 m (despite no insulation or façade layers),
- Layout of the rooms was identical to the one proposed in Table 4 for object B, and with no additional internal partitions in the case of object C.

It is also worth paying attention to the comparative analysis prepared for object A (Tab. 8). The resulting difference of 4 m^2 seems to be fully acceptable, especially that the shape of this structure deviates from regular, rectangular one. Moreover, there are two corridors on each overground storey. There are also three bathrooms in the analysed building. Thus, the assumption about two additional rooms that do not meet the definition of a chamber on each of the storeys of the building are not met in this case. The performed check survey demonstrated further that object A had external walls which were 0.43 m thick.

For the above reasons, Variant III of the method for estimating usable floor area was tested, using the value of the parameter Z appropriate for 5 chambers (on each storey of the object `EGB_Budynek`), and then taking into account the wall thickness of 0.43 m. Finally, usable floor area was determined for both modified parameters. The results are demonstrated in Table 9. The information contained in Table 9 proves that the result of the entire calculation process is more sensitive to the parameter of the thickness of external walls than to the value of the parameter Z, being a derivative of the number of chambers in a residential building. Thus, it can be concluded that the layout of the rooms proposed in Table 4 is sufficiently universal, as well as the determined values of the Z parameters (Tab. 5). It is also confirmed by the final result of the calculations taking into account the corrected values of the individual input parameters (Tab. 9), deviating from the results of the traditional survey of usable floor area by only 0.55 m^2, or 0.3%.

According to Table 8, the largest discrepancies were recorded in the case of object D, which was a non-residential building with the function of a backyard storage place. The noted difference between the survey results and the implementation of the proposed method was -3.66 m^2, which corresponded to a discrepancy of 11.8%. There were no additional building partitions in the analysed structure (with the exception of the one separating the proper room from the vestibule). For this reason, the only factor that decided about the lack of compliance was again the thickness of the external walls. Object D was a brick building, and the actual thickness of the external walls was 0.25 m, which was in accordance with the assumptions presented in Table 3. Nevertheless, this object did not have any additional insulation layers, and therefore, assuming the thickness of its external walls at 0.40 m generated erroneous results. If, however, the actual wall thickness (0.25 m) was used in the calculation process, then the usable floor area would be 31.04 m^2. Thus, the difference to the object D survey result would be only 0.10 m^2, which translates into a discrepancy of 0.3%.

This experiment has proven a great potential of the proposed methodology for estimating the usable floor area of a building. It is worth emphasizing that this approach, thanks to its simplicity and universality, should contribute to meeting the requirement of uniformity of data collected in the real estate cadastre. It is also significant, that the implementation of this method allows for the fastest possible completion of missing information about usable floor area based on the collected cadastral data of a building. The performance time of the calculations for the test structures presented in Table 7 did not exceed 10 minutes, while the classical survey of usable floor area, together with preparation of its results, took the whole working day. Also, if it is necessary to complete any missing data (geometric or descriptive one), conducting a geodetic survey should not bring such a number of difficulties as surveys of individual rooms located inside the building would. It is worth paying attention to a number of innovative solutions for capturing spatial data of buildings with the use of geodetic surveys (Krzyżek, 2017; Krzyżek and Przewięźlikowska, 2017). Unfortunately, in the case of surveying usable floor areas of finished

Table 7. Characteristics of test structures used to verify individual variants of the proposed method

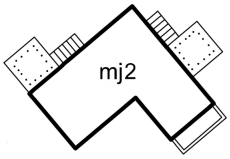
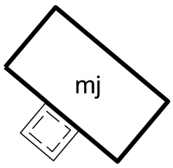
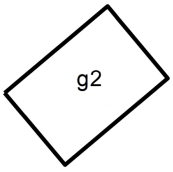
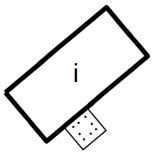
Denotation	Descriptive data	Cartographic representation	Photographic documentation
A	Single-family residential building; Material of external walls: brick; Number of chambers: 8; Number of overground storeys: 2; Number of underground storeys: 1; `EGB_BlokBudynku`: n/a; `EGB_ObiektyTrwaleZwiazaneZBudynkiem`: vestibule (x2), staircase (x2), terrace.		
B	Single-family residential building; Material of external walls: brick; Number of chambers: 3; Number of overground storeys: 1; Number of underground storeys: 1; `EGB_BlokBudynku`: n/a; `EGB_ObiektyTrwaleZwiazaneZBudynkiem`: veranda/porch.		
C	Farm building; Material of external walls: brick; Number of overground storeys: 2; Number of underground storeys: 0; `EGB_BlokBudynku`: n/a; `EGB_ObiektyTrwaleZwiazaneZBudynkiem`: n/a.		
D	Other non-residential building; Material of external walls: brick; Number of overground storeys: 1; Number of underground storeys: 0; `EGB_BlokBudynku`: n/a; `EGB_ObiektyTrwaleZwiazaneZBudynkiem`: vestibule.		

Table 8. Comparison of results of surveying usable floor area with results of implementing three variants of the proposed method

Object	Us. fl. area s. [m²]	Est. total area (Var. I) [m²]	Est. inner area (Var. II) [m²]	Est. us. fl. area (Var. III) [m²]	Difference (Var. III – S) [m²]	Discrepancy (Var. III – S)
A	183.39	242.64	199.04	187.47	4.08	2.2%
B	84.39	105.28	89.46	84.45	0.06	0.1 %
C	185.66	218.01	185.54	185.54	−0.12	0.1 %
D	30.94	37.96	27.28	27.28	−3.66	11.8 %

Us. fl. area s. – usable floor area survey
Est. – estimated
S – Survey

Table 9. Comparison of results of estimating usable floor area of object A for various input parameters

Description	Us. fl. area [m²]	Difference* [m²]	Discrepancy*
Survey	183.39	–	–
Variant III	187.47	4.08	2.2%
Variant III – 10 chambers	185.85	2.46	1.3%
Variant III – wall thickness of 0.43 m	184.45	1.06	0.6%
Variant III – 10 chambers and wall thickness of 0.43 m	182.84	-0.55	0.3%

Us. fl. area – usable floor area
*relative to survey

and used buildings, difficulties were often encountered in ensuring a uniform way of conducting surveying works, which would be consistent with the statutory and normative rules. It resulted from the existing fixed furniture in individual rooms (e.g. kitchenettes, wardrobes, etc.). There is no doubt either, that performing surveys inside building structures, especially residential buildings, may meet with reluctance and resistance of the owners. It should be reminded here once again that, in the current legal status, the surveyor does not hold any appropriate license to carry out surveys and to determine usable floor area to supply public records. Implementation of the proposed method would allow for a subtle avoidance of this limitation.

Due to the small number of test structures, it is not possible to unambiguously state the high level of suitability and feasibility of implementing the methodology for estimating the usable floor area of buildings in practice. Further studies on its improvement and broadly understood usefulness will be carried out as part of the PhD dissertation by one of the Authors of this research paper.

6 Main limitations of the proposed method

The studies carried out on the test structures, analyses of the applicable legal regulations, as well as verification of the current level of updatedness of the database of the register of land and buildings within several cadastral districts, allowed to formulate basic limitations of the proposed approach of estimating usable floor area. They were noted down in the following subsections and provided with relevant commentary.

6.1 Amendments to the regulations on recording geometric data of a building

Amendments to the Regulation on the register of land and buildings (Regulation, 2001) introduced in 2013 and 2015 (Regulation, 2013, 2015b), brought about a lot of controversy with respect to capturing and collecting geometric data of a building. These amendments have been described in detail and explained, e.g. by Benduch et al. (2017a), Buśko (2016). Unfortunately, the manner in which individual provisions of the regulation were formulated and the lack of legal definitions of individual structures, such as overhang, vestibule, veranda, result in a series of ambiguities. The importance of appropriately selected and clarified terminology for the issue of collecting spatial data on real estate has been repeatedly emphasized in the subject literature (Hanus et al., 2013). All ambiguities lead to different interpretations of legal regulations which, in turn, does not allow for a uniform manner of collecting cadastral data throughout the country. This problem may bring erroneous results of estimating usable floor area using the discussed method. If the roof of a building, which is based on pillars, is entered as an overhang (`EGB_BlokBudynku`), or a porch is mistaken with a vestibule (`EGB_ObiektTrwaleZwiazanyZBudynkiem`), unauthorized inclusion of individual surface areas into the calculation of usable floor area may occur. Therefore, it is a good solution to collect digital photos of a building in the real estate cadastre, as allowed by Regulation (2001). Such photos are more and more frequently used when verifying the correctness of the data contained in the modernized database of the register of land and buildings. It is worth noting, that in the case of further amendments to the provisions on entering buildings into the real estate cadastre, it may prove necessary to introduce appropriate modifications in terms of assumptions adopted both for the purpose of introducing this method and for the entire calculation process.

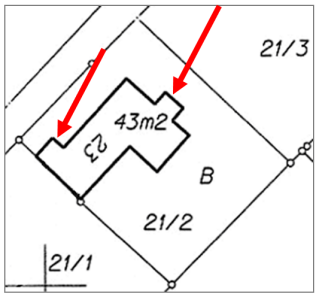


Figure 7. Example of non-compliance of cadastral data of a building with applicable laws (Source: own study based on materials from the database of the national geodetic and cartographic documentation centre)

6.2 Updatedness of the data contained in the real estate cadastre

The problem resulting from frequent amendments to legal regulations is the need to modernize the cadastral data in order to adapt it to the applicable requirements. Unfortunately, recent changes that occurred within only two years (Regulation, 2013, 2015b) resulted in outdated information about buildings contained in the real estate cadastre. Modernization of the register of land and building is a long-term and expensive process, carried out at various paces in individual counties. Thus, it is possible that a great number of cadastral districts may not have adequate data to exploit the potential of the proposed method for estimating usable floor area. An example is test object A (Tab. 7) which, on the current cadastral map, is presented as follows in Figure 7. Apart from nonconformity in determining the main function of a building on the cadastral map constituting a report from the database of the register of land and buildings, it can be clearly seen in Figure 7 that building structures permanently attached to a building (vestibules) were treated as part of the object `EGB_Budynek`. Thus, adoption of such data for the purpose of implementation of the method for estimating usable floor area, would lead to incorrect, double calculation of the usable floor area of a vestibule. This means that geometric data of a building entered into the real estate cadastre should definitely be up-to-date and in accordance with the applicable legal regulations. It is also important that buildings are recorded as objects. Otherwise, the results from estimating their usable floor area may have an average level of reliability.

6.3 Compliance of the assumptions of the method with the actual status

This problem appeared at the stage of empirical verification in the previous subsection. As it was pointed out, the factor of particular importance for the results to be as close as possible to the usable floor area determined by a classic survey is the thickness of external walls of a building. However, the assumptions presented in Table 3 may not be consistent with the actual status. Unfortunately, there is no information in the cadastre about whether a building has got any external insulation layers. Introducing additional values to the attribute: material of building's external walls, such as "insulated wall", would greatly improve the quality of calculations. An even better solution would be information directly specifying the thickness of the external wall, which could be taken from the existing construction design, or as a result of performed surveys. Such changes would, however, require another amendment to the Regulation on the register of land and buildings (Regulation, 2001), and then its modernization in order to complete the missing data. In addition, it may happen that the layout

of the rooms inside a residential building significantly differs from the one used for determining the value of the parameter Z (Tab. 5). Moreover, the walls inside the building may have a thickness other than the predetermined 0.20 m. Nevertheless, the entire calculation process was prepared in such a way that this parameter should have no decisive influence on the final result of estimated usable floor area. Also, in the case of non-residential buildings, i.e. those that do not have information about the number of chambers, inconsistencies with the adopted assumptions may occur. It is enough for a building to have additional partitions inside, which is obviously not uncommon, and their surface area will not be excluded from the calculations. The database of the register of land and buildings lacks relevant data that could be used to include this factor in the process of estimating the usable floor area of non-residential buildings using the discussed approach developed by the Authors. However, as repeatedly emphasized, the proposed method is to be used to estimate usable floor area, and not to determine it strictly. According to the Authors, in the case of determining the usable floor area of buildings, especially for taxation purposes, priority should be given to the uniformity and universality over the accuracy of the calculation method, which together constitute a necessary condition to improve the reliability and usefulness of this important spatial information.

6.4 Impossibility to include rooms of different heights in the calculation process

In regulations (Act, 1991, 2001), the legislator provided for the same rules for determining the usable floor area of rooms of different heights. They are consistent with those contained in the Polish Standard of 1970 (PN-70/B-02365, 1970):

- Rooms or their parts with a height equal to, or greater than, 2.20 m shall be included in the calculation of usable floor area in 100%,
- Rooms or their parts with a height from 1.40 m to 2.20 m shall be included in the calculation of usable floor area in 50%,
- Rooms or their parts with a height of less than 1.40 m shall be omitted in the calculation of usable floor area.

Unfortunately, the use of the proposed method for estimating usable floor area does not provide for a possibility to make an appropriate adjustment due to the varying heights of individual rooms in a building. There is no information in the cadastre, or in any other public record, which would allow to include the height of rooms in the calculation process. Such adjustment would be required primarily by buildings with popular slants in the attic. It is worth considering that classical surveys of such structures usually present numerous difficulties, as it is necessary to determine the extent and area of parts of rooms of various heights. It is also worth noting that in the Polish Standards of 1997 (PN-ISO 9836:1997, 1997) and 2015 (PN-ISO 9836:2015-12, 2015), the rules for determining usable floor areas of rooms of varying heights were not explicitly stated. In the subject literature, a view has been established that, referring to §72 section 1 of the Regulation on technical conditions to be met by buildings and their location (Regulation, 2002), the usable floor area of a room shall be counted as a whole, but parts with a height below 1.90 m are entered separately and they are considered auxiliary surface areas. In the light of the quoted standards, auxiliary surface area is also included in usable floor area and is not reduced in any way. A similar approach was found in foreign standards BOMA, TEGOVA, GIF and IPMS (Łuczyński and Kotarba, 2017). All problems related to the determination of the usable floor area of buildings in a traditional way prove that the binding rules should be harmonized and, as seen by the Authors of this research paper, also simplified. Usable floor area should be identified with usable space, and this is undoubtedly also the space of parts of the rooms that can be used not only for the permanent residence of people, but also for the storage of items. Thus, the fact that the proposed method does not allow for including parts of rooms of varying heights in the calculations is not a disqualifying factor. Entering information about an attic into the cadastre would provide some possibilities for estimation in this respect.

Table 10. Comparison of results of surveys and estimation of usable floor area, inclusive of underground storeys of a building

Object	Us. fl. area s. [m^2]	Est. us. fl. area [m^2]	Difference [m^2]	Discrepancy
A	269.35	278.28	8.93	3.2%
B	171.96	173.66	1.70	1.0%

Us. fl. area s. – usable floor area survey
Est. – estimated

6.5 Polysemy of the term of usable floor area in the Polish legislation

This ambiguity results from the fact that there are different definitions of usable floor area in individual legal acts. The discrepancies between the provisions on taxes and local fees (Act, 1991) and register of land and buildings (Regulation, 2001; Act, 2001) mentioned in the Introduction are particularly problematic. In some cases, they prevent one of the basic functions of this register from being fulfilled: using the data contained therein for real estate tax assessment. Due to the lack of unified definitions of usable floor area, there are differences in rooms being qualified for calculations. The most popular example of a room, taken into account when defining the usable floor area of a building being the basis for real estate tax assessment, is a cellar, which should not be included when determining usable floor area for the needs of a real estate cadastre. Therefore, even in the case of single-family residential buildings, there may be differences in their usable floor areas, which will definitely disqualify information contained in the real estate cadastre as a tax base. It should be emphasized that the results of estimating usable floor area with the use of the proposed approach, included in Table 8, were obtained without including the surface area of underground storeys. Unfortunately, as defined in the Regulation on technical conditions to be met by buildings and their location (Regulation, 2002), a cellar can not be directly identified with an underground storey, which is important in the context of applying the discussed method for the purpose of estimating usable floor area. A cellar may also constitute the overground storey (Regulation, 2002), and therefore, its surface should not be included in the calculation of usable floor area for the needs of the real estate cadastre. Unfortunately, the currently recorded data on buildings does not allow for proper verification and possible adjustment of calculation results in this respect. For real estate tax assessment, however, it is reasonable to include the surface areas of all storeys of a building and include them into usable floor space which is a base for taxation (except for the areas of staircases and lift shafts). Then, for the underground storeys, it is necessary to use Variant II, i.e. omitting the adjustment due to the number of chambers in a residential building. Table 10 demonstrates results of surveys and estimation of usable floor areas of objects A and B, including underground storeys.

Discrepancies in the demonstrated results are a conse-

quence of the presence of building partitions at the level of underground storeys of the analysed structures, which were not included in the implementation of Variant II. Larger differences were noted in the case of object A, resulting from the presence of more rooms (4 rooms) located within the underground storey than in the case of object B (2 rooms). The discrepancies which did not exceed 5% were considered acceptable, without a possibility for their improvement, though. Nevertheless, the results presented in Table 10 provide a good approximation of the usable floor area of a building, defined for the needs of real estate taxation in the current legal status. However, it can be presumed that if the cadastral value of a building constituting a part of the land is taken as taxation basis, the surface area of cellars (or at least underground storeys) shall not be included in the mass valuation process, as it is generally not taken into account when determining the market value of built-up land.

6.6 Main limitations of the proposed method – overview

The limitations and problems described above, and related to the estimation of usable floor area using the proposed method, do not form any grounds for its disqualification. The Authors claim that practical implementation of this method on a national scale could be carried out. Before that, however, it would be reasonable to verify these assumptions in test cadastral districts to get an almost unambiguous answer to the question whether this method could actually prove useful. Nevertheless, even in the case of a positive empirical verification, it would be necessary to amend the relevant legal regulations, together with the Regulation on the register of land and buildings (Regulation, 2001), to formally implement the discussed method for estimating usable floor area. A complete legislative path may ultimately turn out to be the largest of the limitations and problems for exploiting the potential of the discussed method in practice.

7 Conclusions

In the opinion of the Authors, the conducted research and analyses allowed to meet the basic scientific objective of this paper, which involved developing a methodology for estimating the usable floor area of a building based on available cadastral data. As repeatedly emphasized, the results obtained with the use of the individual variants could be used primarily for tax assessment purposes. The surface area calculated in the proposed manner will probably not be able to replace usable floor area determined in a traditional way. Due to the approximate nature of the obtained results, it is unlikely to be used e.g. in the real estate valuation process, nor should it be expected that, even if formally implemented, it will have replaced the one declared by taxpayers, as it would probably be questioned by the public opinion. This method could, however, be used as a tool for the tax authorities for a comprehensive verification of usable floor area declared by taxpayers, which is a base for taxation of buildings. Then, if significant discrepancies occurred, the tax authority could take steps to carry out appropriate controls.

However, the introduction of the 'ad valorem' tax in Poland, which has been discussed more and more frequently in the recent years, seems to be an optimal moment to fully take advantage of the potential of the discussed approach. Then, it would be possible to provide access to the necessary, uniformly obtained data of the real estate cadastre, describing the surface area of buildings which would serve to determine the cadastral value constituting the basis of their taxation. General taxation is known to use the methods applicable to the mass valuation process, and therefore, its result is assumed to be an approximate one, possibly the closest to the market value. Using the surface area of a building, estimated in a uniform manner with the adoption of the same assumptions, could be considered as a natural part of the taxation procedure. This surface area, although characterized by lower accuracy than the one determined in the traditional way, thanks to eliminating a number of subjective factors associated with the performance of classical surveys, should ultimately contribute to the increased reliability of the base for the ad valorem tax for built-up land.

For the concept of usable floor area not to become even more ambiguous, the Authors propose that the surface area determined using the discussed method should be referred to as the cadastral area. It should therefore be included in public records as a new spatial attribute of a building. With regard to buildings other than residential buildings, this would be the area estimated using Variant II, and for residential buildings – the area calculated using Variant III. Thanks to such a solution, tax reliefs for objects used for residential purposes would be indirectly supported. The total area obtained as a result of the use of Variant I, which does not require additional assumptions, should not be completely excluded from use, either.

In any case, considering numerous problems and ambiguities associated with determining and entering the usable floor area of buildings into the real estate cadastre, relevant amendments to the legal regulations should undoubtedly be introduced, which would contribute to improving the level of reliability and usefulness of this extremely important information.

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