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Impact of Modern Technologies on the Organization of the Cadastral Data Modernization Process

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Abstract: Land surface and environmental data (cadastral data) are extremely important in the functioning of the country and society. Upgrading the data is fundamental. Methods of traditional surveying (TM) or using modern remote data acquisition methods (PhM) are used for this purpose. The aim of the study is to compare the process of upgrading space and environmental data made by traditional methods and using modern remote data collection methods. The study established the following research hypotheses: (1) the election of the method of performing the cadastral data modernization process to consider effectiveness, productivity, profitability, quality (accuracy), reliability, and efficiency; (2) technical factors, as well as employee well-being and commitment, are equivalent motivators for the election of the cadastral data modernization method; (3) modern survey technologies using photogrammetric images are more efficient than traditional survey methods. The process evaluation methodology was tested on two objects located in Poland. The analyses considered both technical aspects and the comfort of the process contractors. The results showed that despite the higher unit price per cadastral plot (TM 180 PLN/cadastral plot, PhM 190 PLN/cadastral plot), the remote methods require less time commitment (TM-86 days; PhM-50 days) and involve reduced business travel (TM-65 days; PhM-29 days). The comfort of working with modern methods (PhM) is higher than with traditional measurement methods. In total, considering all the parameters studied, traditional methods required about 33% more commitment than modern remote methods of collecting surface and environmental data collection. Modern data acquisition methods are friendly to process contractors but gain less public acceptance than traditional methods (the level of border non-acceptance is higher in PhM methods than in TM (TM-3, Phm-8).

Keywords: public data about the environment; technical data about land surface; modern remote data acquisition technologies; data upgrading; employee well-being

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1. Introduction

Humans and space are inextricably linked with each other. The relations between them are ambiguous and multidirectional. The physical surroundings provide the living environment for individuals and social groups. The type of bonds and relations between an individual and the territory in which the individual functions determines the nature and specificity of the space. A person is the active subject in these relations and affects the changes in the physical environment with respect to its shape and structure by introducing new objects and demolishing the existing ones according to the technical, legal, and functional requirements. Actions in the space would be chaotic without precise information about it, especially concerning the natural environment and real estate [1,2]. Cadastral data are among the main sources of information on a property and environment. They define and register the spatial location of the property and the extent of property rights, restrictions, and obligations [3]. They also contain a geometrical description of land plots along with other environmental attributes (land surface, forests, bushes, water bodies, etc.) that describe the nature and extent of the shares [4–6]. In many countries, cadastral data are the foundation for decisions taken as regards, e.g., sustainable property management and environmental, investment decisions, spatial planning, and tax rates [7,8]. It is recognised that cadastral data are efficient and effective cadastral systems that are essential for economic development, environmental management, and social stability in both developed and developing countries [9,10].

Due to the widespread use of cadastral data, their timeliness takes on particular importance, as it is the determinant of confidence in the decisions taken. Cadastral data should therefore be permanently upgraded so that they reflect the factual circumstances in the ground surface. The quality and consistency of data in various information systems have been discussed in numerous comparative studies [11,12]. This subject matter is attracting a lot of attention from researchers throughout the world due to the rapid development of modern data acquisition technologies [13,14]. Not only do these technologies support the process of primary data acquisition [14–18], but they are also successfully applied during the technical and environmental cadastral data upgrading process [19–22]. In many countries, the development trends regarding geodetic surveys and mapping are directed towards the development of automatic control engineering and rapid, intelligent, and integrated data acquisition [23,24]. The development and use of modern surveying technologies is supported by the proliferation of easy-to-use platforms and sensors [25–28] and by advances in the field of computer vision [29] and multi-view stereoscopy [30], supporting the photogrammetric processing of aerial photographs [31]. Despite certain disadvantages of the photogrammetric methods (e.g., the range limited to the slope scale, the need for stable weather conditions, public distrust of the use of modern surveying technologies), the use of methods based on photogrammetric studies has many advantages over traditional surveying methods. The source literature indicates that photogrammetric methods are characterised by time savings [32], higher operational flexibility [33], higher spatial resolution flexibility and no line-of-sight constraints [34,35]. For this reason, they are commonly used in numerous surveying projects.

This study fills the knowledge gap in terms of comparing the cadastral data upgrading (technical and environmental data) process carried out using photogrammetric (PhM) and traditional (TM) methods. Efficiency, productivity, profitability, quality (accuracy), reliability and productivity were studied in TM and PhM methods. The decision to select attributes was determined by the characteristics of the spatial and environmental data modernization process, comparable to the production process.

Cadastral data upgrading is a process carried out by specialised organisations whose main aim is to generate profits. When considering the effectiveness, productivity, quality (accuracy), reliability, and efficiency of the TM and PhM methods, the decision to select a cadastral data upgrading method by an organisation that has the initial finance and social capital becomes easier. Although many scientific studies conducted so far in the field of cadastral data upgrading have focused on a segment of the process when analysing strategies, the possibilities for using the technology [19,21] and its accuracy [22], the current study analyses the process of comprehensively developing and analysing all of its parameters. Such a viewpoint on the data upgrading process is of extreme importance as it considers the human factors—persona (contractor/recipient of the upgrading work outcomes) [36–38], the conditions of process implementation and the technological development (modern data acquisition technologies) and its suitability for the analysed purpose on equal terms.

The aim of the article is to comparatively analyse the process of environmental and technical data upgrading collected in the public register carried out by traditional (TM) and photogrammetric (PhM) methods. The comparison was conducted based on the production process parameters, taking into account the social aspect of this process, too. The study established the following research hypotheses: (1) the election of the method of performing the cadastral data modernization process to consider effectiveness, productivity, profitability, quality (accuracy), reliability, and efficiency; (2) technical factors, as well as employee well-being and commitment, are equivalent motivators for the election of the cadastral data modernization method; (3) modern survey technologies using photogrammetric images are more efficient than traditional survey methods.

The article is structured as follows. After the introduction, literature analysis and the presentation of the study object, a schema/algorithm is presented which illustrates the model of OPGK technology for performing a cadastral data upgrade using TM and PhM methods (Section 3.1). Each stage in the process was analysed in terms of the following parameters: effectiveness (Section 3.2), productivity (Section 3.3), quality (accuracy) (Section 3.4), reliability (Section 3.5), and efficiency (Section 3.5) of the process. Moreover, a discussion is presented (Section 4), and the study results are summarised (Section 5). At each stage of the research, the human (performer/recipient/owner) is the core of the process.

2. Materials and Methods

2.1. Materials

The study conducted comparative analyses of the process of environmental and techniacal data upgrading in two objects. The key elements (effectiveness, productivity, quality (accuracy), reliability, and efficiency) of the cadastral data upgrading process were carried out using traditional geodetic (TM) and photogrammetric (PhM) methods. The data for the analyses were acquired from OPGK (Regional Surveying and Cartography Company) in Olsztyn, which specialises in carrying out surveying and cartographic work, including environmental and technical cadastral data upgrading. The data concerned two objects (villages) located in Poland in Warmińsko-Mazurskie Voivodeship (the Prioma object) and Lubelskie Voivodeship (the Chylin object).

The cadastral data upgrading project was implemented at a similar time (2019/2021) and involved a similar range of operations. Consistency over time was the key attribute in terms of the uniformity of existing regulations and the financial rate per comparative unit (this eliminated the impact of inflation, which increased considerably during the COVID-19 pandemic).

The environmental and technical data in the Prioma object were upgraded using photogrammetric methods (PhM), while in the Chylin object, traditional field surveying methods (TM) were used. Table 1 summarises the basic parameters of the objects under analysis.

Table 1. Summary of parameters describing the objects under study.

Features	Unit	PRIOMA Object	CHYLIN Object
Total surface area	ha	588.53	1017.90
Area of agricultural land	ha	408.81	807.3
Area of forests	ha	143.78	155.40
other	ha	35.94	55.20
Number of plots	number	406	649
Number of boundary points	number	1471	1751

2.2. Methods

The study used comparative (functional and indicator) methods, research of documents, statistical methods (multiple regression), and social questionnaire surveys based on expert opinions.

The first stage involved the analysis of the technology of performing cadastral data upgrade by the OPGK Olsztyn, with the emphasis placed on the coherent stages and the stages applying a different technology. The second stage involved a comparison of the basic parameters of the production process analysis (see point 2.3.). Such an approach to the cadastral data upgrading process allows the so-called benefits and the main causes of problems to be analysed [39,40]. By using two types of methods (the TM and PhM methods) in the cadastral data upgrade, the process was assessed in terms of effectiveness, productivity, quality (accuracy), reliability, and efficiency (see Table 2). Thanks to the comparisons, the organisation carrying out the process, investors, and the beneficiaries of the cadastral data upgrade effects gain a broad understanding of its most sensitive stages, difficulties, and added values.

Table 2. Process analysis parameters—methodological diagram.

Process Parameters	Features
Effectiveness	Price per conversion unit Working time External workers Period of work with the property owner Number of computer workstations used Number of field teams Number of surveying instruments used Business trips (days) Number of disagreements with the boundary course Number of written appeals
Productivity	External services Business trips (costs) Materials Room rental costs
Profitability	Data constituting a business secret
Quality (accuracy)	Differences in the surface area Disagreements with the boundary course Model of boundary point location accuracy Assessment of the process in experts' opinions
Reliability	Employee's sickness absence New subcontractor Additional equipment Weather
Efficiency	Using attributes from each stage

2.3. Technology of Environmental and Technical Cadastral Data Upgrading—Analysis of Individual Process Stages Using TM and PhM Methods

The cadastral data upgrading process in Poland can be carried out in three administrative and legal modes: mode A—ongoing cadastral data upgrade; mode B—cadastral data upgrade; and mode C—periodic cadastral data upgrade [41]. These differ in the scale of introduced data changes, the time involved in the process, and the final cost. The cadastral data upgrading process (mode B) is the most desirable, as it involves the supplementation of missing data and their upgrade in order to create a complete set of cadastral data to reflect the actual situation in the field while considering the restrictions arising from the existing regulations.

Each object subjected to the upgrading process, regardless of the method applied, contains a certain range of consistent procedure stages that result primarily from the guidelines of the existing legislation and from the agreement concluded between the organisation/contractor of the upgrading process and their ordering party (and/or investor). In order to fully analyse the cadastral data upgrading process, it is necessary to go deeper into its individual stages and to note the moments where modern, remote data acquisition methods are feasible. Table 3 summarises the individual stages of a cadastral data upgrade and identifies the stages taking into account the differences resulting from the surveying methods applied.

The completion of the formal and legal part (S.1) concerning the agreement for the execution of the cadastral data upgrading project is followed by an analysis and assessment of documents and other administrative and legal materials (S.2) acquired from the National Land Surveying and Cartographic Resource (*Państwowy Zasób Geodezyjny i Kartograficzny*, PZGiK). PZGiK is a national base/resource for surveying and cartographic data. Pursuant to the Land Surveying and Cartographic Law Act of 17 May 1989, all land surveying and cartographic work should be submitted to (and accepted by) the PZGiK after verification. Land surveying and cartographic data stored in the PZGiK resource are used in the national economy, national defense, protection of public safety and order, science, culture, environmental protection, and for the citizens' needs, etc. [42].

A cadastral database update requires knowledge of the number of points of the geodetic control network in the area being upgraded, their location in the field, and the location accuracy (S.3, S.4). A geodetic control network is a set of points with coordinates X, Y, Z specified in the national spatial reference system. They form a reference system for all geodetic and cartographic work that has been accepted by the PZGiK.

Another step is to transform control network coordinates (S.5) and all the data acquired in stage S.2 (S.6) to the currently valid PL-2000 coordinate system [42]. Comprehensive cadastral data upgrades are carried out quite rarely [43], which results in the data transformation stage being essential. After the analysis of the transformed data, ambiguities or doubts about their quality can emerge in certain cases. It is therefore important to indicate them to the District Surveyor (authority responsible for the maintenance of the PZGiK at the district level [42]) (S.7) and to determine a methodology for a solution.

The next stage involves entering the boundary point attributes into the database being upgraded (S.8). These include [44–47]: mean error of the boundary point location (BPP), boundary order symbol (RZG), boundary point monumentation type (STB) and the source of data describing the boundary point location (ZRD).

The stages from S.1 to S.8 are identical, irrespective of the selected method for upgrading cadastral data. Differences emerge at later stages of the process.

At stage S.9, when data are upgraded using traditional (TM) methods and documents for field surveys are prepared. All the data that can streamline the surveying process, e.g., basic sketches along with all data from the surveys taken so far, etc., should be used at this stage. Stage S.10 involves a direct survey in the field intended to supplement the missing data (boundary points).

When the PhM method is applied at stage S.9, a photogrammetric flying pass is designed, minor control is designed, and photo control points are marked in the field and surveyed (S.10) This preparation is followed by a photogrammetric flying pass (S.10.1) which serves the same role as direct surveys in the field and is intended to acquire all information about the situation in the field. It should be performed either in early spring or autumn, i.e., when the sunbeam incidence angle is appropriate and the vegetation does not shade the situation in the field. The excellent visibility of all elements in the image guarantees that the operator, using a stereoscopic model, will correctly identify the situation in the field. The results of photogrammetric surveys, after tonal adjustment, obtaining external orientation elements and image projection centres, performing aerotriangulation, generating a Digital Terrain Model (DTM), verifying DTM correctness, carrying out image orthocorrection and orthoimage mosaicking, and checking the data, are used to create an orthophotomap (S.10.2) and to construct a stereoscopic model. The model enables stereoscopic surveying and the supplementation of missing data on the field, e.g., the location of boundary points, elements of buildings, structures, trees, bushes, changes in land use, etc.

The next stage (S.11) of cadastral data upgrading is identical in both methods. Property owners/holders are informed about the date of the so-called boundary delimitation. The determination of the cadastral plot boundary course, including the location of boundary points determining the plot boundaries, can be carried out directly in the field or based on aerial or satellite imagery or an orthophotomap if these studies are characterised by a resolution ensuring the visualisation of detail features likely to be of importance when determining the course of these boundaries (S.12). Traditional methods used during a cadastral data upgrade require that the course of boundaries and boundary points be indicated directly in the field. Photogrammetric methods allow the location of boundary points and the course of boundaries to be established together with the owner/holder on the orthophotomap (in a computer). There are cases where the owner/holder disagrees with the plot boundary course indicated in documents. In such a situation, the so-called "last state of peaceful possession" is established. If this state also cannot be ascertained, the course of the boundary is established after investigating the location of boundary markers and traces and analysing all the available documents. Where a blurred boundary relates to woodland, forested areas, wasteland, pastures or miscellaneous land (see: Figure 1), the course of plot boundaries and the location of boundary points are determined using an appropriate fragment of the existing cadastral map, with an additional document containing a description of the proposed plot boundary course being attached to the boundary delimitation report. As regards other areas where the PZGiK documents contain no necessary data needed to determine the boundary location, an additional direct geodetic survey in the field is carried out (S.12.1).

Table 3. Technical and legal stages of the environmental and technical cadastral data upgrading process.

Stage	TM	PhM
S.1	Receiving an order to upgrade cadastral data	
S.2	Analysis and evaluation of materials and documents acquired from the PZGiK	
S.3	Analysis of data concerning the geodetic control network existing in the field in either the "1965" or a local system	
S.4	Tracing geodetic control network points in the field, survey, adjustment, and checking for acceptable errors	
S.5	Transformation of the existing control network coordinates ("1965" or a local system) into PL-2000, and an accuracy check according to the existing regulations	
S.6	Recalculation of all documents acquired from the PZGiK concerning the area under analysis	
S.7	Consultation with the District Surveyor about the solutions to be taken in relation to the documents acquired from the PZGiK resource and having low reliability found after the implementation of stages 4–6 and a field visit	
S.8	Entering data into the system, including boundary point attributes from the surveys taken so far (with PZGiK), such as BPP [1], RZG [2], STB [3], ZRD [4]	
S.9	Preparation of documents for field surveys intended to supplement missing data	Designing the photogrammetric flying pass
S.10	Field surveys (by traditional methods) to acquire the missing data on boundary points in order to determine their coordinates	Designing local minor control, marking photo control points in the field, and their survey (e.g., by GPS method)
S.10.1		Performing a photogrammetric flying pass over the area under analysis
S.10.2		Processing of data obtained from the flying pass to produce an orthophotomap
S.10.3		Stereoscopic survey of boundary points (point coordinates)
S.11	Sending a notice to interested parties about the date of boundary delimitation	
S.12	Establishment of the plot boundary course and the location of boundary points in the field together with owners of the adjacent plots and survey of boundary points	Delimitation of boundaries and the determination of boundary points at a community centre (a different property) using the orthophotomap
S.12.1		Supplementary field survey
S.13	Signing the boundary delimitation agreement	
S.14	Supplementing the data with help of direct field survey of the missing data, or acquiring documents from the GUGiK (e.g., orthophotomaps from photogrammetric flying passes) for the purpose of updating data on the area under analysis	The use of photogrammetric flying pass data to build a stereoscopic model
S.15	Survey of remaining missing data	
S.16	Gathering descriptive data on buildings, building blocks, and structures from the architectural and construction administration authority	
S.17	Supplementation and correction of technical information on buildings, building blocks, and structures as well as on the holder	
S.18	Supplementation of the number of the Land and Mortgage Register [9] (Polish abbreviation KW) established for buildings constructed on land to which the right to perpetual usufruct has been granted	
S.19	Supplementation of both the descriptive and graphical (map) part of cadastral data	
S.20	Marking the buildings which, under the current legal status, should not be disclosed in the cadastral data register	
S.21	Making the cadastral data upgrade report open to the public (15 working days)	
S.22	Consideration of comments on the upgraded cadastral data	
S.23	Issuance of a decision approving a draft cadastral data upgrade report by the Surveyor	
S.24	Entry into force of the new state of cadastral data	

[1]—BPP—code/symbol of mean error of the boundary point location relative to the 1st order geodetic control network (according to [44] as valid since 2021, the new acronym is ISD). [2]—RZG—code/symbol of the boundary order (no changes after 2021 [47]). [3]—STB—code/symbol describing the boundary point monumentation type (no changes after 2021 [47]). [4]—ZRD—code/symbol describing the source of data on the boundary point location (according to [44] as valid since 2021, the new acronym is SPD [47]). Source: own study. [9]—Supplemented description.

Figure 1. An example of a plot boundary not visible in the field. Source: OPGK.

The next process stage S.13 involves the signing of the boundary delimitation agreement. (a) the boundaries can be delimited based on unanimous indications of the owners (the neighbouring owners agree on the location of the boundary); (b) the boundary can be delimited based on the last state of peaceful possession/holding on the land (the boundary location is not consistent with the available documents but the owners/holders unanimously declare that the boundary runs as indicated, and that boundary points are monumented on the land); (c) the boundary can only be delimited based on the analysis of maps/documents accepted to the PZGiK resource, and court rulings (owners/holders failed to appear at the meeting concerning the boundary course determination).

Further stages of the cadastral data upgrade are determined by the extent established in the contract between the party ordering the cadastral data upgrade and the organisation/contractor. Most commonly (including in the case under analysis), the upgrade also involves updating the database on buildings, structures, and land uses. As regards the traditional (TM) methods, the cadastral data upgrade can be performed in different ways. Some data are acquired from a direct field survey (e.g., stairs, terraces, entrance enclosures, porches, garage entrances, entrances to below-grade parts of buildings, etc.). In order to determine other data (e.g., boundaries of land-use areas, the extent of areas not used for agricultural purposes, wooded land and bushland, orchards, inland water lines, etc.), orthophotomaps acquired from the resources of the Head Office of Land Surveying and Cartography (Polish acronym: GUGiK—an authority managing land surveying and cartographic data at the national level, acting under the direct supervision of the Surveyor General of Poland [45]). These are documents drawn up for the purposes of the audit of payments from the EU, which originate from the Land Parcel Identification System (LPIS—agricultural plot registration system, the graphical part of the Integrated Administration and Control System (IACS) [46]).

If photogrammetric (PhM) methods are applied at this stage in cadastral data upgrade (S.9), the missing data are supplemented based on a stereoscopic survey of the constructed model from a photogrammetric flying pass.

Irrespective of the methodology for performing the cadastral data upgrade, further stages are identical. First, documentation concerning buildings and structures must be acquired from the architectural and construction administration authority (S.16) to supplement the following data: building uses (residential single-family; multifamily; utility; storage; livestock); descriptive data (e.g., year of construction; materials of walls; number of floors; surface area; entry into a register of historic buildings, etc.); building class (according to the Polish Classification of Built Features, Polish acronym: PKOB—valid until 2021 [47,48]; building type (according to the Fixed Asset Classification, Polish acronym KŚT [49]); number of isolated independent premises; date of placing into service; building status, etc. If such documentation does not exist or is incomplete, the data are supplemented based on field surveys (S.17). The recent amendment to the regulations governing the cadastral data upgrading process [44] eliminated the need for classifying buildings in accordance with the PKOB.

One of the final stages is the supplementation of the Land and Mortgage Register number (S.18) (a public register that presents the legal status of properties, Polish acronym KW [50]), established for the buildings constructed on land to which the right to perpetual usufruct has been granted (a substantive right concerning land property, with characteristics between the right of ownership and rental right, established at a period from 40 to 99 years [51]); supplementation of the descriptive and cartographic parts of cadastral data (S.19); and marking the built features which, according to the existing legal order, should not be revealed in cadastral data (S.20).

In technical terms, the upgrading process is completed at this stage. There remains the organisational and legal stage, as cadastral data must be made open to the interested parties (S.21), their comments must be considered if they arise (S.22), and a decision approving the new cadastral state data must be issued (which is carried out by the Starost, i.e., a state authority that maintains cadastral data) (S.23). The new state of cadastral data will start to apply after the decision issued by the Starost becomes final (S.24).

As can be seen, the cadastral data upgrading process is complex and time-consuming [52] in both administrative and legal as well as technical terms.

3. Results

3.1. Effectiveness of the Environmental and Technical Cadastral Data Upgrading Process

In general terms, effectiveness is the result of actions taken, described by the ratio of the obtained effects to the expenditures incurred [53–56]. In the analysed cadastral data upgrading process, the following were adopted as the effectiveness measures: (1) price obtained per conversion unit (PLN/cadastral plot), (2) time required for the implementation of individual stages, (3) number of workers the company had to additionally employ for the performance of individual process stages, (4) period of work with the property owner, (5) number of computer workstations used, (6) number of teams to perform fieldwork, (7) number of devices used during fieldwork, (8) number of days on which employees had to be transferred to work away from their permanent workplace, (9) number of disagreements with the plot boundary course indicated on the orthophotomap or in the field (a stage before the Starost's approval of the new state of cadastral data), (10) number of appeals against the established plot boundary course (a stage after the Starost's approval of the new state of cadastral data). Individual attributes are shown separately for the cadastral data upgrading process carried out by traditional (TM) and photogrammetric (PhM) methods.

The results of comparisons between the TM and PhM methods (see: Table 4) show at each stage that the PhM methods are generally more effective than the TM. The working time and the number of required staff (external workers) are significantly reduced in the photogrammetric methods. A lower unit price is obtained for performing the upgrade using traditional methods, which, however, does not translate into the organisation's final profit on the project implementation.

3.2. Productivity of the Environmental and Technical Cadastral Data Upgrading Process

Productivity is the ratio of the quantity of output produced and sold over a specified and considered period of time to the quantity of used or consumed input resources [55,56]. In the analysed process of cadastral data upgrading, the costs that differentiated both methods were adopted. The costs that the organisation incurs on an ongoing basis, e.g., utilities, staff costs, etc., were included. For the process under analysis, the following were adopted as the productivity measures: (1) external service costs, (2) business trips costs, (3) costs of materials, and (4) costs of room rental for meetings and consultations. The summary indicates that the PhM methods require a higher cost input than the TM methods, with a difference of approx. 12% (see: Table 5).

Table 4. Technical and legal stages of the cadastral data upgrading process.

Stage	Features	TM	PhM
1	Price per conversion unit (cadastral plot)	180 PLN	190 PLN
2	Working time	86 days	50 days
	Analysis of source materials (S.2)	20 days	12 days
	Analysis, tracing, and survey of points of the existing geodetic control network in the field (S.3)	4 days	4 days
	Preparation of materials for boundary delimitation (S.9)	8 days	12 days
	Boundary delimitation (S.12)	24 days	6 days
	Field inspection covering buildings (S.17)	4 days	3 days
	Survey of buildings in the field (S.17)	1 day	2 days
	Photogrammetric (supplementary) survey of buildings (S.17)	2 days	0
	Plotting buildings on the map (S.19)	4 days	2 days
	Completion of documentation	4 days	4 days
	Work on databases (S.8, S.15, S. 19)	15 days	5 days
3	External workers (days)	35 days	13 days
	Analysis of source materials (S.2)	4 days	4 days
	Tracing the control network points (S.3)	4 days	4 days
	Boundary delimitation (S.12)	20 days	0
	Field inspection covering buildings (S.17)	4 days	3 days
	Survey of buildings in the field (S.17)	1 day	2 days
	Photogrammetric (supplementary) survey of buildings (S.17)	2 days	0
4	Period of work with the property owner	40 min	20 min
5	Number of computer workstations used in the company	1–2	1–2
6	Number of field teams	2 teams/2 people	1 team/2 people
7	Number of own surveying instruments used per day	1 computer set 1 GPS unit	1 computer set 1 GPS unit
8	Business trips (days)	65 days (65 days/406 plots)	29 days (29 days/649 plots)
	Establishment of the plot boundary course (S.12)	24 days	6 days
	Survey of boundary points (S.12)	16 days	0
	Project coordination (analysis of materials, trips to the Centre of Surveying and Cartographic Documentation, etc.)	10 days	8 days
	Making the draft open to the public (S.21)	15 days	15 days
9	Number of disagreements with the boundary course	3	8
10	Number of (written) appeals against the established course of boundaries	0	1

Source: own study.

Table 5. Productivity of the environmental and technical cadastral data upgrading process.

Item	Features	TM	PhM
1	Cost of external services (staff, contracted services)	43,020 PLN	68,400 PLN
2	Business trips (costs)	22,652 PLN	10,537 PLN
3	Materials	8500 PLN	5000 PLN
4	Room rental costs (consultations, meetings, etc.)	0	300 PLN
	Total	74,172 PLN	84,237 PLN

Source: own study on OPGK Olsztyn.

3.3. Quality (Accuracy) in the Environmental and Technical Cadastral Data Upgrading Process

Data quality is a multidimensional concept that contains elements of material and non-material attributes [57,58]; therefore, it is difficult to define [59]. The literature on data quality provides a thorough classification of data quality dimensions; however, most dimensions have discrepant definitions due to the contextual nature of quality [57,60,61]. Despite the above, all definitions converge on only one theory: data quality is strongly related to the use of data [58,62]. Depending on the use of data, the quality of data can be regarded as sufficient for some users, but not sufficient for others [63]. The most popular classification systems account for four data quality attributes: accuracy, completeness, consistency, and timeliness [64–66]. For technical reasons, a standardised conceptual model that accounts for completeness, logical consistency, positional accuracy, thematic accuracy, temporal quality, and usability [67] was proposed to facilitate evaluation and reporting. The presented technical attributes do not account for the views and opinions of data users, data designers, producers, or sponsors [68].

Determination of quality (accuracy) of the cadastral data upgrading process is a complex task, which is due to its multi-stage nature and includes elements for which the accuracy requirements are different (the accuracy of determining the boundary point location is different from that of determining the boundary of different land use). So far, the source literature has not indicated an algorithm that would enable the clear identification of the accuracy of the location of field details using photogrammetric methods [69]. Regulations clearly indicate what accuracy level for the location of boundary points should be achieved if a survey is carried out in a certain way. According to the guidelines, the mean error of boundary point location (Polish abbreviation: BPP/ISD) relative to the first-order geodetic control network [47] valid until 2021) and currently, after amendments to Regulation *on Land and Property Register* [44], relative to the geodetic or minor control network, can take values from 1 to 6. These values are determined by the methodology of measurement and measurement conditions (see: Table 6). In general, field surveys enable obtaining a mean error of the point location in relation to the control network at a level of 0.00–0.30 m, with photogrammetric surveys at a level of 0.11–0.30 m [22,70]. During the cadastral data upgrading process, different surveying methods are involved at various stages of the project implementation. Traditional methods (TM) are based on direct geodetic surveys (with no surveying method imposed) supplemented by a stereoscopic survey. A survey performed on a stereoscopic model in photogrammetric methods (PhM) for upgrading cadastral data allows accuracy comparable to that of field surveys to be achieved.

Table 6. BPP attribute value with the coefficient of accuracy.

BPP	Permissible Values of Mean Error of Boundary Point Location Relative to First-Order Geodetic Control [m]	Surveying Method
1	0.00–0.10	- GPS (RTN) survey with ASG EUPOS adjustments - Tachometric survey based on the control established in ASG mode
2	0.11–0.30	- GPS (RTN) survey with adjustments from private networks of reference stations; - GPS survey (RTK with the base station on the point of the third-order control); - Tachometric survey tied to the third-order control; - Photogrammetric survey—stereo 3D digitisation (pixel < 0.10 m)
3	0.31–0.60	- Vectorisation of maps at 1:500 or 1:1000 scales - Vectorisation of orthophotomaps (pixels < 0.20 m)
4	0.61–1.5	- Vectorisation of maps at 1:1440 or 1:2000 scales - Vectorisation of orthophotomaps (pixels < 0.50 m)
5	1.51–3.00	- Vectorisation of maps at 1:2880 or 1:5000 scales - Vectorisation of orthophotomaps (pixels < 1.0 m)
6	over 3.00	- Vectorisation of maps at 1:2880 or 1:5000 scales - Vectorisation of orthophotomaps (pixels > 1.0 m)

Source: [21].

Each cadastral data upgrading process requires an analysis of the quality of surveying and cartographic work performed so far in the area under analysis. These documents are incorporated into the PZGiK resource after previous verification and are, therefore, supposed to have adequate accuracy. Depending on the type of geodetic procedure aimed at determining the location of boundary points and the course of boundary lines, the accuracy requirements have been legally imposed. Boundary markers and signs are among the first group of detail features, which means that they should be measured with an accuracy of no less than 0.10 m in relation to the nearest points of the horizontal control and minor control [71].

A comparison of traditional (TM) and photogrammetric (PhM) methods for upgrading cadastral data in terms of the accuracy of boundary point location is ineffective, as both methods are permitted by law, and the accuracies to be achieved are officially imposed. This does not mean, however, that other attributes, which indirectly describe the quality of work performed using both methods, cannot be examined.

The authors of the study focused on four aspects that enable a comparison between the TM and PhM methods with certain restrictions. The first one (a) involves the evaluation of the plot area change index for the state before and after the cadastral data upgrade [41].

This parameter does not evaluate directly the quality of work performed, but it has a huge impact on the human psyche. Here is an example: if an owner possessed a plot with an area of 10,000 m^2 (according to the entry in cadastral data before an upgrade), and after the upgrade, the area decreased to 8000 m^2, then the owner's objection arises, and he/she is not inclined to accept the implemented project. The arguments concerning the use of modern surveying methods or errors in previous surveys do not convince property owners/holders. However, they willingly accept the reverse situation in which the area of their plot has increased due to cadastral data upgrade. This index is rather a feature related to the quality of primary data, but it also describes the variation between the state in the field and in cadastral documentation. Another aspect associated with the quality of performed work (b) is related to the recording of a disagreement [72] to the course of the boundary of property owners/holders and to the number of written appeals submitted to the authority approving the new state of cadastral data. The third aspect of comparisons (c) between the TM and PhM was based on the construction of a model of relationships between the boundary point location accuracy and its other attributes [73]. The last aspect (d) considers an assessment of the upgrading process from the experts' (contractors') point of view [59]. The assessment was carried out based on the online questionnaire survey, which asked questions concerning the comparison of TM and PhM methods.

3.3.1. Differences in the Surface Area

The differences arising in the plot area between the state before and after the upgrade were analysed for traditional (TM) and photogrammetric (PhM) methods. The results showed (see: Figure 2) that when cadastral data were upgraded using traditional (TM) methods in the Chylin object, Figure 2 here was an 89% change in the surface area of plots, while for the photogrammetric (PhM) method, the area of 77% of plots changed. The average change in the surface area was at a similar level, and for traditional methods, it amounted to 243 m^2, while it was up to 201 m^2 the photogrammetric methods. The highest and lowest increases and decreases in the plot area were noted for traditional methods (TM) and amounted to 4879 and 16,210 m^2, respectively. The distribution of individual differences between the plot areas is shown in Figure 2.

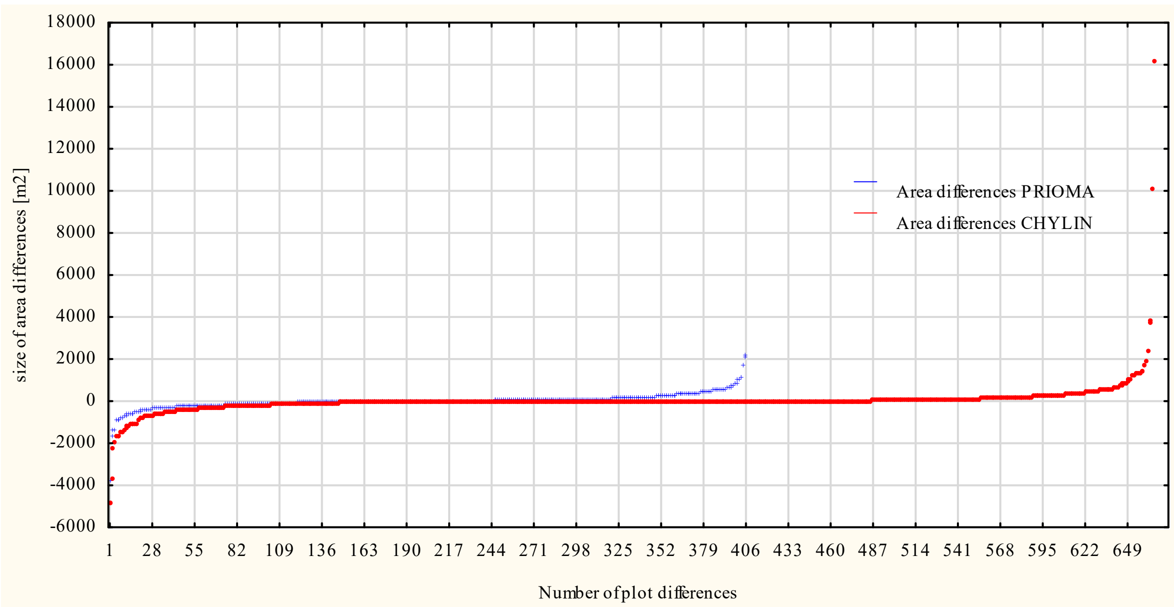

Figure 2. A diagram showing changes in the area of plots due to the upgrading process Source: own study.

3.3.2. Disagreement with the Plot Boundary Course in Owners' Opinions

The method for process assessment, based on the analysis of public objections to the designed new state of space, is applied in many design processes [72], especially when private property is involved. When analysing the cadastral data upgrading process, owners/users may disagree with the proposed new state of a plot/property. They can indicate their disagreement both at stage S.12 of determining the plot boundary course (see: Table 2, stage S.12), after making the upgraded cadastral data open to the public (stage S.21), and after approving the upgrade design (S.24). Statistics on the owners'/holders' disagreement with the establishment of plot boundary course on an orthophotomap concern approx. 5% of those arriving at meetings [74].

3.3.3. Model of Boundary Point Location Accuracy

While examining another aspect related to the quality (accuracy) of carrying out the cadastral data upgrading process, a model of the dependence of the plot boundary point location accuracy (BPP) on other attributes, e.g., a method for acquiring data on plot boundary (ZRD), type of boundary point monumentation/marking (STB), and the order of the plot boundary between boundary points (RZG), was used. Moreover, the year in which surveys were performed to determine the boundary point location was also taken into account (YEAR). Table 7 provides a description of the attributes of the model.

Table 7. Summary and description of attributes.

Symbol	Description	Symbol	Description
BPP	Plot boundary point location error	1	over 3.00
		2	1.51–3.00
		3	0.61–1.50
		4	0.31–0.60
		5	0.11–0.30
		6	0.00–0.10
ZRD	Method for acquiring data on the plot boundary	1	Geodetic field surveys preceded by property delimitation, re-establishment of boundary markers, determination of boundary points or of their location in a different mode
		2	Geodetic field surveys not preceded by legal and administrative proceedings mentioned in point 1
		3	Geodetic photogrammetric surveys preceded by the establishment of a cadastral plot boundary course or the indication of boundary markers before taking aerial photographs
		4	Geodetic photogrammetric surveys not preceded by the establishment of a cadastral plot boundary course or the indication of boundary markers before taking aerial photographs
		5	Approved designs for property division or consolidation and division
		6	Approved designs for land consolidation or exchange
		7	On-screen vectorisation of raster cadastral map while using field survey results
		8	On-screen vectorisation of raster cadastral map without using field geodetic survey results
		9	other data sources
STB	Boundary point monumentation type	1	No information
		2	non-monumented
		3	Surface marker
		4	Surface and buried marker
		5	Buried marker
RZG	Plot boundary order	1	Cadastral plot boundary
		2	Cadastral district boundary
		3	Cadastral unit boundary
		4	Municipality/commune boundary
		5	District boundary
		6	Voivodeship boundary
		7	Border of the state
YEAR	Year in which the surveys were performed to determine the boundary point location	1963, etc.	year in which the survey report was completed and accepted into the PZGiK

Source: own study on [47].

Table 8 provides the model estimation results for TM and PhM methods. The built models were not corrected. The parameters were estimated using the licensed software *STATISTICA 13.3*.

Table 8. Results of model estimation.

Feature Symbol	TM (Chylin)	PhM (Prioma)
ZRD	−0.0240	−0.1794
STB	0.2749	0.1083
RZG	0.0864	0.2118
YEAR	0.0007	0.0088
R2	0.51	0.63

Source: own study on *Statistica 13.3.*

All independent variables were statistically significant at a confidence level of over 0.90, which means that they affected the accuracy of the location of the plot's boundary point. The PhM model fitted the accumulated data better (R^2 = 0.63) than the TM (R^2 = 0.51).

In both the TM and PhM models, with an increase in accuracy of the boundary point location (BPP): confidence in the source of data on the boundary point location (ZRD) decreases; the variable describing the type of boundary point monumentation (STB) method increases along with the variable describing the order / administrative validity of the plot boundary (RZG) and the year in which geodetic surveys of the boundary point were performed (YEAR). The most accurate sources of data on boundary points are geodetic field surveys preceded by the procedure of delimitation, re-establishment of boundary points, or determination of boundary points, with all these procedures being different. Property delimitation is carried out in accordance with the provisions of the Land Surveying and Cartographic Law in a situation where the boundary course is determined, as there are no data on boundary points or the course of boundaries in the field or in documentation [42,73]. Re-establishment of boundary points is carried out in accordance with Article 39(1) of the Land Surveying and Cartographic Law [42] in a situation where boundary markers were previously established, and where legal documents confirming this fact exist, but it was found in the field that the points are relocated, damaged or destroyed [42,73]. Boundary points are determined where the boundaries, according to the legal status, have never been delimited, and the boundaries revealed in cadastral data are consistent with the actual state of holding and where reliable data exist that enable the determination of these boundaries with geodetic accuracy [42].

Determination of the boundary point location and of the plot boundary course using on-screen vectorisation of a raster map are operations which, according to the estimated model, are less accurate than field surveys. This impact proved to be greater in the Prioma object than in the Chylin object.

In the Prioma object, where the data were upgraded using PhM methods, the accuracy of boundary point location was influenced the most by the order/validity of the plot boundary in administrative terms (RZG). State borders, as well as voivodeship or district boundaries, are determined more accurately than boundaries of single cadastral plots. This is linked to the method for marking the boundary point in the field. In Poland, administrative boundaries are most commonly marked with a surface and buried marker, while plot boundaries can be marked with a so-called concrete boundary stone, a plastic marker, a rod, an iron pipe, a pin, etc., which can be easily destroyed [75].

In the Chylin object, where the cadastral data upgrade was carried out based on TM methods, the accuracy of boundary point location was affected the most by its monumentation method (STB). The highest accuracy is represented by points monumented only by a buried marker (presumably due to less exposure to damage), and the lowest by non-monumented points.

The attribute YEAR, which represents the time when surveys of boundary points were performed, exhibits a similar trend in both models. The closer the year is to the date of the cadastral data upgrade, the smaller the error of boundary point location is. This can be explained by the development of surveying technologies which have also covered geodetic surveys. The surveying equipment used nowadays enables obtaining surveying accuracy higher than that obtained by the equipment used 50-60 years ago (the oldest survey taken into account in the study was taken in 1963).

3.3.4. Assessment of the Cadastral Data Upgrading Process in Experts' Opinions

Questionnaire surveys are used in many scientific fields and are one of the methods for evaluating product quality [59,72]. The method was also employed to evaluate the quality of the cadastral data upgrading process. An online questionnaire survey was conducted using the *Microsoft Forms* tool. Experts in the field of cadastral data upgrading were asked 13 questions. which concerned the work performance process, quality (accuracy), and the convenience of implementation of the cadastral data upgrading project. The questionnaire survey was conducted in December 2021, and received 50 responses.

58% of respondents had professional experience in carrying out cadastral data upgrading of more than 15 years, and 28% of respondents from 5 to 15 years, with only 14% with professional experience of less than five years. 58% of the respondents held the position of surveyor, while the remaining 42% held other positions, including managerial positions. 29% of the respondents were state-qualified surveyors.

In the section where the methods are compared: 43% of the respondents replied that both methods, TM and PhM, reflect the factual circumstances found in the field to the same extent. 86% of the respondents stated that traditional (TM) methods require more time commitment than photogrammetric (PhM) methods. 43% of the respondents replied that both methods, TM and PhM, equally require professional experience, and the same proportion replied that more professional experience is required when performing operations by traditional (TM) methods. As many as 57% of respondents claimed that both the TM and PhM methods were equally accurate in technical terms. 43% of the respondents stated that more inconsistencies occur for photogrammetric (PhM) methods, both before and after approval of the new state of cadastral data.

The vast majority, i.e., 86% of respondents indicated that the performance of cadastral data upgrading using photogrammetric methods (PhM) was more convenient for the organisation employees/contractor than traditional methods (TM). Table 9 provides the set of survey questions asked.

Table 9. Set of questions used in the online questionnaire survey.

No	Questions Sent to Respondents
1	Have you worked on a team performing work related to the upgrading of Land and Building Register data?
2	What is your professional experience?
3	What is your length of service with your current company?
4	What position do you hold?
5	Do you have a certified surveyor's qualifications?
6	In your opinion, which method for upgrading the Land and Property Register data reflects the factual circumstances found in the field more faithfully?
7	In your opinion, which method for performing operations related to the Land and Property Register data update requires more time commitment from employees?
8	In your opinion, which method for performing work related to the Land and Property Register data requires more professional experience of staff?
9	In your opinion, which method for upgrading the Land and Property Register data is more accurate in technical terms?
10	In your opinion, which method for carrying out the Land and Property Register data upgrade leads to more conflicts with plot/property owners/users? (this concerns a disagreement that can be corrected before the boundary recognition agreement is signed)
11	In your opinion, which method for upgrading the Land and Property Register data is affected by a greater number of appeals against the established course of boundary/other data identified during the upgrade?
12	In your opinion, which method for the Land and Property Register data upgrading requires more equipment/additional software?
13	In your opinion, which method for upgrading the Land and Property Register data is more convenient to the contractor/worker?

Source: own study.

3.4. Reliability of the Environmental and Technical Cadastral Data Upgrading Process

Reliability is defined differently in relation to a human and to a process. It is understood as its ability to maintain the required level of efficiency during work over a specified period of time [76]. Rather commonly, this feature is equated to resistance to disruptions occurring in the course of operation. Therefore, analysis of the reliability of the human-technical object system involves the ability to carry out assigned tasks with a minimum risk of error, under specified conditions, and within a specified time [76–78]. In the studied process of cadastral data upgrading, the reliability element was based on (A) the likelihood of occurrence of organisation employees' diseases that prevent the execution of work. As regards the traditional (TM) methods, many operations are performed in the field by two field teams (of 2 people each), which exposes workers to flu and related diseases and, currently, in the COVID-19 pandemic era, also to the virus infection. Owners/holders/observers are interested in what is happening in their locations and often ask about the reasons for taking surveys, which creates situations that expose them to infection. Most work performed by photogrammetric (PhM) methods are based on on-site work performed on a computer. The risk of using PhM methods was assessed as lower.

The risk associated with searching for a new subcontractor (B) to carry out the assigned tasks is greater for traditional (TM) methods than for photogrammetric (PhM) methods. This is due to the fact that TM methods require greater involvement of people from outside the organisation/the contractor at various stages of the process. External workers were employed for 35 days for TM methods, and for 13 days for PhM methods.

The reliability of equipment (C) in both the TM and PhM methods is the same. The essential equipment includes a computer set and a GPS receiver. For both methods under analysis, there is always a potential need for an additional set in case of a failure.

The last element of the process reliability analysis is related to the weather conditions (D). In this case, the PhM methods are subject to greater risk, as a photogrammetric flying pass must be carried out under specified weather conditions (trees with no leaves, appropriate sunbeam incidence angle). When these are not provided, the orthophotomap and the stereoscopic model used for surveying operations are not sufficiently clear and affect all stages of the process implementation. The TM methods also require fieldwork, but this relationship is not as strong as it is for the PhM method. Unfavourable weather conditions postpone TM work by 1 or 2 days, which does not have as great an impact as for the PhM method.

3.5. Efficiency of the Environmental and Technical Cadastral Data Upgrading Process

Efficiency is an indicator of the organisation's utilisation of all its resources, e.g., capital, labour, energy, and materials for manufacturing products and providing services [79]. Many authors and organisations indicate that the calculation of the partial efficiency index is more useful when one category of resources is considered. In the case under analysis, efficiency indices were calculated in terms of the use of human resources (external workers, number of teams), equipment (computers, surveying instruments), working time (overall, together with the owner, outside the organisation's headquarters), number of materials produced. The indices were calculated as a ratio to the maximum value that occurred in the case under study. It follows from the analyses that carrying out a cadastral data upgrade using traditional (TM) methods, 100% of available resources are used, while photogrammetric (PhM) methods only require 70% of these resources (Table 10).

Table 10. Efficiency elements of the environmental and technical cadastral data upgrading process.

Features	TM	PhM
Price per unit	0.95	1.0
Overall working time	1.0	0.58
External workers	1.0	0.37
Period of work with the property owner	1.0	0.50
Number of field teams	1.0	0.50
Business trips	1.0	0.25
Use of computer/surveying equipment	1.0	1.0
Productivity	0.88	1.0
Number of materials produced	1.0	0.58
$\sum$	8.83	5.78

Source: own study.

4. Discussion

Upgrading the environmental and technical cadastral data is a very important process from the perspective of state and society functioning, as cadastral data are used in many environmental, social, and economic aspects. Carrying out the process requires significant financial and time resources.

The process is carried out in order to maintain consistency between the state of data functioning in documents and the actual situation in the field. This coherence supports the protection of elements of the natural environment thanks to social awareness of the existing state of space. The causes of the discrepancies arising between the data included in documents and what is found in the field are diverse.

First of all, it should be understood that while performing work related to cadastral data upgrading, three types of boundaries are involved: (a) a plot boundary determined according to the "legal status"—a boundary determined based on geodetic documentation drawn up in proceedings concerning delimitation, plot divisions, consolidations, land exchanges, enfranchisements, other proceedings concluded by a final decision, resolution, or other regulation approving the boundary according to the legal status; (b) a plot boundary determined according to the "current status in the Land and Property Register"—a boundary which is not a legal boundary (as it is not derived from documents concluded by a decision). Most commonly, it is a boundary entered into the database and determined based on cadastral map vectorisation; (c) a plot boundary according to the "factual circumstances" on the land that is used by the neighbouring plot owners.

The fact that the current state of boundaries found in documents has been established in a different way contributes to discrepancies between the situation in the field/on the ground and the situation in the documents that are likely to emerge. The main aim of carrying out the cadastral data upgrading process should be to synchronise both states, which, however, is not always possible.

The passage of time since the latest upgrade is one of the main causes of discrepancies. If cadastral data upgrades are carried out rarely (in Poland, several decades can pass before the next upgrade), then the documents will fail to reflect the actual situation in the field. This involves introducing many changes in the documents reflecting the situation in the field, as well as the development of environmental elements on the ground (trees, shrubs, range of water areas, etc.).

Graphical elements that visualise cadastral data are maps that, in their original form, were produced in an analogue manner. After scanning them to the digital form [80–82], in certain situations, map deformation errors were not considered, sheet contact was not harmonised, etc. Therefore, as mentioned above, this boundary may not reflect the actual situation in the field/ on the ground. If additionally, no investments have been made in such an area, there has been no need to perform new surveys, and the supervisory authority has had no grounds to initiate proceedings related to cadastral data upgrade.

Property owners/holders also contribute to the emergence of discrepancies. The descriptive part of cadastral documents often contains entries concerning deceased persons, while property holders have failed to regulate the right to its possession. This is due to the fact that no inheritance proceedings have been carried out to assent the right of ownership and reflect the actual circumstances.

Lack of consistency between the documents and the conditions in the field frequently occurs in agricultural regions due to their natural blurring, especially where adjacent plots are used in the same manner. Cereal cultivation is one such example. Where a plot boundary is not based on clearly identifiable elements of the situation in the field, the agricultural producer may deform this boundary every time during the cultivation process. Figure 3a,b show adjacent plots which are ploughed. Every year, during fieldwork (ploughing), the agricultural producer misidentified the plot boundary. Figure 3a—a clearly identifiable plot boundary in the field due to the planting of natural vegetation elements

(**a**) (**b**)

Figure 3. (**a**) Distorted plot boundary (plot border visible only on the map) and (**b**) plot boundaries are limited by natural elements (the plot boundary is marked by trees and bushes). Source: OPGK.

Another cause of discrepancies between documents and the field are frequent amendments to legislation. This concerns the data that determined the sharpness of area recording in the descriptive part of cadastral data in agricultural areas (currently, it is required to record up to 1 m^2, while several decades ago, up to 1 are), types of objects that should be included in the graphical part of cadastral data (e.g., a well, a shed, a building under construction, etc., the inclusion of which in cadastral data has been changed over the years), and changes in the way different land uses are described (e.g., agricultural drainage ditches, parking areas, flower beds, vegetable gardens on the farm premises, etc.).

The so-called human errors cannot be ignored either, as they can emerge during both the supplementation of the descriptive and cartographic base of cadastral data and the performance of surveying work. For example, the plotting of buildings into the cartographic part of cadastral data, without referring them to the existing holding boundaries, or a survey and plotting into the cartographic part of cadastral data of buildings that were measured in the local system, without referring to the state control network, is a direct route to the emergence of inconsistencies.

In the cadastral data upgrading process, if the data in the documentation are not consistent with the situation in the field, it may indicate [70] that: (a) surveys were performed against the existing regulations; (b) in the documentation, there is a contradiction with other documents gathered in the Land and Mortgage Register resources, state archives, and owners' collections; (c) local coordinate system does not allow the coordinate transformation to be carried out; (d) there are manifest and gross error that cannot be corrected; and (e) the data are characterised by the lack of sufficient accuracy, e.g., linear deviation for a monumented point exceeds 0.15 m, while for a non-monumented point, it exceeds 0.25 m; the distances do not exceed, for monumented points, $f_i < 0.15$ m, while for the non-monumented points, $f_i < 0.30$ m; the difference in the plot area calculated based on the coordinates and revealed in the Land and Property Register, exceed the value dP_{max}). According to Hanus [70], field inspection and control surveys can help assess the PZGiK materials that should be used in the environmental and technical cadastral data upgrading process. It should be noted, however, that the contractor of the cadastral data update has no right to amend the issued final administrative decisions approving the factual state found in the documents, which results in certain constraints in correcting errors appearing in the documents.

The main aim of the analyses was to compare the methods for upgrading environmental and technical cadastral data, applied using traditional field geodetic surveys (TM) with the methods based on a photogrammetric flying pass (PhM) (remote acquisition of data about the land surface). Regardless of the method applied, certain groups of discrepancies will not be eliminated as human errors will always occur, regulations will be amended, and the property owners' involvement in disclosing the emerging changes are independent of the selected method. However, there is a large group of benefits that reflect well on the use of remote—photogrammetric (PhM) methods.

A comparison of effectiveness in terms of the time of execution, the number of external workers used, business trips, and the work performed together with the owner of a property that was investigated based on two implemented projects indicates that photogrammetric methods are more effective. On the other hand, a lower price per comparative unit and fewer owner's objections to the boundary course plead in favour of traditional (TM) methods. This affects productivity [83], as the traditional (TM) methods in the analysed case exhibit better parameters. In general, the accuracy of both methods is the same, as it is imposed by the regulations. The cadastral data upgrading contractors also stated that TM and PhM were equally accurate. They believe that the PhM methods are superior to the TM methods in terms of time commitment and work convenience, as much work is performed on the computer with no need to carry out field surveys.

The process reliability is comparable but the scales turn in favour of the photogrammetric (PhM) methods. Generally, both methods are equally likely to be affected by an employee's illness [84] or weather-related inconveniences. Since the traditional (TM) methods require more time to be spent working in the field, the likelihood of disease occurrence increases. The situation is similar when it comes to acquiring new subcontractors. As regards the traditional (TM) methods, more stages require that an external contractor be employed, and for this reason, the likelihood of not finding one increases.

The results of analysis on the efficiency of application of TM and PhM methods show that photogrammetric methods are more efficient than the traditional methods by approx. 33%.

To sum up, according to Warzuta and Kulicz [74], the photogrammetric (PhM) methods applied during the environmental and technical cadastral data upgrading process: (a) require less time social commitment, (b) PhM methods enable better supervision over the performance of work (access to the situation in the environment is permanent), and thus (c) the likelihood of technical and human errors occur is lower, (d) PhM methods facilitate contact with owners (who are more willing to participate in boundary delimitation as it is carried out faster), (e) the developed orthophotomap for surveys is uniform and easy to verify, (f) the materials that document the course of delimited boundaries of the plot or environmental elements are more comprehensible, as they clearly indicate topographic details that determine the boundary course. Certainly, risks are indicated as well, and they primarily concern: (a) the experience of the employee-operators performing a survey on a stereoscopic model; (b) difficulties in interpreting certain feature elements (environmental); (c) improper flying pass design, thanks to which data about space/earth is obtained remotely and (d) the public's distrust of modern technology [74].

5. Conclusions

Modern surveying technologies are displacing traditional methods every day. In the area of spatial and environmental data modernization (cadastral data), as well, modern remote data recording capabilities are increasingly being used. They make the process of cadastral data modernization require fewer human and time resources. The work comfort of specialists is higher than in traditional surveying methods. The research and analysis presented in the article can guide practitioners when deciding on the method of cadastral data modernization, as it allows for harmonizing the company's potential with the requirements of the principal.

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