Possible Negative Legal Impacts on Cadastral Work Due to Lack of Perception on Spatial Uncertainty

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SUMMARY

Every measurement, modeling, and estimation procedure consists of uncertainty, and the uncertainty concept may not be understood in the same manner by all parts of society. The lack of uncertainty perception for cadastral activities and the resulting registries in the society, particularly legal experts and policymakers, has numerous consequences. Although the reality must come before the registers, legal entities consider the registers as facts. Recently, an unexpected development about the registration of parcel area information has occurred in Europe and caused adverse effects on geospatial professionals and has a potential of producing unprecedented costs for the states. The parcel area information is one of the most frequently used attributes of a parcel in different domains, such as real estate finance, spatial planning, land development, land readjustment, expropriation, taxation, agricultural subsidies, land regulations, land valuation, etc. Thus, the negative impacts of weak uncertainty perception in this domain have potential for diffusing to a wide range of application fields.

In this paper, the shortcomings of insufficient spatial uncertainty perception by property right holders and legal experts are addressed based on a court decision made by the European Court of Human Rights (ECHR) in 2015. Cases from different countries, e.g. Germany, Switzerland, Turkey, etc., are discussed accordingly. The potential implications of the decision for geospatial professionals and real estate finance sectors are evaluated. The authors also consider that timely discussions and outreach activities on this subject are essential in the light of new land administration trends, such as 3D city models with various levels of details, urban digital twins, etc.

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1. INTRODUCTION

The level of doubt about the validity of a surveying, modeling, calculation, or estimation is defined as uncertainty, which estimates the accuracy (ICSM, 2014). The measurement and estimation processes involve various levels of uncertainty (Yildiz et al., 2022) that can basically be identified with precision and probability (Goodchild, 2007). The uncertainty concept and the error theory have been an essential part of Engineering education including the fields of geomatics and geoinformatics. Although the human brain also considers uncertainty instead of assuming "true or false" only, an attitude which has drawn interest of many researchers in numerous scientific fields (e.g., see modeling of vagueness with fuzzy approach (Zadeh, 1988)); the term still needs to be promoted in the society. Although both social and economic parts of human life consist of various elements which must be measured or estimated, the uncertainty concept remains essential for correct interpretation of concepts by all parts of the society coming from various educational backgrounds.

The measurement activities, whether in engineering, finance, agriculture, Earth Observation, or any other application field, process the uncertainty in various ways legally and technically. As an example, commercial activities for everyday essentials consist of various weighing and the other measurement activities; and people are buying prepackaged products in all parts of the World. However, a court case for lacking five grams of packaged one-kilogram rice bought from a supermarket is out of imagination. Thus, the tolerable error in the contents of prepackaged products was defined with a European Council (EC) Directive (76/211/EEC) that establishes the error magnitude and the package information content for consumer products (EC,1976). The Directive is essential for showing the uncertainty perception in various parts of social and economic life.

With the technological advancements and the digital transformation in spatial data collection and presentation, the traditional role of cartographers and surveyors was altered; as the producers and users of spatial data have become almost all parts of the society (ISO, 2013; Morrison, 2013). Thus, the technology has transformed people into spatially enabled citizens (Williamson and Wallace, 2007). This situation also affected the perception and communication of spatial data quality, which involves several elements such as lineage, positional and attribute accuracy, completeness, logical consistency, semantic accuracy and temporal information based on International Cartographic Association (Guptill and Morrison, 2013). Several authors (e.g., see Devillers et al., 2002 and Gervais et al., 2009) drew attention to the risk of misuse or misinterpretation as well as legal, social, and economical implications with the lack of understanding in data quality. Morrison (2013) also pointed out that the possible legal consequences sourced from the technological shift were not yet sufficiently considered and enacted. Thus, the liability for decisions or activities based on geodata must be addressed, and an increasing interest for this in legal communities is noticable. Furthermore, he emphasized that the liability may induce fear on geospatial professionals, which indicates that the common understanding of spatial data quality is essential for all. Yet, professionals from the other disciplines, such as managers who are users of big data, may see data quality as a minor concern for their business (Lavalle et al., 2011), and the awareness on the fitness for use of data must be increased (Harding et al., 2013).

When it comes to the uncertainty perception related to the measurement and representation activities of immovable properties, even geomatics or geoinformatics professionals may have insufficient perception due to the rapid technological advancements in instruments and methods. Although the novel tools and algorithms may provide high accuracy nominally, the environment and operator related errors remain in application projects. Thus, provision of high precision and accuracy by novel methods and technologies can also cause an illusion for uncertainty perception.

Cadastral activities in many land administration systems aim at spatial representation of the boundaries of rights, restrictions, and responsibilities registered into the official registers. Thus, the responses to "where" and "how much" questions related to land rights are the main objectives of cadastral systems. As the prime geometric element of cadastral activities, land parcels are used to regulate human-land relationship, and almost all rights and regulations are associated with parcel data. The technical part of parcel information is often identified with the geometric boundaries either on a reference plane (2D) or space (3D). However, with the recent developments in 3D city modeling applications, there is an increasing tendency to measure further physical details on real estate properties, such as the volumetric information of independent units. The current cadastral practice usually involves the identification and representation of the parcel boundary geometry and the parcel attributes linked to the geometry or derived thereof.

Inarguably, among various parcel attributes, parcel area information has the greatest impact on financial systems. In parcel-based registration systems, the area information can be accepted as a derivative acquired as a result of a production line, which generally consists of procedures like delineation, demarcation, measurement, drawing or modeling, calculation, and registration. The information derived from such procedures contains the accumulation of errors and must be considered in mature perception of spatial uncertainty in cadastral works. On the other hand, almost all parts of the society and governmental institutions, who do not have surveying competency are the users of this information.

Although spatial data quality and the uncertainty must be extensively discussed and well-understood by many stakeholders and community divisions, there is a significant deficiency in its perception in the society. Although the term, its perception by policymakers and practitioners, and its implications have been addressed by scientists in different domains (e.g., Swart et al., 2009; Smith and Stern, 2011; Höllermann and Evers, 2017), induced by a decision of the European Court of Human Rights (ECHR) in 2015, the topic has been pressing for cadastre especially due to the economic impact of parcel area information. The latest court cases from Continental Europe showed that area calculations registered into official registers as a result of cadastral surveying activities could be evaluated under state responsibility, if there is a guarantee mechanism defined for keeping land registers. Thus, in case of a difference between the factual (geometric) area and the registered area, the parties who incur losses have a right to demand compensation (Yildiz et al., 2022). However, the spatial uncertainty concept was not considered in the court cases, which is elaborated in this paper. The lack of perception of spatial uncertainty can cause negative impacts on cadastral works due to these court decisions. Considering that 3D registration or digital twins are on tap due to rapid urbanization and the pressure on land as a scarce resource, the spatial uncertainty perception and communication needs to be handled in various platforms for people from different educational backgrounds.

In this paper, we address the lack of spatial uncertainty perception especially by legal experts due to the urgency of the topic. We summarize the utilization of parcel area information and the spatial uncertainty handling in cadastral activities in the next Section. In Section 3, we present the recent legal developments with examples from different European countries and cases; and identify the possible legal impacts in Section 4. Future directions from our point of view are presented in the final Section.

2. UTILIZATION OF PARCEL AREA INFORMATION

Cadastral works consist of technical, legal, administrative, and social aspects. Although the spatial uncertainty can be seen as a technical issue, the remaining aspects can not be dissociated from technical parts since cadastre is an engine of modern land administration systems (Williamson and Wallace, 2007). Land parcels are considered as the primary unit of any cadastral system and the property rights are often defined based on them (Williamson, 2010). The parcel can be defined as a "single area of Earth surface, under homogeneous real property rights and unique ownership" (INSPIRE, 2014) and can be accepted as the heart of a parcel-based information system (Tuladhar, 1996).

Spatial representation of the boundaries of land parcels could have been done with conventional two-dimensional (2D) cadastral maps in countries using parcel-based registration systems. The identification of the position and coverage of all rights, restrictions, and responsibilities related to immovables was determined as a main strategy for Australia and New Zealand in Cadastre 2034 (Grant, 2014). Considering rapid urbanization rates and increases in the World's population, 3D cadastral activities will gain importance for most parts of the World for identifying the location and extent of rights regarding complex structures above and under the land parcels.

In parcel-based registration systems, the area information can be accepted as a derivative attribute acquired from a production line, which generally consists of procedures like delineation, demarcation, measurement, drawing or modeling, calculation, and registration. The information derived from such procedures contains an accumulation of errors. Regardless of the approach applied, establishing and maintaining cadastres, which are important layers of spatial data infrastructures, are costly and time-consuming. Thus, parcel attributes derived from spatial information consist of different uncertainty levels, depending on the production date, surveying, modeling, and calculation approaches, local influences, the types of parcel corner points (monumentation), types of boundary definitions (general or fixed), and even the legislation and technical standards applied. These elements form a unique nature for cadastral activities.

Geographical data can be utilized in a broad range of application fields beyond the pre-defined use purposes foreseen by the producer (ISO, 2013). The parcel area information, a derivative attribute of cadastral activities' technical parts, is used by parties from different backgrounds. The utilization fields of the parcel area information are summarized in Table 1. As shown in Table 1, the affected parties of various implementations using parcel area as base information are always spreading over societies. However, the unique nature of cadastral activities can only be interpreted by geospatial professionals comprehensively from a point of view which includes the spatial uncertainty perception.

Utilization Field of Parcel Area Information	**Use Purpose**	**User Profile**	**Affected Parties**
Land and Property related transactions (Real Estate Market)	Defining the monetary equivalent, price.	Brokers, agents, real and natural persons	All parts of the society
Valuation Experts, Agencies	Comparison of real properties, value estimation	Valuation experts from various educational backgrounds	All parts of the society
Land planning authorities	Defining development rights	City planners, politicians.	All parts of the society
Land Readjustment Implementations (Urban and Rural)	Redistribution of the rights	Experts from various educational backgrounds	All parts of the society
Expropriation of real property rights	Calculation of compensation	Expropriators	All parts of the society
Land and Property taxation	Defining tax value in value-based taxation systems	Tax authorities	All parts of the society
Agricultural support	Calculation of amount of subsidizing	Agricultural authorities	All parts of the society

Table 1. Utilization Field of Parcel Area Information

3. RECENT LEGAL DEVELOPMENTS (COURT CASES RELATED TO PARCEL AREA INFORMATION)

Having western type land administration systems with complete cadastres might also conduce towards unexpected legal impacts unless the perception level of spatial uncertainity by legal experts and the society is high as part of the whole process. As mentioned in previous studies (e.g., by Devillers et al., 2002; Gervais et al., 2009; Morrison, 2013), the lack of understanding for spatial data quality has led to legal cases in Europe as explained in detail by Yildiz et al. (2022).

The ECHR stated in a recent decision for Gürtaş Yapi Ticaret ve Pazarlama A.S / Turkey (Application No: 40896/05)[1] that applicant's property rights were violated due to misregistered parcel area information in the land registry. The applicant, which is a construction company, applied to the ECHR after exhaustion of domestic remedies in Turkey. While the area of the land parcel bought by the applicant was 485.200 m^2 at the time of transaction, the General Directorate of Land Registry and Cadastre (GDLRC) corrected the area information to 201.951 m^2 after a cadastral modernization project. In the project, it was revealed that a clerrical error was made by the technical officers when transfering the computed value from planimeter sheet to the related land ledger during systematic registration works in 1955. After the correction, the applicant sued the State for indemnity according to the Turkish Civil Code art. 1007[2]. The claim was that the sales price was determined based on the area data in the offical register, and the applicant would have paid less if the registered parcel area information was correct. Although the boundaries on the cadastral sheet were shown correctly, a gross error which reflects almost half of the registered area was seen as in violation of the property rights' protection extent as defined in the Protocol 1 of the European Convention on Human Rights by the ECHR.

According to the ECHR decision, the reliance on the land registry also covers the registered parcel area (para. 55). So, the State is liable for incorrect parcel area information in the official registers. Another essential topic related to the Court Case was that although the State mentioned in the justification that the applicant should have inspected the land parcel on site and has ability the compare the cadastral documents with the field as a professional construction company, the ECHR did not accepted them. Since the land parcel is a part of a larger area, which constitutes a natural continuation, and there are also no physical boundaries separating the parcel on site, it is not possible for the Company to conjecture the area of the parcel (para.

[1] The original language is French. There are also a Turkish translation and a German summary.

[2] Turkish Civil Code Art states that "*The State is liable for any losses arising from the maintenance of the land register*."

59). In conclusion, the Republic of Turkey was found liable for financial losses arising from errors in the registered area information (Yildiz et al., 2022).

Later, the Turkish Constitutional Court (Anayasa Mahkemesi in Turkish) followed the decision of the ECHR in an individual application case (Sefa Koşar Application No 2015/18352). Thus, the State was held liable if there is a difference between the registered and the real parcel areas. Again, the selling price was determined based on the parcel area acquired from the land registry. After the sales transaction, the GDLRC rectified the parcel area due to the errors occured in first registration. The Constitutional Court accepted the case and considered the situation as infringement to the property rights. According to the Constitutional Court's decision, if the property sale price is determined based on the parcel area, the party who suffers from a financial loss can be indemnified under State's liability rule (Turkish Civil Code art. 1007).

Yet, there are differences in the decisions of the Turkish Court of Cassation on this topic. Although there are decisions that do not consider parcel area errors within the State's liability (Court of Cassation 13th Civil Circuit 29.1.2014, E. 2013/23648, K. 2014/2374), others decided that the State should compensate the damage (Court of Cassation 5th Civil Circuit 1.7.2014, E. 2014/3862, K. 2014/19389). The former one argumented that the concerned party could inspect the actual parcel area and as long as the plans are correct, the State is not liable. The latter decision did find the State responsible for parcel area errors. However, it was observed that the Court of Cassation and the Constitutional Court converged to the ECHR case in recent decisions (the Court of Cassation 20th Civil Circuit (26.9.2019, E. 2019/528, K. 2019/5526, Sapanoğlu, 2020, p. 137).

When the court decisions on this topic in Switzerland are analyzed, it can be said that the Swiss Federal Court's opinion has not been crystallized yet. In an old decision in 1931, the Swiss Federal Court did not accept the State's liability from the survey activities, based on the historical ratio legis of the Swiss Civil Code Art. 955 (source of the Turkish Civil Code Art. 1007 (BGE 57 II 567)[3] in the year 1931. However, later in 1993, the Court left the question, whether the State or Cantons are liable for damages arising from survey, open (BGE 119 II 219).

When the situation in Germany is analyzed, a single decision relating to the State's liability for measurement errors was found. OLG Karlsruhe (9. Civil Circuit (Zivilsenat), 11.05.2006 - 9 U 98/05, BeckRS 2006, 19843) decided that the State is liable for damages, when the measurement carried out by the surveyor's office was false. The Court considered the fact that sale price was determined based on the parcel area information obtained from an on-demand ground survey. The immovable was purchased in 1983, the official surveying office calculated the parcel area as 376 m^2 although the factual area was 356 m^2. Thus, the plaintiff paid for an additional amount for 20 m^2. The error was rectified by the surveying office in 2004 and in its decision in 2006, the OLG Karlsruhe decreed the State liable for the losses of the plaintiff.

[3] Accessed via https://www.servat.unibe.ch/dfr/pdf/c2057567.pdf (5.4.2022).

4. POSSIBLE NEGATIVE LEGAL IMPACTS

4.1. Implications on Geospatial Professionals

Although it is a basic geometric derivative, errors in parcel area calculations sourced from cadastral activities may have unprecedented consequences for geospatial professionals. The lack of spatial uncertainty understanding might lead to the conclusion by the users that the primary responsibility for even minor differences between the registers and the physical reality belongs to geospatial professionals since they are in charge of the technical parts of cadastral activities and the resulting registers.

As a prominent outcome of court cases explained in Section 3, compensations have been paid to the plaintiffs in Turkey including the lawsuit expenses. According to Article 1007 of the Turkish Civil Code, the state has the right of recourse for the paid amount to the public officers, who have a responsibility for the computations and the error if they acted in fault. The technical staff of the Turkish GDLRC and the external or emeritus geospatial professionals who have been involved in cadastral activities for several years, have been facing lawsuits for area differences even in the order of 1-2 m^2, which sum up a large amount of compensation in the end.

Two aspects need to be explored for the recourse cases from the point of view of spatial uncertainty perception. First, area differences smaller than the tolerance value defined in technical regulations are also subject to the compensation cases due to lack of perception of spatial uncertainty in the legal community. The second and even more critical negative legal impact is that apart from the area information, the differences in the physical locations and the mapped coordinates of parcel corner points might be subject to court cases, even when the difference is within the limits of surveying accuracy. Thus, the uncertainty related to the physical boundary definitions, relative and absolute positioning, mapping, and even in visualization must be communicated in all possible platforms (e.g., Web maps, paper and electronic documents, etc.) to avoid liability claims.

4.2. Implications on Real Estate Finance Sector

Land as a scarce resource has a fundamental role in the economic and social lives of both developing and developed countries (Yildiz et al., 2020). De Soto (2000) describes the role of confidence in property rights as fundamental to the success of capital in developed countries. Land administration systems have been designed for securing land rights and increasing confidence in different ways in the World. Moreover, they act as one of the most important data suppliers for land markets.

Dale and Baldwin (2000) described three regulatory pillars in support of land markets: land registry and cadastre, valuation, and financial services. The valuation pillar, which can be defined as estimating value, functions as a bridge between the real estate finance sector and land markets. Since the main elements of real estate are land and its improvements, spatial representation of the real world ensures essential data for various kinds of analyses for the valuation pillar. Inarguably, the area information has the greatest impact on valuation approaches among various other parcel attributes. In addition to the magnitude and location of land parcels and improvements, adjacency to other real properties and facilities, including roads, parks, and similar facilities, are the primary spatial data that affects value.

The real estate finance sector also benefits from technological developments for increasing target groups. Since the spatial attributes are the fundamental ones affecting the value, new instruments like fractional investment tools via blockchain technology (Bennett et al., 2019) also use the spatial information or derived attributes.

The value of a real estate can be seen as an economic representation of property rights. Real estate finance sector uses this representation for securing the liens given to the debit side with collateral mechanisms. When the collateral real estate needs to be liquidated, the accuracy of the valuation is the determinative for the loss and its extent. Thus, the differences in parcel area registers or accuracy of spatial representation of boundaries may affect the valuation process of real properties in lack of perception on spatial uncertainty.

4.3. Future implications with 3D city models and digital twins

The scarcity of land and rapid urbanization have generated pressure on land worldwide (Van Oosterom et al., 2021). Various efforts have been made to provide progress on establishing 3D land administration systems. Stoter et al. (2012) addressed the importance of the collaboration between technical and legal experts in 3D cadastre implementations. Paasch et al. (2016) considered the integration of national legislation for 3D cadastres as an important step. Legal aspects of 3D cadastres have recently been discussed, and the uncertainty handling in land administration has been getting attention for a much longer time. Yet, linking the two must be studied continuously from both technical and legal aspects.

On the other hand, it is considered that the precision and accuracy of the modern measurement techniques and prediction algorithms with the advances machine learning methods increased. Thus, the magnitude of spatial uncertainty is expected to decrease, but remains larger on legacy data still represented in the registers[4]. However, the novel methods also introduces new uncertainty sources, such as classification errors, and related metrics may need to be involved in land administration. Yet, people or systems may presume that the spatial data or products are certain due to the lack of clarity in law; which in the end affects the liability. This topic can be even more prominent with the implementations of 3D cadastres.

The information about the area or volume of individual parts in complex or multilevel structures has been used in many applications, similar to the parcel area information. Various international standards for floor area measurement have been developed by different international organizations (Kara et al., 2018). On the other hand, 3D city models and digital twins are used

[4] Like the fact that the Turkish case before the European Court in 2015 was based on a mistake made in 1955.

as data sources for 3D land administration system establishment works in several regions. Building Information Modeling (BIM) to Geographic Information System (GIS) integration for land administration purposes is also a popular topic especially in the geospatial industry. Since there are more spatial details in 3D modeling and data management tools than the traditional 2D representation of the real world, the accuracy aspects related to these new trends gain even more importance.

5. CONCLUSIONS AND FUTURE DIRECTIONS

Spatial data involves uncertainty sourced from measurements and processing. Yet, several studies emphasized that policymakers and the public may not comprehend this concept and the uncertainty distributions (e.g., Patt and Desai, 2005; Pappenberger and Beven, 2006). The definition of parcel boundaries, their measurements and representations are perceived in different ways by geospatial and legal professionals (Grant et al., 2020). The differences between the physical and mapped boundaries may source from operator errors, poor technical standards at the time of measurement, surface changes due to natural processes, and records created for a specific purpose but used for other purposes. Bennett et al. (2012) emphasized that it may be difficult to perceive by lawyers the fact that the true spatial extent of cadastral boundaries cannot be measured and presented without errors.

Even if the area information is calculated under official work such as parcel-based systematic registration, or predicted in any other way like farmers and landowners did it in the ancient times, uncertainty always existed undoubtedly. Therefore, improvement of the uncertainty perception by all parties including; farmers, right holders, tax authorities, land developers, planning authorities, expropriators, and finally, legal experts, are crucial for proper understanding and interpretation of the registers, which consist of uncertainty inherited from cadastral activities. As emphasized by Devillers et al. (2010), the inclusion of other professionals, such as legal experts, psychologists, human computer interface designers, insurance firms, risk managers, cognition scientists, etc., is also important for increasing the awareness and contributing to problem-solving.

Significant changes in technology have broadened the public use of spatial data. Thus, expectations of the public from the registers in land administration systems have raised dramatically. The monopoly powers of the land administrators (Grover, 2007) have also been curbed due to technological advancements and open data tendencies. While even generally locating parcel boundaries on site was a service which surveyors took charge of, thanks to the spatial cadastres especially in the developed countries, people who have Global Navigation Satellite System (GNSS) receiver integrated smart mobile phones are able to conduct this work by themselves. Thus, spatial enablement can take the role of the middle man out and induce disintermediation (Parsons, 2017). The level of spatially enabled societies which was shown as a cultural and governance revolution can be measured with indicators like comprehensiveness, coverage, reliability, and accuracy (Williamson et al., 2011). Accordingly, spatial uncertainty perception as a part of all these indicators is an essential ability for avoiding possible negative impacts for geospatial experts, land markets, financial institutions, and states.

3D registration is a strong trend for land administration domain nowadays. The problems faced with traditional 2D registration due to lack of uncertainty perception will lead to challenges in boundary determination (Grant et al., 2020) and interpreting the derived data from complex spatial elements. The experiences gained in improving spatial uncertainty perception on the determination, recording, and dissemination in the conventional phase (2D) of land administration works will shed light to new land administration trends. Thus, the experiences spanning centuries for cadastral activities and negative effects of lack of spatial uncertainty need to be elaborated for tackling possible negative legal impacts in future works. For this purpose, simple statistical metrics and user-friendly graphical representations depicting the uncertainity level in spatial data and their attributes can be developed and utilized in data presentation, analytics and reporting platforms for increasing the awereness in all parts of the society.

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