GEODESY

THE ROLE OF GEODETIC MEASUREMENT IN ENSURING ACCURACY AND RELIABILITY IN REAL PROPERTY VALUATION

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Accurate geodetic measurements play a vital role in ensuring fair and reliable property valuations. This article explores how geodetic measurements help define property boundaries, calculate land areas, and assess topographic features, ultimately impacting property market values. Through real-world examples and case studies, we illustrate how precise measurements prevent disputes, improve transparency, and enhance valuation accuracy. We also discuss the common challenges in geodetic measurements, including data accuracy and cost constraints, and explore solutions that enhance reliability. Finally, we highlight the transformative role of geoinformation technology in modern real estate valuation practices.

Keywords: *Geodetic measurement, real estate appraisal, spatial data, boundary disputes, property market value, geoinformation technology*

Introduction

Property valuation is a fundamental aspect of real estate economics, impacting decision-making for buyers, sellers, investors, and policy-makers. It determines tax assessments, influences investment feasibility, and helps urban planners allocate resources effectively. However, the accuracy of property valuations heavily relies on geodetic measurements, which provide the fundamental data required for defining legal property boundaries, land dimensions, and positional attributes [1].

Geodetic measurements go beyond basic surveying; they are essential in legal compliance, urban planning, dispute resolution, and infrastructure development. With technological advancements such as satellite-based positioning, LiDAR, and remote sensing, geospatial data collection has improved dramatically, enhancing valuation accuracy and transparency [2]. However, challenges persist in the form of outdated cadastral records, measurement errors, and limited access to high-precision surveying tools.

This study delves into the impact of geodetic accuracy on property valuation by analyzing key measurement techniques, geoinformation applications, and valuation methodologies. The discussion includes recent advancements, case studies illustrating the consequences of inaccurate measurements, and strategies for integrating modern geospatial technologies into property valuation processes.

Materials and Methods

This study employs a combination of qualitative and quantitative methodologies to assess the role of geodetic measurements in real property valuation. We utilized a literature review, case study analysis, and mathematical modeling techniques to evaluate how measurement precision influences property valuation outcomes. A detailed assessment of different geodetic techniques and technologies was also conducted to compare traditional survey methods with modern digital mapping and remote sensing tools [3].

Data Collection

Data were obtained from a combination of primary and secondary sources to ensure a well-rounded analysis of valuation accuracy.

- **Primary Data:** High-precision surveying tools, including GNSS devices, total stations, LiDAR systems, and drone-based aerial imaging, were utilized to collect real-time land measurement data.
- **Secondary Data:** Cadastral maps, government land records, historical valuation reports, and satellite imagery databases provided background information and validation for primary data.

Analytical Methods

Several analytical techniques were applied to process and assess the collected data:

- **Mathematical Modeling:** The Least Squares Adjustment method was implemented to minimize errors in geodetic calculations and refine measurement precision [4].
- **GIS-Based Spatial Analysis:** GIS was utilized to analyze spatial interrelationships between property parcels, topographical features, and infrastructure developments [5].
- **Comparative Analysis:** A comparative study was conducted between traditional transit/chain surveying methods and modern GNSS-based techniques to evaluate their impact on valuation accuracy [6].
- **Error Assessment:** The Root Mean Square Error (RMSE) methodology was applied to quantify discrepancies in measurement accuracy [7]. The collected data were validated through cross-comparison with records from authoritative survey institutions to ensure reliability and accuracy.

By integrating these methodologies, the study provides an in-depth analysis of the role of geodetic measurement in property valuation and highlights the significance of adopting advanced surveying techniques for improving accuracy and reliability in real estate assessments.

Overview of Common Valuation Methods

Several valuation methods are commonly employed in real estate appraisal, each with its unique approach and formula:

1. **Sales Comparison Approach:** This approach estimates property value by comparing it to similar properties that have recently sold. The formula for this approach is:

$$Estimated\ Property\ Value = \frac{Adjusted\ Sale\ Price\ of\ Comparable\ Properties}{Number\ of\ Comparable\ Properties}.$$

2. **Income Approach:** The income approach determines property value based on its potential income stream. The formula for this approach is:

$$Property\ Value = \frac{Net\ Operating\ Income}{Capitalization\ Rate}.$$

2. **Cost Approach:** This method estimates property value by considering the cost of reproducing or replacing it. The formula for this approach is:

$$Property\ Value = Cost\ of\ Land + Cost\ of\ Improvements - Depreciation.$$

Calculating the Surfaces of Real Estate Units

Calculating the surfaces of real estate units typically involves determining the area of various geometric shapes such as rectangles, triangles, circles, or irregular polygons. The accuracy of these calculations depends on the precision of the measurements and the chosen method of computation. Here's an overview of common methods along with detailed steps and formulas:

1. Rectangular Units:

- **Process:** For properties with rectangular shapes, such as buildings or parcels of land, the area can be calculated by multiplying the length by the width.
- **Formula:** $Area = Length \times Width.$
- **Steps:**

1. Measure the length (L) and width (W) of the rectangular unit using a tape measure or surveying equipment;
2. Multiply the length by the width to calculate the area.

- **Example:** Consider a rectangular plot of land with a length of 50 meters and a width of 30 meters. The area is $50 \times 30 = 1500$ *square meters*.

2. Triangular Units:

- **Process:** For properties with triangular shapes, such as triangular lots or roof areas, the area can be calculated using the formula for the area of a triangle.
- **Formula:** $Area = 0.5 \times Length \times Width.$
- **Steps:**

1. Measure the length of the base (B) and the height (H) perpendicular to the base.
2. Multiply the base length by the height and divide by 2 to calculate the area.

- **Example:** Consider a triangular plot of land with side lengths of 60 (a) meters, 80 (b) meters, and 100 (c) meters. We will use Heron's formula to find the area.

1. Calculate the semi-perimeter (*s*):

$$s = \frac{a+b+c}{2} = \frac{60+80+100}{2} = 120.$$

2. Apply Heron's formula:

$$Area = \sqrt{s(s-a)(s-b)(s-c)} = \sqrt{120(120-60)(120-80)(120-100)} =$$
$$= \sqrt{120 \times 60 \times 40 \times 20} \approx 2400 \; square \; meter \; .$$

3. Circular Units:

- **Process:** For properties with circular shapes, such as ponds or circular buildings, the area can be calculated using the formula for the area of a circle.
- **Formula:** $Area = \pi \times (Radius)^2.$
- **Steps:**

1. Measure the radius (r) of the circular unit from the center to the edge.
2. Square the radius, multiply by π (approximately 3.14159), to calculate the area.

- **Example:** Consider a circular garden with a radius of 25 *meters*.

The area is $\pi \times 25^2 \approx 3,14 \times 625 \approx 1962,5 \; m^2$.

4. Irregular Units (Polygonal):

- **Process:** For properties with irregular shapes, the area can be calculated by breaking down the shape into smaller, simpler shapes (e.g., triangles) and summing their areas.
- **Formula:** $Area = 0.5 \times \sum (x_i \times y_{i+1} - x_{i+1} \times y_i).$
- **Steps:**

1. Divide the irregular shape into simpler shapes (e.g., triangles, rectangles).
2. Calculate the area of each simpler shape using the appropriate formula.
3. Sum the areas of all simpler shapes to obtain the total area of the irregular unit.

Example: Consider an irregularly shaped plot of land:

➤ Rectangle: Length = 60 *meters*, Width = 40 *meters*,

➤ Triangle 1: Base = 40 *meters*, Height = 20 *meters*,

➤ Triangle 2: Base = 20 *meters*, Height = 40 *meters*,

Calculate the area of each shape:

- Rectangle Area: 60×40=2400 *square meters*,

- Triangle 1 Area: 0.5×40×20=400 *square meters*,

- Triangle 2 Area: 0.5×20×40=400 *square meters*,

➤ Sum up the areas: 2400+400+400=3200 *square meters*.

Results and Discussion

The Impact of Measurement Inaccuracies on Property Valuation

One of the critical findings of this study is that inaccurate geodetic measurements can lead to significant financial and legal consequences. Consider the case of a commercial property listed as 1,200 square meters but later verified to be 1,050 square meters through an advanced GNSS survey. Such discrepancies result in valuation inconsistencies, loss of buyer trust, and potential legal disputes.

- **Financial Ramifications:** Overestimation or underestimation of land size directly affects property market value, leading to taxation errors, investment risks, and incorrect loan approvals [8].

- **Legal Disputes:** Boundary disputes stemming from measurement inaccuracies often require costly litigation and arbitration to resolve [9].

- **Market Transparency:** Inaccurate property data reduces investor confidence and distorts market comparability [10].

This example highlights why accuracy in geodetic measurements is essential in avoiding disputes and ensuring smooth property transactions.

Boundary Determination: Clearly defining property boundaries is crucial to preventing conflicts among property owners. Geodetic surveys offer an objective, precise method for boundary delineation, reducing the risk of disputes and ensuring compliance with legal requirements [9]. Modern surveying techniques, including GPS-based positioning, total stations, and laser scanning, ensure property owners and real estate professionals have reliable boundary data. Inaccurate boundary determination can lead to legal disputes, encroachment issues, and financial losses for property owners [8].

Land Area Calculation: The size of a property directly influences its market value. If a property's area is miscalculated, it can lead to significant overpricing or underpricing. Modern technologies like LiDAR and RTK-GPS provide more accurate land measurements, reducing valuation errors [6]. In large real estate developments, even minor errors in land measurement can result in substantial financial discrepancies. Implementing advanced land measurement techniques ensures fair pricing and prevents disputes.

Location and Accessibility: A property's location relative to infrastructure, transportation hubs, and commercial centers greatly impacts its value. Geodetic measurements ensure that properties are accurately positioned on maps, helping real estate professionals provide correct valuations. Misaligned property data can mislead investors and buyers, affecting their decision-making process [10]. For instance, a property initially classified as being within a prime commercial area may, upon re-evaluation, be found outside that zone, impacting its perceived market value.

Topographic Features and Their Influence on Value: Topography plays a key role in property valuation, as factors like elevation, slope, and terrain affect a property's usability and desirability. For instance, properties with scenic views or favorable terrain conditions tend to have higher values. By employing digital elevation models (DEMs), surveyors can accurately assess these characteristics and ensure they are reflected in valuations [5]. Properties located on steep slopes may require additional infrastructure investments, reducing their attractiveness for buyers.

Risk Assessment: Geodetic data are essential in evaluating environmental risks, such as flooding or seismic activity. Using remote sensing technologies and GIS, real estate professionals can incorporate risk assessments into property valuations. A failure to account for such risks can result in financial losses for buyers and investors [11]. For example, a property unknowingly located in a flood-prone area may be significantly overvalued, leading to unexpected financial burdens for its owners.

The Role of Geospatial Technologies

Modern surveying techniques have significantly enhanced the precision of geodetic measurements.

- **LiDAR Technology:** This remote sensing method enables highly detailed elevation and land feature assessments, particularly useful in complex terrains [6].
- **Real-Time Kinematic GNSS:** Provides centimeter-level accuracy, significantly improving boundary delineation and spatial assessments [12].
- **GIS and Remote Sensing:** These tools integrate multi-source data to visualize property boundaries, detect encroachments, and analyze spatial patterns affecting property valuation [11].

Conclusions

Geodetic measurements are fundamental in real property valuation, ensuring accuracy in boundary determination, land area calculation, and the assessment of topographic and environmental factors. The precise definition of property boundaries helps prevent legal disputes, improves market transparency, and provides a foundation for fair and reliable property transactions. When geodetic data is inaccurate, misvaluations can occur, leading to financial loss, legal conflicts, and decreased trust in the real estate industry.

The integration of modern geospatial technologies, such as GNSS, LiDAR, and GIS-based analysis, has significantly improved the precision of property appraisals. These technologies allow surveyors and valuation professionals to collect, analyze, and interpret spatial data more efficiently. As demonstrated in this study, measurement inaccuracies can lead to misrepresentation of land value, increased risks for buyers and sellers, and challenges in urban planning and development. The adoption of advanced geodetic techniques ensures that property values reflect true market conditions, supporting equitable transactions.

However, the implementation of high-precision geodetic measurement systems presents several challenges. Data interoperability, equipment costs, and expertise gaps among professionals remain significant obstacles. Addressing these challenges requires investment in technological advancements, continuous professional training, and policy frameworks that enforce strict data validation and quality control measures in property valuation processes.

Looking forward, the integration of artificial intelligence and machine learning in geodetic data processing can further enhance property valuation accuracy. Automated algorithms can process vast amounts of spatial data, identify patterns, and generate more precise property appraisals. Moreover, the increased use of real-time geospatial monitoring through satellite imagery and drones will contribute to an even more dynamic and responsive property market.

In conclusion, the role of geodetic measurements in property valuation cannot be overstated. The continued advancement of geodetic tools and methodologies will lead to more accurate valuations, fostering a real estate market that is transparent, efficient, and equitable for all stakeholders.

To maximize the benefits of geodetic measurements, industry professionals must address challenges related to data accuracy, interoperability, and cost. Investing in advanced surveying equipment and following strict quality control procedures will help improve measurement precision, fostering a more transparent and trustworthy real estate market [13].

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Վարազդատ Փայլակի Հովհաննիսյան*, Սեդա Աղաբեկի Բադեյան

Ճարտարապետության և շինարարության Հայաստանի ազգային համալսարան, ք. Երևան, ՀՀ

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Ճշգրիտ գեոդեզիական չափումները հիմք են հանդիսանում անշարժ գույքի հուսալի գնահատման համար: Հոդվածում քննարկվում է գեոդեզիական չափումների նշանակությունն անշարժ գույքի սեփականության օբյեկտի սահմանների որոշման, հողատարածքների մակերեսների հաշվարկման և տեղագրական հատկանիշների գնահատման համար: Ուսումնասիրելով գնահատման տարբեր մեթոդներ և իրական օրինակներ ՝ ընդգծված է ճշգրիտ չափումների ազդեցությունն անշարժ գույքի շուկայական արժեքի վրա: Հոդվածում քննարկվում են նաև այնպիսի խնդիրներ, ինչպիսիք են տվյալների ճշգրտությունը, համատեղելիությունը և ֆինանսական սահմանափակումները, առաջարկելով լուծումներ չափումների հուսալիությունը բարձրացնելու համար: Գոյություն ունեցող գրականության համապարփակ վերանայման միջոցով ընդգծված է անշարժ գույքի գնահատման ժամանակակից գործունեությունում աշխարհատեղեկատվական տեխնոլոգիայի փոխակերպող դերը:

***Բանալի բառեր**. գեոդեզիական չափումներ, անշարժ գույքի գնահատում, տարածական տվյալներ, սահմանային վեճեր, անշարժ գույքի շուկայական արժեք, աշխարհատեղեկատվական տեխնոլոգիա*

РОЛЬ ГЕОДЕЗИЧЕСКИХ ИЗМЕРЕНИЙ В ОБЕСПЕЧЕНИИ ТОЧНОСТИ И НАДЕЖНОСТИ ОЦЕНКИ НЕДВИЖИМОСТИ

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Точные геодезические измерения являются основой для надежной оценки недвижимости. В статье рассматривается значение геодезических измерений при определении границ собственности, расчете площадей земельных участков и оценке топографических особенностей. Изучая различные методы оценки и реальные примеры, подчеркивается влияние точных измерений на рыночную стоимость недвижимости. В статье также рассматриваются такие проблемы, как точность данных, интероперабельность и финансовые ограничения, предлагая решения для повышения надежности измерений. Путем всестороннего обзора существующей литературы подчеркивается преобразующая роль геоинформационной технологии в современной практике оценки недвижимости.

***Ключевые слова:** геодезические измерения, оценка недвижимости, пространственные данные, споры о границах, рыночная стоимость недвижимости, геоинформационная технология*

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