Research Journal of Agricultural Science, 57 (3), 2025; ISSN: 2668-926X

http://doi.org/10.59463/RJAS.2025.3.23

MODERN GEODETIC METHODS USED FOR FIELD DATA ACQUISITION AND GIS INTEGRATION FOR BUILDING EXPERTISE

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Abstract. *The paper analyses the issue of registering buildings in the land register, considering the complexity of situations arising from their construction without full compliance with the authorization framework or with deviations from the approved documentation. It highlights the main particularities of the registration process, influenced by the time of construction and the degree of conformity with the legislation in force. The study addresses both the legal dimension, by presenting the relevant regulatory framework and the solutions provided by current legislation, as well as the technical dimension, through the use of modern topographic surveying and photogrammetric methods. It also highlights that for buildings erected without a construction permit, but for which the sanctioning term has expired, legalization may be achieved on the basis of a technical expertise. A practical case study illustrates how these instruments can substantiate the required documentation, ensuring both the accuracy and the reliability of the data. The integration of GIS provides a unified framework for recording buildings, by correlating cadastral and legal data with the actual field situation. Orthophotoplans obtained from UAV flights can be overlaid with information from the electronic eTerra system, which manages land registers and cadastral plans, thus facilitating the identification of buildings without legal documentation. Such a system would support both institutions and citizens, in a manner similar to systematic registration processes, although its implementation requires significant financial and logistical resources. The conclusions emphasize the importance of complying with legal procedures and using modern geodetic technologies to integrate buildings into the legal circuit, thereby contributing to the strengthening of real estate security and to a more efficient management of the built heritage.*

Keywords*: land register, building registration, technical expertise, GIS, UAV photogrammetry, orthophotoplan.*

INTRODUCTION

The registration of buildings in land books constitutes a fundamental stage in managing the civil circuit of immovable property, ensuring transparency and legal security of real rights. This process has a dual nature—both technical and legal—and represents a necessary condition for the legal recognition of ownership as well as for its enforceability against third parties. From a normative perspective, the procedure is governed by a set of principles and procedural requirements expressly provided in the Civil Code and in the Cadastre and Real Estate Publicity Law no. 7/1996, republished, which establish the legal and technical framework for the registration process[16].

In the context of sustainable development, the legalization of constructions erected without compliance with authorization procedures becomes a crucial requirement, both through the performance of technical assessments aimed at certifying their safety in use and through the updating of fiscal records and their integration into the real estate publicity system[14].

An analysis of the various scenarios of building registration reveals that, while essential for safeguarding the legal security of property rights, the process reflects a complex regulatory and temporal context[7]. Between strict compliance with urban planning requirements and pragmatic solutions applicable to constructions erected prior to the current legal framework, each registration pathway illustrates a distinct modality of regulation and integration of real estate assets into the system of real estate publicity.

The registration of buildings in the land book is therefore indispensable for ensuring the enforceability of property rights and the stability of the civil circuit[8]. The procedure varies depending on the period of construction and the degree of compliance with applicable legislation: newly authorized and officially received buildings follow a transparent process based on urban planning documentation, the building permit, the certificate of attestation of completion, and cadastral documentation; constructions erected before 2001 benefited from a simplified procedure based on the fiscal certificate[16]; and buildings constructed after 2001 without permits or with deviations, but for which contraventional liability has become time-barred, require a technical expertise and an attestation certificate, without this implying urban planning legalization. These differentiated mechanisms reflect the adaptation of the legal system to the specific conditions of distinct periods, all pursuing the same objective: the integration of buildings into the system of real estate publicity and the clarification of their legal status[1].

The registration process in Romania relies on a legislative framework that integrates urban planning regulations with real estate publicity rules. Law no. 350/2001 establishes urban planning documentation (General Urban Plan – PUG, Zonal Urban Plan – PUZ, Detailed Urban Plan – PUD), building indicators, and the conditions for issuing building permits[17]. Law no. 7/2020, through amendments to the Cadastre and Real Estate Publicity Law no. 7/1996, introduced solutions for unauthorized constructions that are time-barred from contraventional liability, by requiring technical expertise to confirm the existence and safety of the building, without equating this with urban planning legalization[16]. At the procedural level, ANCPI Order no. 600/2023 specifies the preparation and reception of cadastral documentation, serving as the practical instrument for implementing land book registration[18]. Overall, the legal framework defines both the conditions for construction and the mechanisms of legal regularization through technical expertise, with the ultimate objective of integrating buildings into the real estate publicity system.

MATERIAL AND METHODS

The aim of this study is to develop a GIS database that integrates information on existing buildings within a defined study area, thereby facilitating both the analysis and the accurate representation of on-site reality. This database serves as a support tool for the technical expert certified by the Ministry of Development, Public Works and Administration (MDLPA) in the process of evaluating buildings erected without a building permit. The role of the technical expert encompasses verifying the compliance of the property with applicable urban planning regulations, as well as assessing structural performance through the analysis of the materials used and their conformity with resistance and safety standards in construction[11].

The process of registration and analysis of buildings begins with the fundamental contribution of the geodetic engineer, whose primary responsibility is the collection and verification of the existing legal and technical documents related to the properties and constructions under review. This preliminary stage is followed by the identification of the site, aimed at providing a contextual understanding of the positioning of the land and the building under analysis in relation to the actual field situation. For this purpose, a topographic plan is prepared, serving as an essential document for the precise representation of the property's location and for supporting subsequent stages of the cadastral and urban planning process[5].

The execution of any topographic survey requires the establishment and precise determination of a geodetic control network, which constitutes the reference framework for all measurements. This network ensures the consistency and accuracy of the collected data, enabling the faithful transfer of physical field elements into technical plans and documentation. Its role is critical for the validity of the processes of representation, analysis, and approval of geodetic works, and it provides the necessary foundation for achieving results compliant with professional and legal standards[6].

The second stage of the process involves the preparation of the building survey, which requires on-site inspection and a direct, detailed analysis of the property. The main objective of this stage is to identify and record the essential geometric characteristics of interior spaces and structural elements. Data are collected according to the classical methodology of building surveys, resulting in separate drawings for each level of the construction[3].

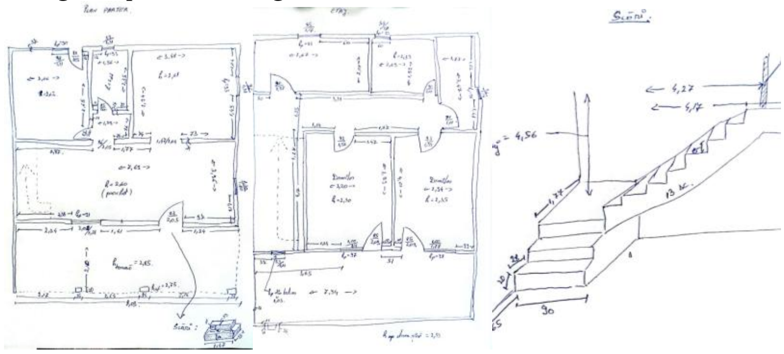

Figure 1. Building measurement sketch

The information obtained includes room dimensions (lengths, widths, heights), wall thicknesses, positions of doors and windows, as well as the location of major structural and functional components, such as load-bearing walls, beams, columns, and staircases. This dataset provides a comprehensive and accurate representation of the building's geometric configuration, forming the indispensable technical basis for the preparation of cadastral, urban planning, and technical expertise documentation[9].

Following the processing of the field measurements, site and boundary plans of the property are generated, along with the measured building survey drawings, which provide a detailed representation of the building's geometric configuration.

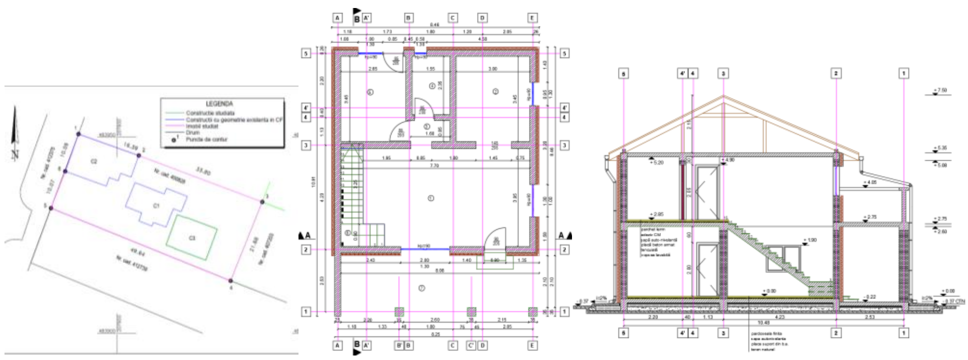

Figure 2. Plans of the Property and the Building

Research Journal of Agricultural Science, 57 (3), 2025; ISSN: 2668-926X
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In the subsequent stage of the process, the role of the technical expert becomes central, with their activity relying on the documentation provided by the geodetic engineer. The expert conducts on-site inspections aimed at collecting relevant samples from the structural elements of the building and at observing cracks and other forms of deterioration. These samples are then subjected to specific analyses and laboratory tests, carried out in accredited facilities, in order to assess the physical and mechanical properties of the materials and their degree of compliance with technical standards of resistance and stability. Based on the results obtained, the expert develops proposals for intervention where deficiencies are identified and formulates well-founded conclusions regarding the structural behavior of the building. The ultimate purpose of this approach is to ensure an adequate level of structural safety and to facilitate the integration of the construction into the legal and technical framework of the real estate system[17].

Figure 3. Structural assessment of the building

The technical expertise process finds both its inception and conclusion in the work of the geodetic engineer, whose role is to ensure the coherence and juridical-technical validity of the entire procedure. Their contribution is essential within the process of legalizing and integrating the building into the official registry system managed by the National Agency for Cadastre and Real Estate Publicity. This stage represents the practical materialization of the evaluation process, in which technical data and legal requirements are correlated to enable the registration of the building in the land book and to confer enforceability of property rights within the civil circuit[18]. The entire procedure is based on a rigorous set of supporting documents, prepared and verified in accordance with legal standards, attesting the completion of construction works in compliance with the building permit, urban planning documentation, and applicable regulations. Thus, the role of the geodetic engineer extends beyond the mere execution of measurements and technical representations, encompassing the safeguarding of the juridical-technical integrity of the process and constituting an indispensable element for the validation and official recognition of the building within cadastral records.

In the context of the legal and technical complexity associated with land registration procedures, it becomes evident that the traditional process—based exclusively on documentation and isolated technical expertise—can be strengthened through the integration of modern spatial analysis tools. In the era of digitalization of cadastral and urban planning processes, the use of a Geographic Information System (GIS) provides the necessary framework for the coherent correlation and unified interpretation of information derived from multiple sources, including cadastral data managed through the eTerra platform, fiscal records maintained by local authorities, and on-site reality documented through geospatial technologies[2].

The evolution of geodetic technologies and the accessibility of open-source GIS platforms such as QGIS now make it possible to create an integrated system for recording and analysing constructions, one that combines the legal dimension of properties with their observable physical reality. QGIS provides a flexible and interoperable environment for importing, overlaying, and comparing thematic layers, while also enabling the automation of analytical processes through advanced spatial processing and modeling tools[15].

A key element of this approach is the acquisition of orthophotos through UAV flights, which provide an updated and detailed image of the study area. These orthophotos serve as the base layer upon which cadastral boundaries and existing legal information are superimposed, allowing for a direct comparison between the official situation and the actual one. In this manner, unregistered buildings or constructions erected with deviations become visible and can be directly identified and recorded within the GIS database[13].

Figure 4. The orthophoto of the study area

The practical implementation of the project in the GIS environment was carried out using the QGIS platform, an open-source tool renowned for its flexibility and accuracy in processing geospatial data. The entire workflow was designed to ensure consistent correlation between cadastral data, fiscal information, and field reality, with the aim of providing a comprehensive and objective overview of the building situation within the study area.

The data provided by the city hall, containing information on cadastral and topographic numbers, as well as measured and taxed areas, were entered into a CSV file. This file was imported into QGIS using the Add Delimited Text Layer tool, selecting the No geometry (attribute only table) option, to be subsequently used as an attribute table.

The cadastral plan of the study area, initially created in AutoCAD, was exported in DXF format and imported into QGIS using the ”DWG/DXF Import” tool. The chosen coordinate system was EPSG:3844 – Pulkovo 1942 / Stereo 70, which is used at the national level. Following the import, separate layers for ”Parcels” and ”Buildings” were generated and subsequently saved in a GeoPackage file for unified management[4].

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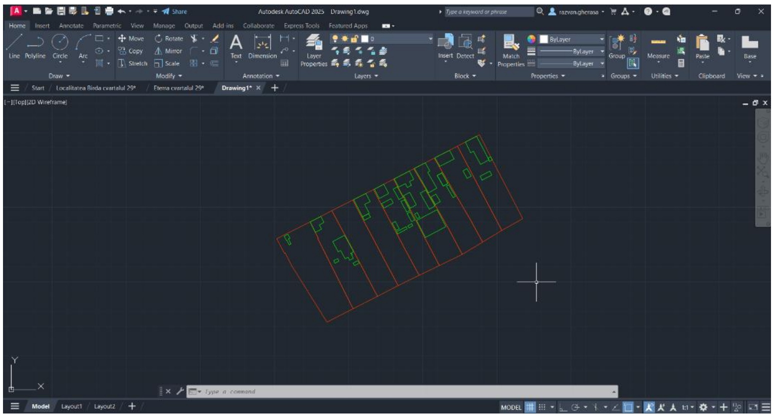

Figure 5. The cadastral plan created in AutoCAD

To clearly delineate the parcel areas, the linear layer resulting from the DWG import was converted into polygons using the “Lines to Polygons” tool. In this way, each parcel became a closed vector entity, ready for spatial analyses and surface area calculations.

The “Parcels” layer was linked to the data table through an association based on the common field “Cadastral Number”. This operation enabled the connection of numerical information (areas, owners, cadastral codes) with the graphical representation of the parcels, facilitating comparative analysis.

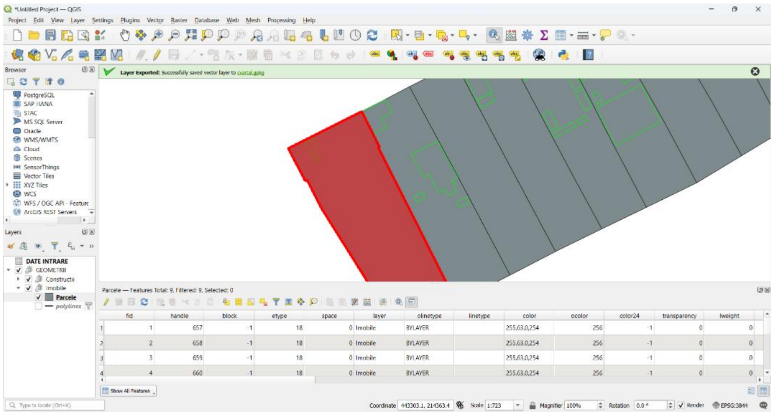

Figure 6. The association of spatial data with tabular data

To link the building data to their corresponding parcels, the “Join Attributes by Location” tool was used. The operation was configured so that each building was associated with the parcel that contains it (contain). In some cases, the Buildings Centroids layer was used to more accurately identify the position of buildings within the parcels.

After merging the data, new fields were generated in the attribute table for the measured area and the taxed area of each building. The values were displayed on the map using dynamic expressions in the “Field Calculator”, in the form of text labels showing, for each building, its identifier and the corresponding values of the two types of areas.

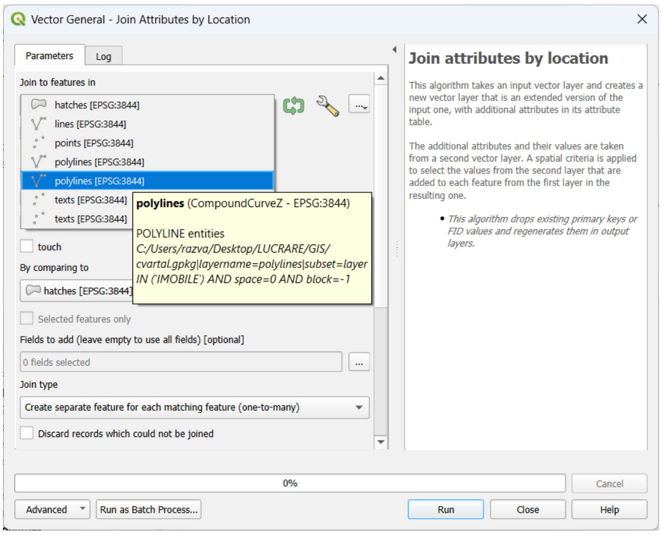

Figure 7. Configuration for Building–Parcel Relationship Analysis

The final database was saved in a GeoPackage (.gpkg) file containing all thematic layers (parcels, buildings, lots, and tabular data). The final map illustrates the correlation between buildings and their corresponding parcels, allowing the visual identification of differences between the measured and the taxed areas.

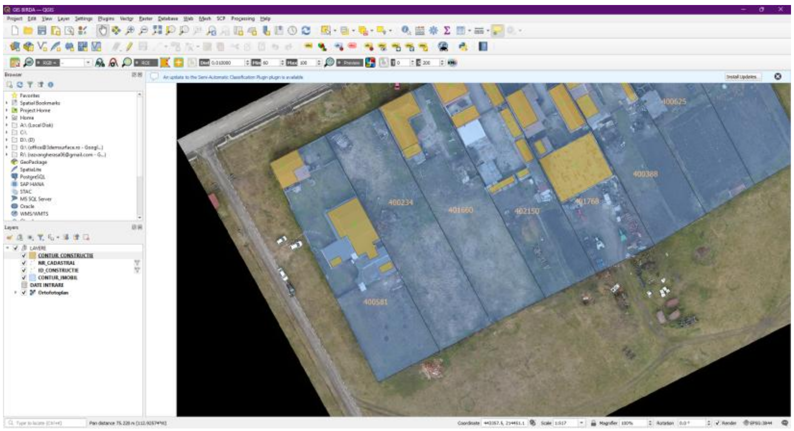
Figure 8. The final map

RESULTS AND DISCUSSIONS

The spatial analysis consisted of comparing overlaps and detecting discrepancies between cadastral data, fiscal records, and the situation visible on the orthophotomap. Using the analytical tools integrated in QGIS, missing, non-compliant, or undeclared buildings were identified, as well as potential positioning or boundary errors of the parcels. The results of this analysis were summarized by classifying the buildings according to their degree of legal and technical compliance, generating thematic maps and statistical reports[10]. These maps provide an intuitive representation of the proportion between compliant properties and those outside the legal

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framework, while the percentage charts derived from the database allow for a quick interpretation of the overall situation in the field.

The results obtained from correlating cadastral data with fiscal records and their graphical representation within the GIS environment reveal a significant degree of discrepancy between the measured and the taxed areas. The comparative analysis, summarized in the taxation charts for properties and buildings, enabled the quantification of the proportion of areas that are not properly reflected in fiscal registries.

According to the Property Taxation Chart (Figure 9), the taxed area represents 88.82% of the total analysed parcel surfaces, while 11.18% remains untaxed. Although relatively small, this difference indicates inconsistencies between the cadastral and fiscal databases, possibly caused by recent changes in property boundaries, update errors, or the failure to declare land parcels associated with existing constructions.

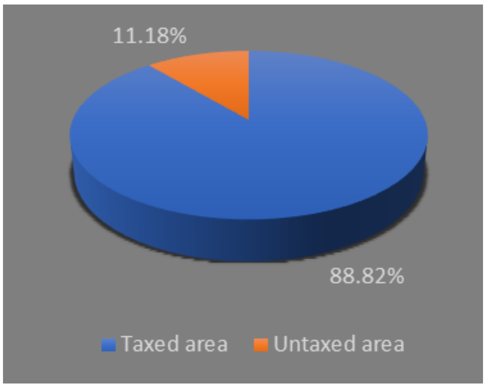

Figure 9. Property taxation chart

Regarding the Building Taxation Chart (Figure 10), the situation is more imbalanced: only 61.61% of the analysed buildings are recorded as taxed areas, while the remaining 38.39% are untaxed. This significant percentage confirms the necessity of updating municipal databases and periodically integrating the results of topographic measurements into local fiscal systems. The discrepancies may stem from the absence of building permits, undeclared extensions, or the omission of temporary and auxiliary structures from official records.

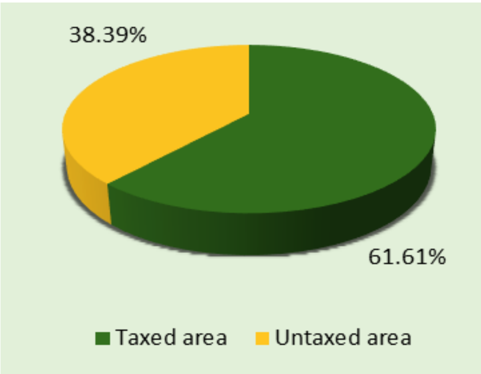

Figure 10. Building taxation chart

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CONCLUSIONS

The relevance of a GIS extends far beyond the simple function of static archiving of spatial information. Its essence lies in the ability to act as a dynamic tool for analysis, decision-making, and optimization of territorial processes, integrating technical, legal, and fiscal dimensions within a unified framework. Cases identified as non-compliant through spatial analysis can subsequently be directed to specialized teams for detailed topographic surveys and structural technical assessments, transforming the GIS into a preliminary verification mechanism and a strategic decision-making platform for local administrations.

Through this approach, the GIS system assumes an active role in prioritizing interventions, optimizing resource allocation, and supporting the legal compliance process of buildings, ensuring efficient and transparent territorial management. From this perspective, GIS no longer represents a simple auxiliary technological support, but rather an integrated informational infrastructure for geospatial diagnostics, directly contributing to the digitalization of monitoring, control, and management processes of the built environment.

Thus, the integration of GIS into cadastral and fiscal processes marks a paradigm shift: from a reactive model, based on documentation and case-by-case verification, to a proactive approach grounded in spatial analysis, data transparency, and continuous monitoring of the built environment. This transformation supports sustainable territorial governance, enhanced administrative efficiency, and the implementation of sustainable development principles at the local level[12].

The spatial analysis carried out in QGIS, by correlating attribute data with the graphical representation of real estate assets, has demonstrated the effectiveness of GIS methodologies in rapidly detecting discrepancies between cadastral, fiscal, and on-site realities. The interactive visualization of the building–parcel relationship, combined with the automated comparison of measured versus declared fiscal areas, provides local authorities with a powerful operational tool for database verification, updating, and harmonization.

The results obtained confirm the efficiency of an integrated approach between the technical cadastre and fiscal systems, establishing a solid foundation for urban planning, territorial development control, and sustainable management of the build environment.

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