



UNIVERSITY OF LIFE SCIENCES "KING MIHAI I" FROM  
TIMISOARA  
"YOUNG PEOPLE AND MULTIDISCIPLINARY RESEARCH  
IN APPLIED LIFE SCIENCES"

13-14 November 2025



"Young people and multidisciplinary  
research in applied life sciences"

MODERN GEODETIC TECHNIQUES FOR UPDATING CADASTRAL  
MAPS IN RURAL AND AGRICULTURAL ZONES

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Abstract:

Accurate land measurement and mapping play a crucial role in agricultural development, environmental management, and sustainable land use planning. Traditional cadastral and surveying methods, while precise, are often time-consuming, labor-intensive, and limited in spatial coverage. The integration of Unmanned Aerial Vehicle (UAV) technologies with Geographic Information Systems (GIS) offers a modern, efficient, and cost-effective alternative for precision land measurements in agricultural environments.

This research article explores the potential of UAV-based photogrammetry for generating high-resolution orthophotos and digital surface models (DSM) used in cadastral mapping and land monitoring. UAV data were processed using structure-from-motion (SfM) techniques to produce detailed 3D models and accurate georeferenced maps. The outputs were integrated into a GIS environment for spatial analysis, parcel delineation, and comparison with existing cadastral boundaries. The positional accuracy was validated using GNSS ground control points (GCPs), ensuring compliance with national geodetic standards.

The results demonstrate that UAV and GIS integration provides centimeter-level accuracy suitable for agricultural cadastre, boundary verification, and land use monitoring. Furthermore, the method enables rapid data collection over large areas while supporting the assessment of topographic and environmental changes. This approach contributes to precision agriculture, improved land administration, and environmental protection by offering reliable spatial information for sustainable rural planning. The findings highlight the importance of incorporating modern geospatial technologies into land management systems to enhance efficiency, accuracy, and long-term sustainability in agricultural development.

Keywords: land measurements, geodesy, mapping, rural, agriculture, technologies



Results and discussions

The integration of UAV and GIS technologies yielded highly detailed and accurate geospatial products suitable for cadastral and agricultural applications. The orthophotos and DSM provided centimeter-level resolution, allowing precise identification of parcel boundaries, irrigation systems, and topographic variations. The positional accuracy analysis revealed an RMSE below 5 cm, confirming the reliability of the UAV-derived data for cadastral purposes. Comparative analysis with existing cadastral maps revealed small discrepancies in boundary placement, often due to outdated or imprecise legacy data. UAV mapping provided a more realistic representation of field conditions, facilitating boundary verification and land parcel adjustment. The integration into GIS enabled efficient visualization, spatial queries, and thematic mapping for land monitoring and agricultural planning. Moreover, the use of UAVs significantly reduced the time and labor required for land surveys, demonstrating a clear advantage over conventional techniques. The system also proved useful for environmental applications such as monitoring soil erosion, crop condition, and drainage networks, further emphasizing the value of geospatial integration in sustainable land management.

Introduction

Land measurement and cadastral mapping are fundamental components of effective land administration and sustainable agricultural management. In many regions, traditional surveying methods rely on ground-based instruments that require considerable time and manpower, especially in large or difficult terrains. With the rapid growth of geospatial technologies, new tools such as UAVs (drones) and GIS now provide faster, more detailed, and more cost-efficient ways to capture and analyze spatial information.

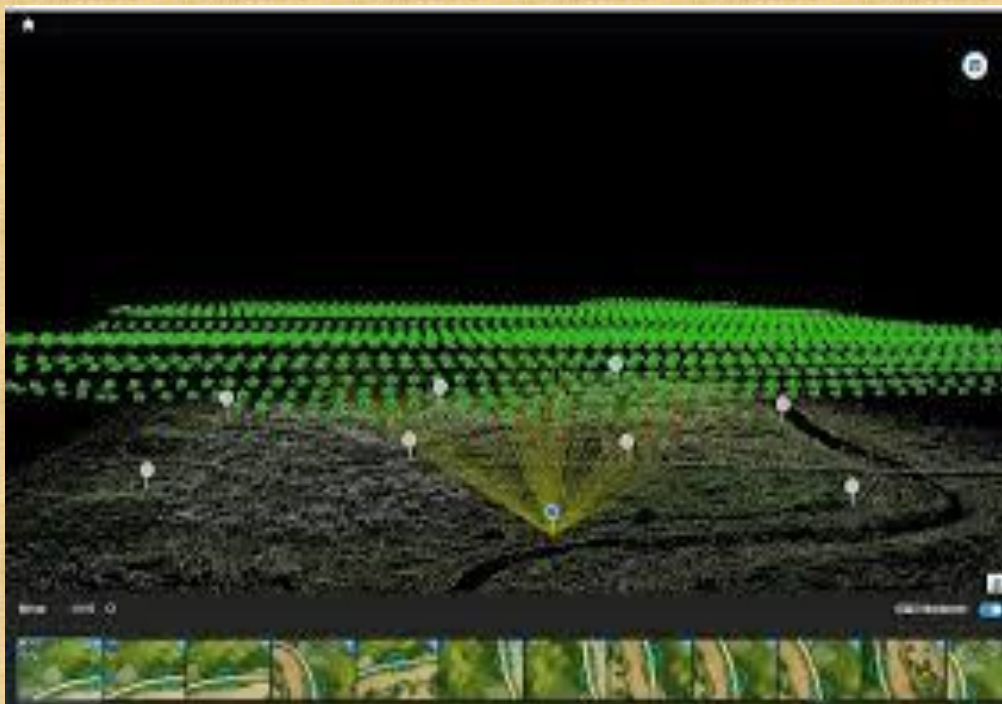
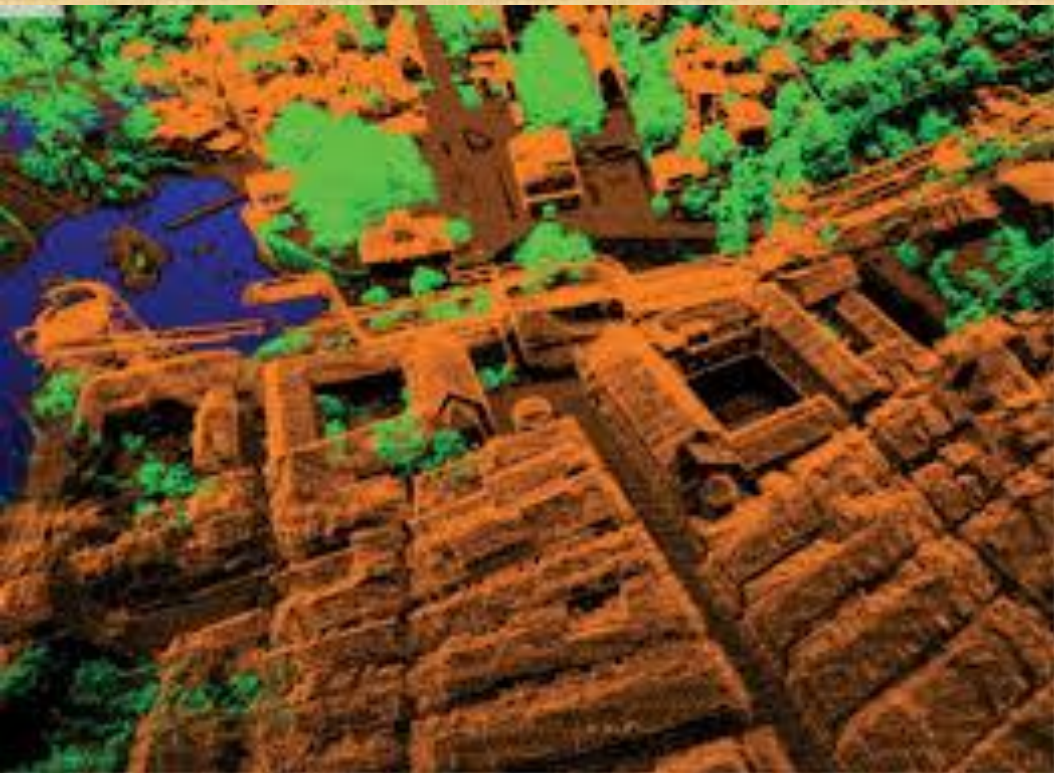
UAV-based photogrammetry allows the generation of accurate orthophotos and 3D models that can support multiple applications, including land parcel delineation, infrastructure mapping, and environmental monitoring. When integrated into a GIS platform, these datasets can be efficiently analyzed, updated, and shared among institutions, improving transparency and decision-making in land management.

The main objective of this research is to demonstrate how UAV and GIS technologies can be effectively combined to achieve high-precision land measurements in agricultural areas. The research focuses on data collection, processing workflows, accuracy assessment, and potential applications in agricultural cadastre and environmental planning.



Conclusions

The results of this research confirm that UAV and GIS integration provides a powerful, efficient, and precise solution for land measurement and cadastral mapping in agricultural areas. The combination of UAV photogrammetry and GIS analysis ensures high spatial accuracy, rapid data acquisition, and versatile applications for both agricultural and environmental monitoring. This technology supports the modernization of cadastral systems, enabling better land use planning, resource management, and environmental protection. Its implementation can greatly benefit local authorities, farmers, and researchers by offering reliable spatial data for decision-making. Future research should focus on the automation of data processing, cost-benefit analysis, and integration with AI-based image classification for land cover and crop monitoring. Overall, UAV-GIS systems represent a cornerstone in the transition toward digital, sustainable, and precision-oriented land management.

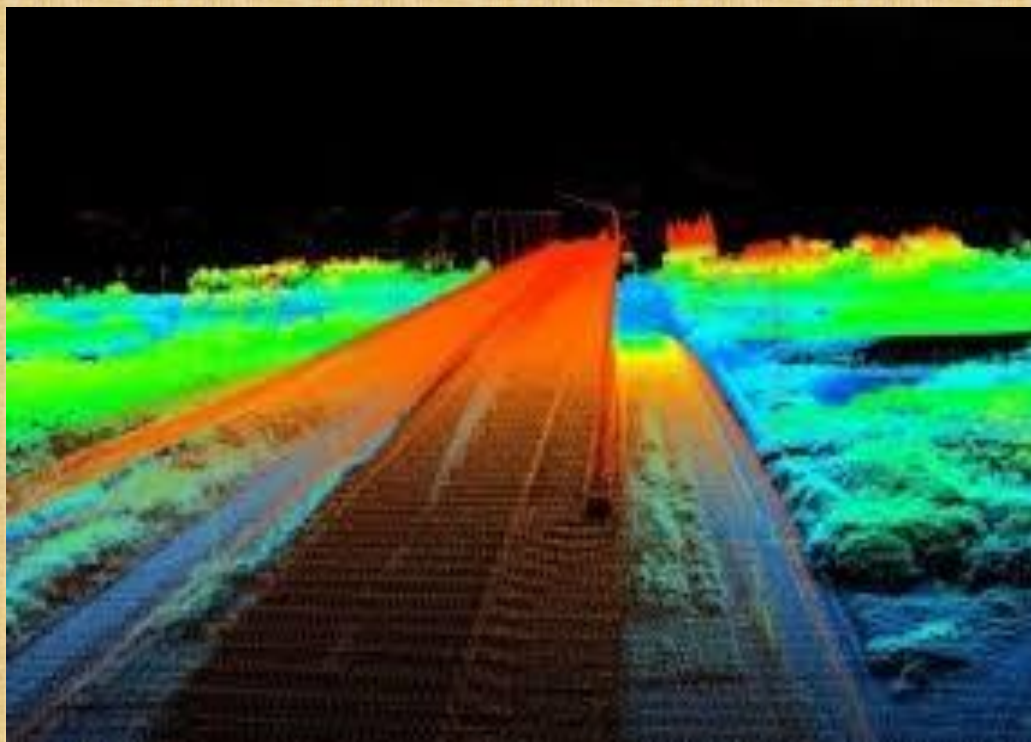


Material and methods

The research utilized UAV imagery captured using a multirotor drone equipped with a high-resolution RGB camera. Flights were conducted under stable weather conditions at an average altitude of 100 meters, ensuring a ground sampling distance (GSD) of approximately 2–3 cm per pixel. Ground control points (GCPs) were surveyed using GNSS equipment with centimeter-level accuracy to georeference the imagery.

The UAV data were processed using Structure from Motion (SfM) algorithms to generate orthophotos, digital surface models (DSM), and point clouds. These outputs were imported into QGIS and ArcGIS for further spatial analysis, including parcel boundary extraction, surface area calculation, and overlay with existing cadastral data.

Accuracy was evaluated by comparing the UAV-derived coordinates with GNSS ground measurements. The Root Mean Square Error (RMSE) was calculated to assess positional accuracy. In addition, spatial statistics were used to evaluate consistency between UAV and official cadastral data.



Acknowledgement:

Support was also received by the project Horizon Europe (HORIZON) 101071300 - Sustainable Horizons - European Universities designing the horizons of sustainability (SHEs)