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Modernizing Land Records in Tulumba Through GIS: Massavi Reconstruction Under the Pulse Project

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This research presents a comprehensive methodology for developing digital Massavis (land record maps) using Geographic Information System (GIS) technologies to address persistent challenges in land record management. The study focuses on the Punjab Urban Land System Enhancement Project (PULSE), specifically examining the digitization of Mouza Tulamba in District Khanewal. Through systematic georeferencing, boundary digitization, and grid adjustment techniques, this study demonstrates how digital technologies can overcome traditional limitations in land record management, including unavailable or damaged physical records and staff reluctance to create new maps. The methodology successfully processed 207 Murabajaat covering 4,189 acres with 8,052 Khasra records, establishing a replicable framework for digital land record transformation.

Keywords: Digital Massavi, GIS, Land Records, Punjab, Georeferencing, Spatial Data Management

Introduction:

Land record management systems in developing countries face significant challenges due to aging infrastructure, damaged records, and inadequate digitization efforts. In Punjab, Pakistan, the traditional land record system relies heavily on physical documents, including Massavis (village land record maps), Latha maps, and field books, which are susceptible to damage, loss, and human error. The Punjab Urban Land System Enhancement Project (PULSE) World Bank Project was initiated to address these systematic challenges through digital transformation.

The importance of accurate land records cannot be overstated, as they serve as the foundation for property rights, agricultural planning, taxation, and urban development. However, the current system faces multiple obstacles that necessitate immediate technological intervention.

Literature Review:

In contemporary Pakistan, a mouza is defined as a territorial unit with a unique name, precise boundaries, and area measured and subdivided into plots or khasras, each with its survey number. Except in Sindh—where it is called a deh—each mouza has a cadastral map maintained within the land revenue department and, outside of Sindh, carries a designated Hadbast number for record-keeping [1]. Functionally, a mouza encompasses physical land, agricultural parcels, communal resources, and habitation clusters such as abadis or bastis. With reliable cadastral and textual surveys, mouzas form the legal backbone for agricultural revenue collection, resource planning, rural development, and land demarcation [2].

The mouza system has deep historical roots, tracing back to the Mughal empire, where land revenue systems were organized hierarchically—subahs, Sarkars/parganas, and mahals/mouzas. Raja Todar Mal's reforms under Emperor Akbar further standardized measurements, survey protocols, and land record systems, setting the foundation for later colonial-era land registers [1].

The British formalized this through settlement surveys, led by zamindars or mouzadars who were responsible for revenue collection and legal adjudication at the ground level. These structures have persisted, forming the basis of modern rural land administration [3]. At the heart of mouza-based administration lies cadastral mapping, which visually defines every plot within a mouza using maps known locally as latha or massavi. Accompanying these are field books, which record plot dimensions, ownership, land-use type, boundaries, and adjacency [4].

Together, these form the foundational documents for land record systems, enabling legal clarity and administrative consistency. However, despite their centrality, traditional methods of cadastral surveying in Pakistan exhibit multiple systemic shortcomings. Most maps were manually drawn on paper or cloth during settlement cycles, lacking formal cartographic standards such as coordinates, datum references, or precise bearings. Field books, maintained by patwaris, have seen decades of manual amendments—due to land parcel subdivision, transfers, or record updates—often without meticulous archiving. This results in inconsistencies, duplication, or information loss [5].

A cadastral information system consists of procedures for collecting data related to parcels or properties, encompassing aspects such as land tenure, land use, and land value. Originally, the main purpose of the Massavis maps was to represent the distribution, condition, and productivity of arable fields; however, other features like rivers were depicted with less accuracy, causing geometric distortions. These inaccuracies have led to substantial setbacks in revenue collection and the achievement of other related goals. The importance of knowledge in ensuring the success of any planning, development, or management effort cannot be overstated. This is particularly true for developing countries that face resource constraints, where having a dependable knowledge base is vital. Additionally, many of these countries struggle with inaccurate land records within their real estate markets, often due to issues such as unclear ownership titles and ambiguous boundaries between private and collective rights. Consequently, there is an urgent need to prioritize the establishment and implementation of a national digital cadastral information system [5].

Survey field books have seen considerable transformation over the centuries, impacting the way measurements and directions are recorded. These changes often complicate the identification and interpretation of original data. Below is a detailed historical review, highlighting the nature of these shifts with references to sources [6]. The earliest known issued field book in New South Wales, for example, dates to 1794 and was largely a personal diary, blending technical measurements with anecdotal notes and environmental descriptions. Lathas are often hundreds of years old, created on cloth or paper without modern preservation considerations. Over time, they suffer from fading ink, tears, stains, insects, and dampness [7].

The fundamental land registration process, based on patwari-maintained lathas, loses legitimacy if verification sources are unreliable. Use multispectral imaging and clean restoration environments to maximize legibility before digitization. Teams deploy to remap damaged parcels using GPS/UAV, creating precise vector-based alternatives [8].

Due to the increased use of land, air, and water spaces brought about by population growth, high rates of urbanization, and global agenda issues, cadastral systems that oversee the interaction between people and land have developed into a multifunctional structure that facilitates a range of land-based activities [9].

Traditional Land Record Systems:

Traditional land record systems in South Asia have historically relied on manual documentation methods, creating vulnerabilities in data preservation and accessibility. Studies have shown that paper-based systems are prone to deterioration, manipulation, and loss, leading to disputes and administrative inefficiencies. Land parcel serves as the physical unit for decision-making about land-use change cadastral data are significant. Cadastral data is used to identify land parcels, the Land rights registration, land valuation and taxation, and the current and prospective future uses of land [10]. The cadastral system's primary goal is to offer a way to inventory land and natural resources. For taxation purposes, natural resources that originated in Moscow are valued and described using the cadastral system [11].

In Bangladesh, land measurement records are kept on mouza maps, which serve as a means of estimating and interpreting land ownership. Regretfully, there is still work to be done on the automatic land determination system. Land administrators must therefore overcome several obstacles when assessing any region by hiring a local civil engineer [12].

They were traditionally unique; no formal copy was made, so loss or damage often means permanent disappearance of critical land information. Parcel boundaries (*khasra* numbers, murabba, sub-khasra) become illegible, compromising property definitions [13]. In digitization efforts, damaged or faded sections hinder mosaic creation across maps. Field teams report topological errors and misalignment with satellite imagery, with illegible boundaries, parcel lines become ambiguous, fuelling court disputes and overlapping claims. Poor readability leads to inconsistent area records, miscalculations, and potential revenue [8].

The first major push for digital LIS began in 2003 with Ghana's Land Administration Project (LAP 1). Despite efforts, adoption has been slow due to infrastructural, institutional, and policy limitations, as well as challenges in digitizing legacy paper-based records. Digitization involves scanning millions of historical land documents, parcel mapping using satellite imagery and drones, and developing centralized digital databases [14].

It highlights strategic modernization steps, legislation, capacity building, and integration of digital cadastral systems within Ghana's land administration. Updating paper maps and their associated registers is expected to be a challenging process for various reasons.

Primarily, in the traditional Indian system, cadastral maps and land records are kept separately by different organizations [15].

Using various methods, including the collection of secondary data and documents, primary investigations, data analysis using a 5-level Likert scale, and modelling techniques, research was conducted to establish a theoretical foundation for the development and operation of Cadastral Database Systems (CBS) in Vietnam. Simultaneously, the study assessed the current status of the CDB in Thu Dau Mot City, Binh Duong Province [16]. Although efforts have been made to develop 3D cadastral database schemas, a complete solution that fulfils all the necessary criteria for efficient data storage, manipulation, and retrieval has yet to be established. It seeks to review the existing literature on 3D cadastral databases in order to identify the methods and technologies used for storing and managing such data [17].

Creating an effective land administration system is not a one-size-fits-all solution that can be universally applied. Instead, it must be tailored to reflect the unique historical, social, economic, technological, and political context of each country [18]. Historically, cadastral systems have been primarily associated with tax policies and the taxation of real estate. However, recent research has shown that cadastres serve purposes beyond taxation, proving valuable for government-led interventions aimed at urban and rural development [19].

GIS in Land Management:

Geographic Information Systems have become indispensable tools in contemporary land record management, providing sophisticated capabilities for spatial analysis, seamless data integration, and comprehensive visualization of land-related information. Current research consistently demonstrates the transformative potential of GIS technologies in modernizing traditional cadastral systems and significantly enhancing land governance practices. These systems enable efficient management of complex spatial data, facilitate informed decision-making through advanced analytical tools, and support transparent land administration processes that benefit both government agencies and citizens.

Research Objectives:

Based on the literature review, key research gaps were identified and have defined the objectives accordingly.

To design and implement a systematic methodology for developing digital *Massavis* using advanced GIS technologies.

To establish a replicable and scalable framework for the digitization of land records.

To evaluate and demonstrate the feasibility of digital transformation under challenging and inconsistent data conditions.

To ensure precise and reliable spatial representation of land parcels and boundaries through digital mapping.

Study Area:

The research focuses on Mouza Tulamba, located in the administrative hierarchy as follows:

Table 1. Mouza Overview

Division	Multan
District	Khanewal
Tehsil	Mian Channu
Qanoon Goi	Tulamba
Patwari Circle	Tulamba
Land Type	Muraba Bandi
Total Area	4,189 acres (33,513 Kanal - 10 Marla)

Available Data Sources:

The study utilized three primary data sources:
Latha/Shajra Parcha: Damaged but containing essential boundary information.
Field Books: Five field books with measurement and area data for each Khasra.
Jama Bandi: Revenue records providing ownership and cultivation details.

Methodology and Workflow Development:

The research employs an eight-step systematic approach, as illustrated in Figure 1 and Table 1

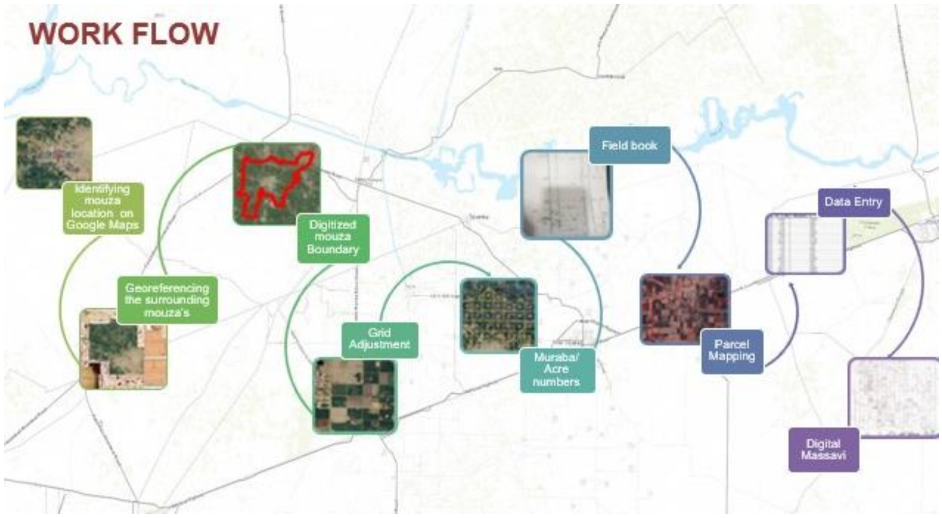

Figure 1. Methodology workflow

Table 2. Meta data

Record Year	1964-65
Record Types	Field Book Year 1964-65 and Sharja Parcha (Mouza Map) in parts are Damaged Conditions.
Data Source	Revenue Department, District Record Room NTO Office and concerned Patwari office
Data Format	Hard Copy record
Mouza Boundary / location Identification	With the help of neighbouring Mouza's Mussavies (Like Trijunction Piller and Burji) and satellite image/ Google maps.
Ownership Record	Register Haqdarian Zameen (RHZ)

Mouza Location Identification:

The initial step involves identifying the mouza location on Google Maps using coordinate systems:
Longitude: 73°22'56.997"E
Latitude: 32°39'51.873"N

To identify the location of a mouza (Figure 2), the initial step involved determining its latitude and longitude coordinates using Google Maps, particularly in cases where the tentative boundary of Tulamba was unavailable. The geographical boundaries of the mouza were then defined through a combination of old land records, survey maps, and local testimonies. Each mouza was uniquely identified by assigning a Jurisdiction List (JL) number or mouza number, after which its boundaries were physically demarcated and mapped.

Georeferencing Surrounding Mouzas:

The availability of adjusted mouza *Massavis* was first verified, after which all accessible records were georeferenced. A spatial reference framework was subsequently established by georeferencing the *Massavis* of all 15 adjacent mouzas (Figure 3)

Figure 2. Mouza Location Identification

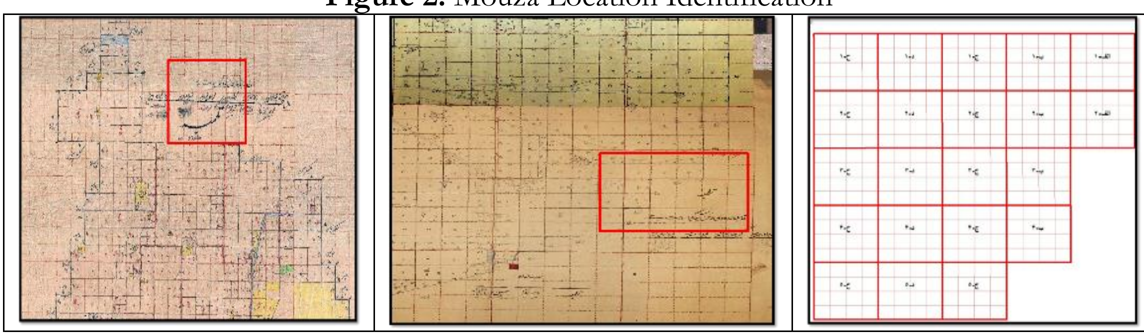

Figure 3. Georeferencing the Surrounding Mouzas and Massavi arrangement

Boundary Digitization:

Digital boundary creation through georeferencing. Boundary verification using adjacent mouza data. Spatial accuracy validation After georeferencing, the boundary of the mouza is digitized. The boundary of the mouza is verified from the Adjacent mouzas.(Figure 4).

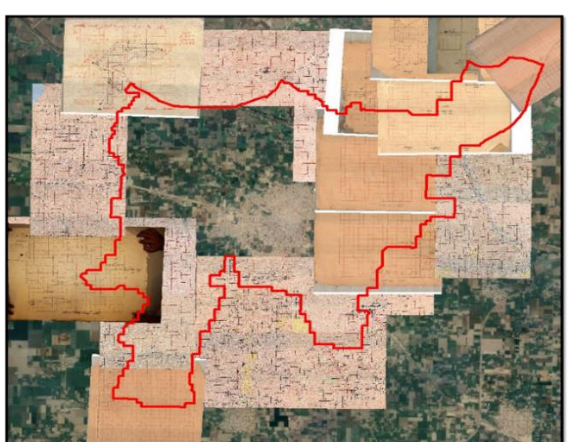

Figure 4. Boundary Digitization

Grid Adjustment:

The grid adjustment process begins with scale identification through measurement scale determination using Latha maps, followed by acre grid creation developed according to the Massavi scale. Ground adjustment was performed using Google imagery to maintain direction and distance accuracy, with the initial step being to identify the measurement scale with the help of Latha maps. Grid adjustment represents a critical process in surveying and spatial data management that corrects and refines measurements to account for distortions caused by Earth's curvature and map projections, ensuring that spatial data aligns accurately with the coordinate system used and maintains geometric integrity throughout the digitization process. (Figure 5)

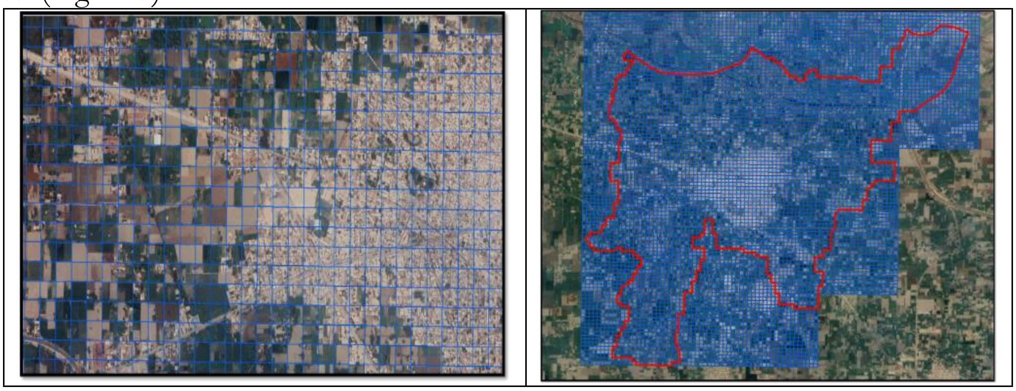

Figure 5. Grid Adjustment

Muraba/Acre Numbering:

A Muraba is a traditional unit of land measurement used primarily in the northern parts of India (Punjab and Haryana) and Pakistan (Punjab region). It is historically significant for measuring large tracts of agricultural land. Assignment of temporary Murabba numbers from the upper corner.Acre numbering within each Murabba using the zigzag method (1-25). Systematic spatial organization numbers are assigned in each murabba using the zigzag method, ranging from 1 to 25. According to the standard of massavi maps, temporary murabba numbers are assigned starting from the upper corner. (Figure 6)

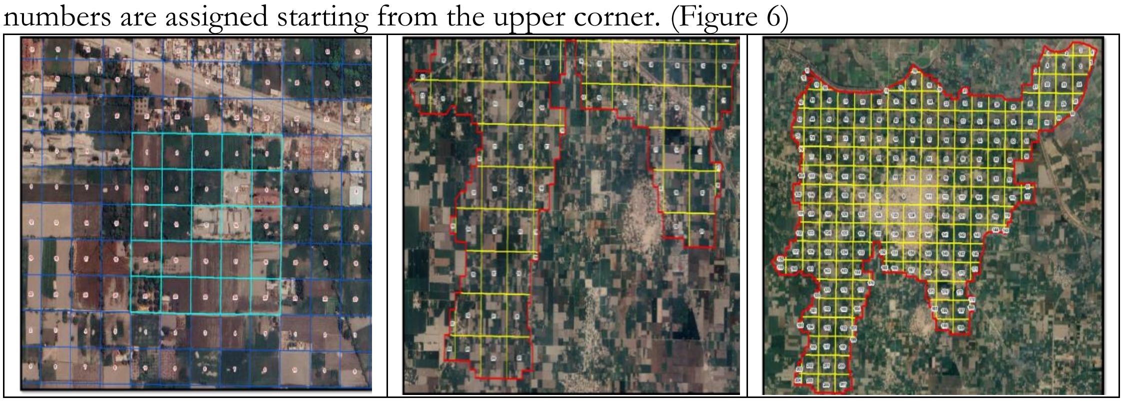

Figure 6. Muraba/Acre Numbering

Field Book Analysis:

The field book analysis process involves systematic extraction of measurement and area data for each Khasra (Khasra is a land parcel identification number used in Pakistan, India, and Bangladesh to denote a specific piece of agricultural or rural land in the village-level revenue records) along with direction information compilation using the traditional direction stone called *Sheen-Meem Stone*. Field books serve as essential tools for Khasra mapping, containing directional information, measurements, and area calculations for each parcel recorded in the traditional language of the Patwar system. These documents act as the primary, original record of survey data collected in the field, providing comprehensive information including on-site measurements, observations, land type classifications, and detailed notes that enable accurate mapping, plotting, and further spatial analysis. The process includes rigorous data validation and quality control measures to ensure the accuracy and reliability of extracted information before integration into the digital land record system. (Figure 7)

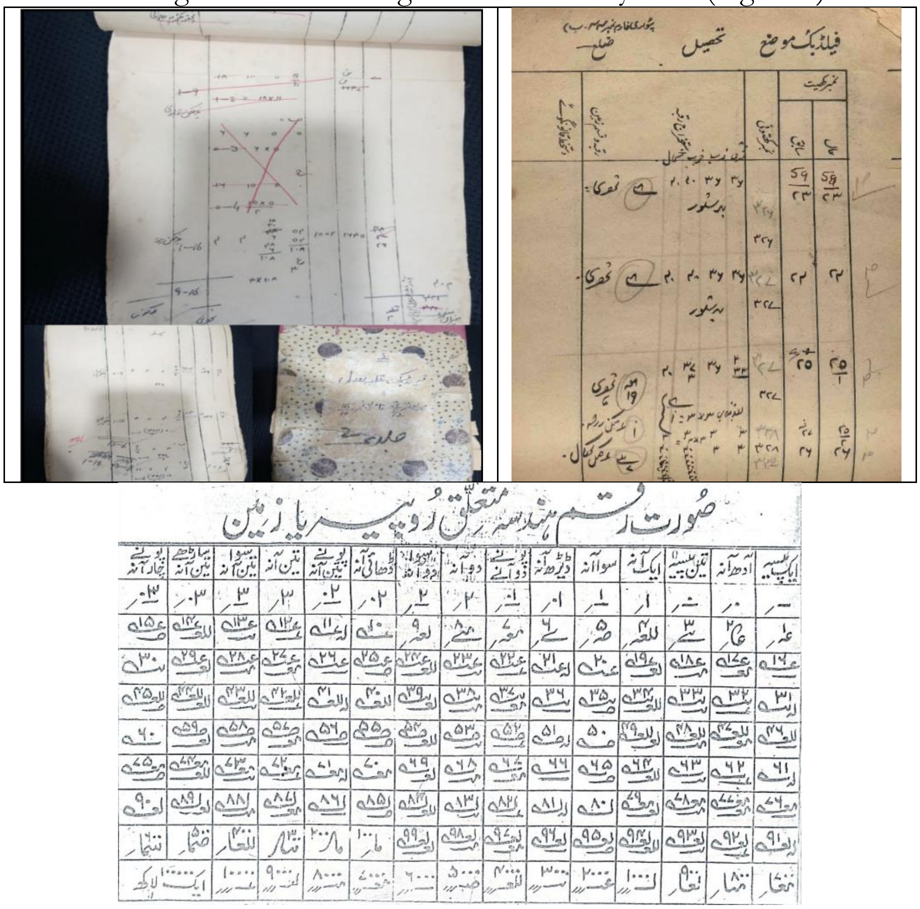

Figure 7. The traditional language of the Patwar system and the Field book

Digitization and Record Modernization:

Traditional handwritten records are now digitized under schemes like:

DILRMP (India)

LRMIS (Pakistan)

DLRS (Bangladesh)

Scanning, data entry, and georeferencing of maps are conducted. Online access is provided to landowners and officials.

Demographic and Census Data Integration:

Mouza-level data was also collected during national censuses. Information includes. Population, Number of households, Infrastructure (schools, roads). Useful for development planning and welfare schemes.

Data Updating and Mutation Process:

Whenever there's a land transaction (sale, inheritance, division), it's recorded through. Mutation applications, Field verification by revenue staff, Updated records are maintained in mutation registers and online systems.

Parcel Mapping:

The parcel mapping process involves systematic Khasra and sub-Khasra(a division of a main Khasra number) digitization using field book data, with careful maintenance of accurate measurements without shape distortion and precise cutting within mouza boundaries. The digitization begins with cutting the Khasras and sub-Khasras with the help of field book data, ensuring that no shape, dimensions, or areas are distorted during the parcel cutting process, with every cutting within the mouza performed using accurate measurements. Parcel mapping represents the comprehensive process of creating detailed, geographically accurate maps that show the boundaries, ownership, and characteristics of individual pieces of land, known as parcels, which play a crucial role in land management, urban planning, property transactions, and legal documentation by providing precise spatial representation of land holdings and their associated attributes.(Figure 8)

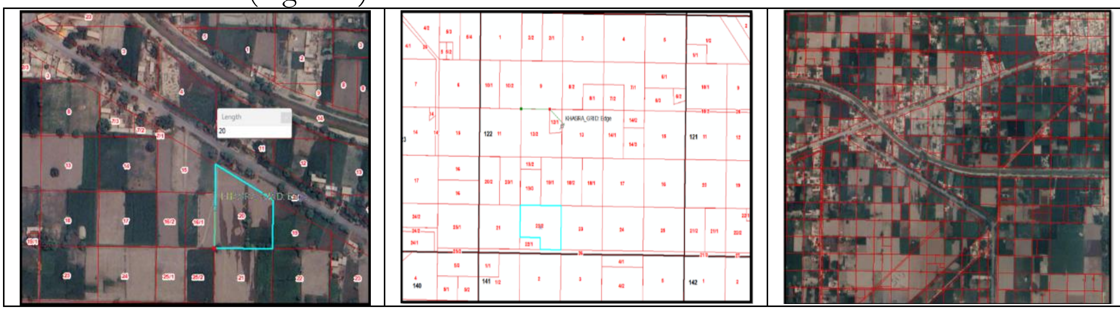

Figure 8. Parcel Mapping

Data Entry and Attribute Assignment:

Comprehensive attribute assignment to all parcels. Database development for spatial and non-spatial data. Quality assurance protocols. After completing the digitization process, the next step is to assign attributes to all parcels. (Figure 9)

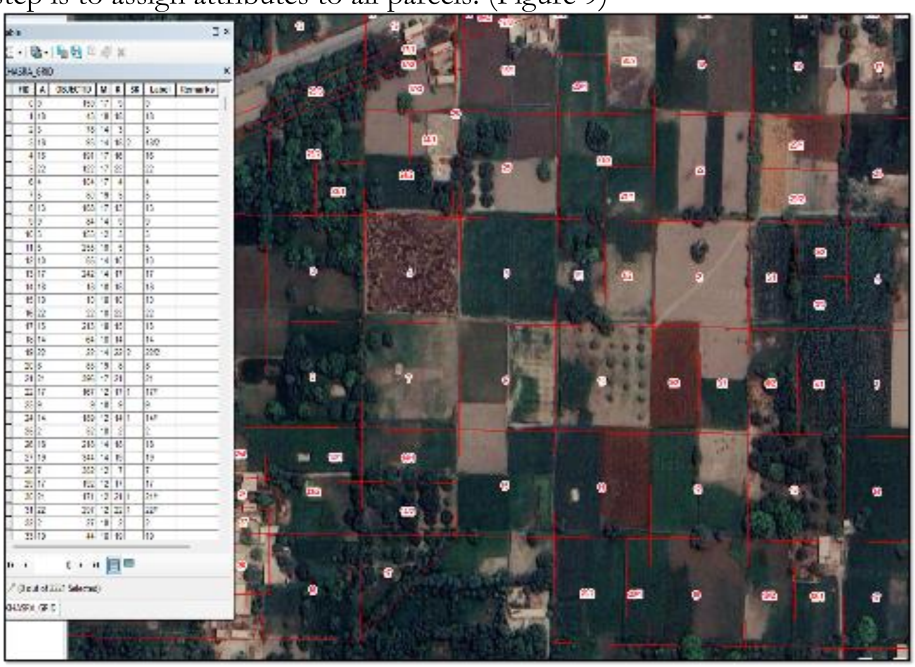

Figure 9. Data Entry in Vector data

Digital Massavi Creation:

The final phase of digital Massavi creation involves a systematic four-step process utilizing advanced GIS techniques. Reference Massavi identification was conducted using adjacent mouza data to resolve overlaps and gaps, ensuring proper alignment and spatial continuity across boundaries. This was followed by Massavi grid generation, which created a systematic grid structure with standardized naming conventions allocated to each Massavi unit. Directional measurements were then recorded for north, south, east, and west orientations for each Massavi to ensure accurate spatial representation and boundary definition. The process concludes with comprehensive index map creation, developing a complete index mouza map that serves as a reference framework for the entire digitized land record system, providing a unified spatial database that integrates all individual parcels within the broader administrative structure.

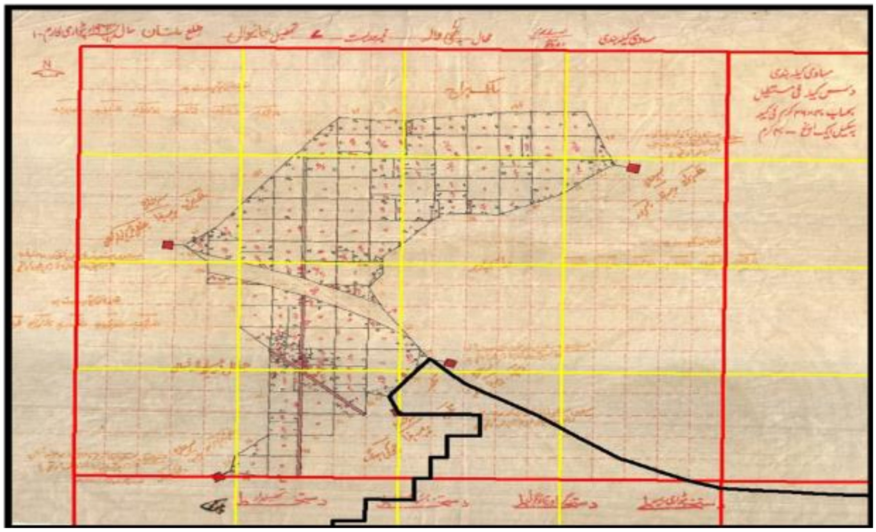

Figure 10. Index map.

The methodology successfully processed 207 Murabajaat with complete spatial representation, digitized 8,052 individual Khasra records, covered a total area of 4,189 acres, and georeferenced 15 adjacent Mouzas for boundary verification. This comprehensive digitization effort demonstrates the effectiveness of the GIS-based approach in transforming traditional land records into a modern, spatially accurate digital system that encompasses all land parcels within the study area while maintaining precise boundary definitions and spatial relationships with neighbouring administrative units.

Spatial Accuracy:

The grid adjustment process ensured spatial accuracy through:

Google imagery alignment.

Direction and distance maintenance.

Coordinate system consistency.

Data Integration:

Successful integration of multiple data sources:

Physical Latha maps with digital coordinates.

Field book measurements with GIS parcels.

Revenue records with spatial boundaries.

Challenges:

The transition from analog to digital land records presents both opportunities and challenges, including technical capacity requirements, data quality issues, and institutional resistance to change.

Primary Challenges:

Unavailability of Existing Massavis: Physical Massavis are frequently missing from the tehsil and district record rooms. Damaged Latha/Shajra Parcha Maps: Available Latha/Shajra Parcha documents are severely damaged and torn. Deteriorated Field Books: Field books contain damaged sections that are difficult to read and interpret. Administrative Resistance: Revenue staff's reluctance to create new Massavis due to workload and technical limitations.

Technical Challenges:

Surrounding Mouza Identification: Limited availability of boundary data

Damaged Latha Condition: Poor readability of source documents

Field Book Inconsistencies: Historical changes affecting measurement accuracy

Document Deterioration: Pathetic condition of source materials

Solutions:

To ensure data accuracy and reliability, a multi-source verification approach was adopted by cross-referencing information from various data sources. Satellite imagery, particularly Google Maps, was integrated into the process to support ground-truthing efforts and enhance spatial accuracy. A systematic quality control framework was implemented, incorporating validation protocols to maintain consistency and reliability throughout the data collection and analysis phases. Additionally, standardized procedures were developed to establish a replicable and transparent methodology for future applications.

Implications and Applications:

Administrative Benefits:

The digitization of land records has significantly improved accessibility, allowing users to conveniently access information across multiple platforms. It has enhanced data accuracy by reducing human error through automated processes and supports efficient dispute resolution by establishing clear spatial boundaries. This digital transformation has streamlined revenue operations, enabling faster processing of land transactions and better management of public resources. Accurate digital mapping has resolved long-standing measurement issues in revenue courts and facilitated precise land demarcation. Additionally, it has improved the process of land partition, aiding in transparent decision-making in land revenue matters.

Technical Contributions:

The project's success lies in its replicable methodology, enabling consistency and scalability across similar contexts. Integration of GIS showcases the use of modern geospatial technology in traditional land systems, enhancing efficiency and accuracy. Digitization has improved data preservation, ensured long-term accessibility, and reduced risks of data loss. Spatial analysis capabilities have broadened the project's analytical scope. Overall, the project sets a strong technical foundation for future land administration improvements.

Policy Implications:

The transition toward digital governance in land administration highlights several key policy implications. There is a strong need to support e-governance initiatives that promote transparency, efficiency, and accessibility in public service delivery. Capacity building emerges as a crucial area, emphasizing the importance of technical training programs to equip personnel with the skills necessary to manage and operate digital systems. Furthermore, infrastructure development is essential to facilitate the widespread adoption of technology, ensuring connectivity and access across various regions. Legal reforms must also be considered, particularly in the context of revenue courts, to grant legal recognition to digital land records, thereby strengthening the legitimacy and enforceability of digital documentation in legal proceedings.

Results and Outcomes:

This research has successfully demonstrated the feasibility and effectiveness of developing digital Massavi maps using advanced GIS technologies. The approach not only modernizes traditional land record management but also establishes a replicable model for large-scale digital transformation.

A total of 207 Murabajaat were systematically processed, covering 4,189 acres and documenting 8,052 Khasra records, proving both the technical robustness and administrative viability of the methodology.

The transition to digital systems has streamlined revenue operations, enabling faster processing of land transactions, improved record retrieval, and efficient public resource management.

Accurate spatial mapping has resolved long-standing measurement discrepancies that previously hindered transparency and created bottlenecks in revenue courts.

The introduction of precise land demarcation has facilitated dispute resolution, reduced conflicts and ensuring fair adjudication in land-related cases.

The system has significantly enhanced the process of land partition, ensuring clarity of ownership rights and supporting transparent decision-making in land revenue matters.

By addressing the core challenges of manual records—including data loss, inaccuracies, and accessibility issues the digital methodology has ensured long-term preservation, accuracy, and reliability of records.

The outcomes demonstrate a scalable and replicable framework, offering strong potential for expansion across other districts and provinces to establish a unified digital land record system.

The research confirms that GIS-enabled Massavie digitization not only strengthens governance and operational efficiency but also builds a sustainable foundation for transparent, accessible, and citizen-centered land administration.

Challenges: The transition from analog to digital land records presents both opportunities and challenges, including technical capacity requirements, data quality issues, and institutional resistance to change.

Administrative	Technical
1. Unavailability of Existing Massavis: Physical Massavis are frequently missing from tehsil and district record rooms. 2. Damaged Latha/Shajra Parcha Maps: Available Latha/Shajra Parcha documents are severely damaged and torn. 3. Deteriorated Field Books: Field books contain damaged sections that are difficult to read and interpret. **4.** Administrative Resistance Revenue staff reluctance to create new Massavis due to workload and technical limitations.	1. Surrounding Mouza Identification: Limited availability of boundary data. 2. Damaged Latha Condition: Poor readability of source documents. 3. Field Book Inconsistencies: Historical changes affecting measurement accuracy. 4. Document Deterioration: Pathetic condition of source materials. 5. Missing / destroyed trijunction pillars and burjies Marks. 6. shortage of Land Record Experts who translate the Patwar language. 7. limited availability of Location based equipment’s.

Results and Outcomes:

The implementation of the GIS-based methodology for digital Massavi development in Mouza Tulamba has produced several significant results and practical outcomes:

Successful Digitization of Land Records: A total of **207 Murabajaat** covering **4,189 acres** with **8,052 Khasra records** were successfully digitized. This demonstrates the **technical feasibility** of reconstructing damaged and incomplete records into reliable digital formats.

Improved Spatial Accuracy: Through grid adjustment, parcel mapping, and georeferencing of 15 adjacent mouzas, spatial accuracy was achieved, ensuring that boundaries are aligned with ground realities. This directly addresses long-standing measurement discrepancies that complicated land disputes in revenue courts.

Streamlined Revenue Operations:

The digital transformation has **enhanced revenue operations** by enabling faster processing of transactions, improving data retrieval, and ensuring efficient management of public resources. This has reduced dependency on fragile manual records.

Support for Dispute Resolution and Land Demarcation & Court Matters:

Clear digital boundaries have simplified dispute resolution, minimized overlapping claims, and provided precise demarcation of land parcels. This is particularly beneficial in revenue courts and for land ownership verification.

Facilitated Land Partition:

The system has improved the **land partition process**, ensuring fairness and transparency in cases of inheritance or ownership division. The clarity of parcel boundaries aids decision-making in revenue matters.

Preservation of Historical Data:

The project has preserved and modernized records from Field Book 1964–65 and Shajra Parcha, which were previously damaged and incomplete. This ensures long-term data accessibility and minimizes the risk of permanent information loss.

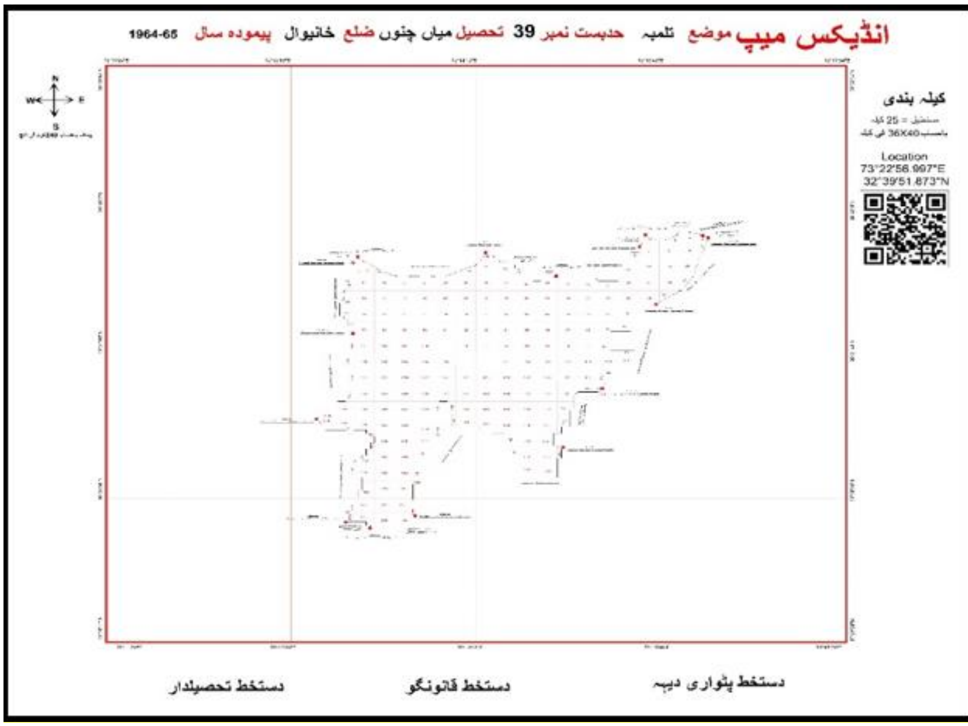

Figure 11. Index map of Survey Plot No. 39 in Chakwal District (Project Year 1964–65).

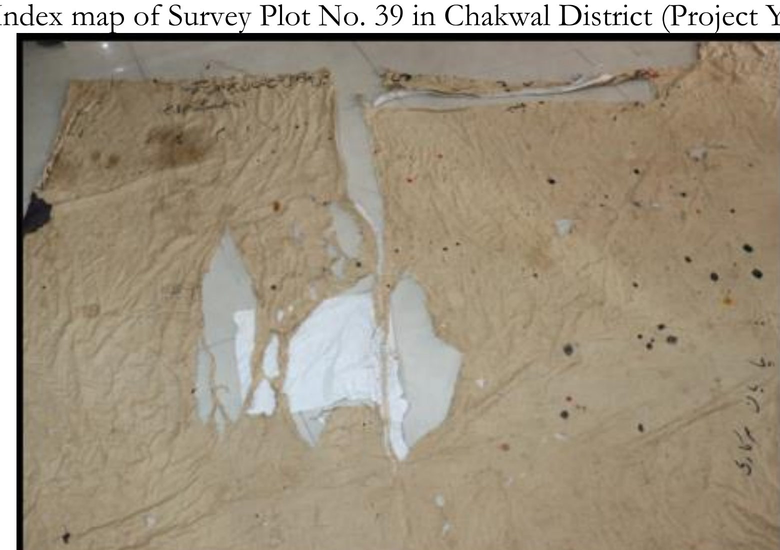

Figure 12. Damaged and worn-out survey map sheet showing signs of deterioration

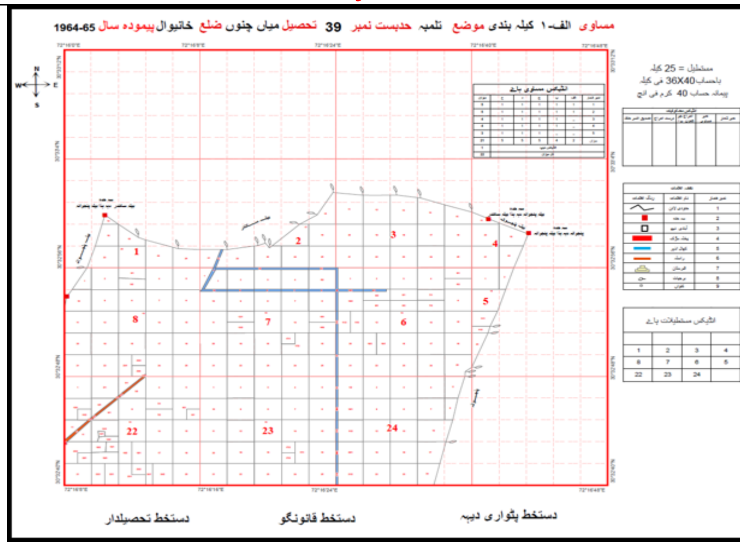

Figure 13. Cadastral map of Survey Plot No. 39, Chakwal District (Project Year 1964–65) showing grid division and land parcel numbering

Capacity Building and Institutional Learning:

Revenue staff and technical teams gained exposure to modern GIS-based systems, building institutional capacity for future digital land administration projects.

Replicable Framework:

The success of this pilot in Tulamba has established a replicable model that can be scaled across Punjab and other provinces, providing a foundation for a national digital land record system.

Integration Potential:

By combining textual records (Jama Bandi, field books) with spatial data, the system supports integration into broader **e-governance platforms**, aligning with government digitization policies.

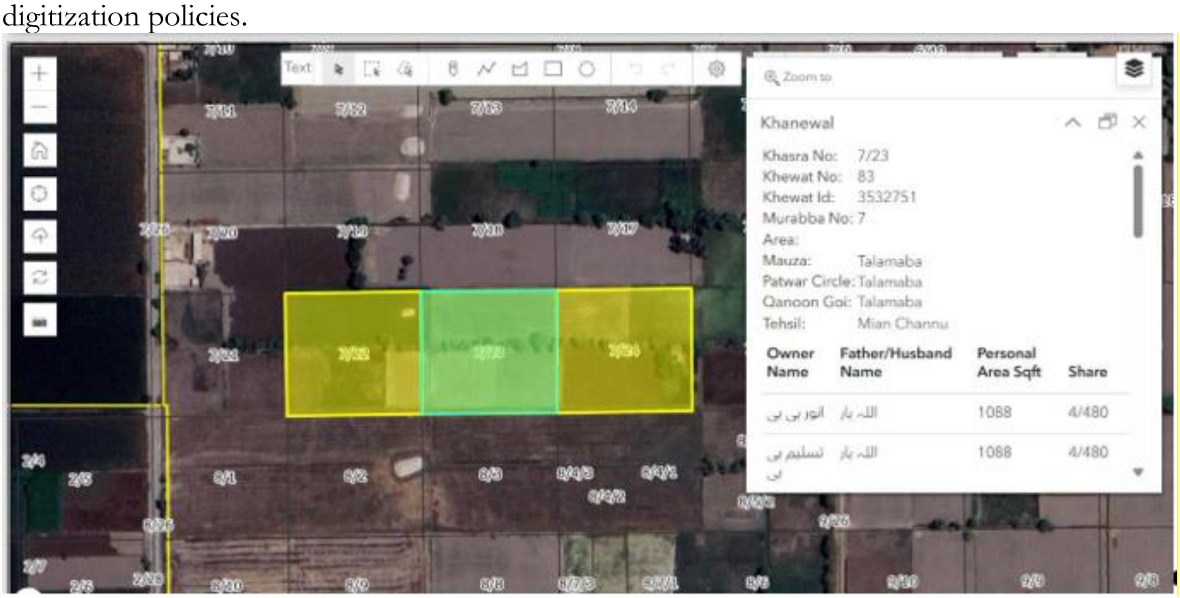

Figure 15. Land ownership map of Khanewal showing divided plots with area details.

Enhanced Transparency and Public Trust: Public access to reliable and accurate digital land records improves **citizen trust** in the land administration system by reducing manipulation and corruption opportunities inherent in manual record-keeping.

In summary, the outcomes of this research confirm that digital Massavi reconstruction using GIS is not only technically and administratively viable but also socially impactful, creating a transparent, accurate, and scalable system that strengthens land governance and paves the way for modernized land administration in Pakistan.

Conclusion:

This research successfully demonstrates the feasibility and effectiveness of digital Massavi development using GIS technologies. The methodology addresses critical challenges in traditional land record management while providing a systematic approach for digital transformation. The successful processing of 207 Murabajaat covering 4,189 acres with 8,052 Khasra records establishes the technical and administrative viability of the approach. It contributes to the broader discourse on land governance modernization by providing a practical framework that can be adapted to similar contexts. The integration of traditional knowledge with modern technology offers a balanced approach to institutional change while preserving essential administrative functions. Future research should focus on scaling the methodology to larger administrative units, developing automated quality control systems, and establishing legal frameworks for digital record recognition. The Punjab Urban Land System Enhancement Project provides a foundation for comprehensive land record modernization across Pakistan and similar developing country contexts.

Recommendations:

The successful implementation of digital land records requires four foundational pillars: establishing robust legal frameworks for digital record recognition, providing strong institutional support through updated policies and organizational structures, ensuring adequate resource allocation for technology adoption and staff training, and maintaining meaningful stakeholder engagement across all relevant parties. Key operational measures include developing standardized data collection protocols, implementing automated validation systems for quality assurance, establishing comprehensive capacity-building programs, and ensuring seamless technology integration with existing systems. These elements collectively create an efficient foundation for transitioning from traditional paper-based systems to transparent, accessible digital platforms that meet modern land administration needs. Scalability studies are needed to examine how current methodologies can be effectively applied at larger scales across diverse geographic and administrative contexts.

References:

[1] P. Zahir ALI and Abdul NASIR, "Land Administration System in Pakistan - Current Situation and Stakeholders' Perception," *XXIV FIG Congr. 2010 "Facing Challenges - Build. Capacit.*, 2010, [Online]. Available: https://www.researchgate.net/publication/215766308_Land_Administration_System_in_Pakistan_-_Current_Situation_and_Stakeholders'_Perception

[2] E. H. Muhammad Sheraz Ahsan, "Deriving requirements for integrated and standardised cadastre profile from the legacy Board of Revenue and the contemporary land administration systems," *Surv. Rev.*, vol. 57, no. 401, 2025, [Online]. Available: https://www.tandfonline.com/doi/full/10.1080/00396265.2024.2351624

[3] S. C. Crommelinck, "Automating image-based cadastral boundary mapping," *Univ. Twente*, vol. 10, 2019, [Online]. Available: https://research.utwente.nl/en/publications/automating-image-based-cadastral-boundary-mapping

[4] L. J. S. P. Carmen Femenia-Ribera, Gaspar Mora-Navarro, "Evaluating the use of old cadastral maps," *Land use policy*, vol. 114, p. 105984, 2022, doi: https://doi.org/10.1016/j.landusepol.2022.105984.

[5] Atta Ur Rehman, Waqar Ahmad, Zahid Khan, "Application of GIS Based Re-Settlement of Land Record of Mouza Shahbat Khel, District Mardan (Pakistan)," *J. Asian Dev. Stud.*, vol. 13, no. 3, pp. 1467–1481, 2024, doi: 10.62345/jads.2024.13.3.119.

[6] T. J. Martin Tauchman, "Positional accuracy of cadastral maps digitized from the stable cadastre system," *Stavební Obz. - Civ. Eng. J.*, vol. 33, no. 2, p. 7, 2024, [Online]. Available:

http://ojs.cvut.cz/ojs/index.php/cej/article/view/9892
[7] M. Ali, "Modernizing land records: Pakistan's journey from patwaris to digital GIS-based systems," *Asian J. Geoinformatics*, vol. 19, no. 4, pp. 57–64, 2019.
[8] M. P. Václav Šafář, "The Use of UAV in Cadastral Mapping of the Czech Republic," *ISPRS Int. J. Geo-Inf*, vol. 10, no. 6, p. 380, 2021, doi: https://doi.org/10.3390/ijgi10060380.
[9] A. K. Burak Uşak, Volkan Çağdaş, "Current Cadastral Trends—A Literature Review of the Last Decade," *Land*, vol. 13, no. 12, p. 2100, 2024, doi: https://doi.org/10.3390/land13122100.
[10] P. Golob and A. Lisec, "Success factors in cadastral boundary settlements based on land surveyor's opinions," *Land use policy*, vol. 114, p. 105990, 2022, doi: https://doi.org/10.1016/j.landusepol.2022.105990.
[11] S. O. and Aniket Verma, Amar Prakash, Ajay Kumar and S. K. Mandal, "Precise mosaicing of mouza plans for the preparation of digital cadastral map using GNSS," *Curr. Sci.*, vol. 123, no. 4, p. 4, 2023, [Online]. Available: https://www.currentscience.ac.in/Volumes/124/04/0467.pdf
[12] M. O. R. Yeasmin Ara Akter, Md. Ataur Rahman, "Quantitative analysis of Mouza map image to estimate land area using zooming and Canny edge detection," *TELKOMNIKA (Telecommunication Comput. Electron. Control.*, vol. 18, no. 6, p. 12, 2020, [Online]. Available: https://telkomnika.uad.ac.id/index.php/TELKOMNIKA/article/view/16179
[13] S. A. Muhammad Sheraz Ahsan, Ejaz Hussain, Christiaan Lemmen, Malumbo Chaka Chipofya, Jaap Zevenbergen, "Applying the Land Administration Domain Model (LADM) for Integrated, Standardized, and Sustainable Development of Cadastre Country Profile for Pakistan," *Land*, vol. 13, no. 6, p. 883, 2024, doi: https://doi.org/10.3390/land13060883.
[14] C. L. Rosemond Owusu Ansah, Zaid Abubakari, Benjamin Quaye, Dimo Todorovski, Chipofya Malumbo, "Navigating the Terrain of Digital Transition: Ghana's Journey of Developing a Digital Land Information System," *Land*, vol. 13, no. 4, p. 528, 2024, doi: https://doi.org/10.3390/land13040528.
[15] J. D. O. Priscilla Badaweh Coffie, "Building an Efficient Land Information System in Ghana: Insights from Land Governance," *J. Energy Eng. Thermodyn.*, vol. 4, no. 3, p. 5, 2024, [Online]. Available: https://journal.hmjournals.com/index.php/JEET/article/view/4207
[16] X. K. N. and T. H. H. N. D T L Truong, T T Do, "Solutions to operate the cadastral database serving the national digital transformation program: a case study in Thu Dau Mot City, Binh Duong Province," *IOP Conf. Ser. Earth Environ. Sci*, 2025, doi: 10.1088/1755-1315/1501/1/012006.
[17] A. R. Javad Shahidinejad, Mohsen Kalantari, "3D Cadastral Database Systems—A Systematic Literature Review," *ISPRS Int. J. Geo-Inf.*, vol. 13, no. 1, p. 30, 2024, doi: https://doi.org/10.3390/ijgi13010030.
[18] A. Dias-Da-fe, R. Rodriguez, and R. Abreu, "THE CADASTRAL SYSTEM AS AN ENGINE OF MUNICIPALITY TO SPREAD THE SUSTAINABLE DEVELOPMENT GOALS," *Dev. Corp. Gov. Responsib.*, vol. 24, pp. 53–72, Nov. 2024, doi: 10.1108/S2043-052320240000024003/FULL/XML.
[19] D. Rokos, P. Lolonis, and D. Stathakis, "Real Estate Property and Cadaster: The Impact of New Mapping Techniques on Land Management and Planning in Greece," *World Reg. Geogr. B. Ser.*, vol. Part F3078, pp. 257–274, 2024, doi: 10.1007/978-3-031-29819-6_16.

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