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REGULATING THE USE OF DRONE TECHNOLOGY IN LAND SURVEYING AND ADMINISTRATION IN TANZANIA: A COMPARATIVE LEGAL ANALYSIS WITH LESSONS FROM SOUTH AFRICA, RWANDA AND KENYA.

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ABSTRACT

The rapid advancement of drone technology, commonly referred to as Unmanned Aerial Systems (UAS), transformed land surveying and administration globally, offering efficient, accurate, and cost-effective methods for geospatial data collection. Governments increasingly deployed drone-assisted surveying in cadastral mapping, land registration, urban planning, environmental monitoring, and land dispute resolution. In Tanzania, however, the legal and institutional framework governing land surveying did not evolve at the same pace as technological innovation. Key legislation, including the Land Survey Act [Cap 324 Revised Edition 2023], the Professional Surveyors (Registration) Act [Cap 270 Revised Edition 2023], and the Civil Aviation Act [Cap 80 Revised Edition 2023], was enacted before the widespread adoption of drone technology and therefore lacked comprehensive provisions regulating drone-assisted cadastral surveying. The existing legal regime created uncertainty regarding the legal recognition of drone-generated geospatial data, institutional responsibilities, professional accountability, evidentiary admissibility, and privacy protection. Through comparative legal analysis, this article evaluated the adequacy of Tanzania's regulatory framework, drawing on reform experiences from South Africa, Rwanda, and Kenya. Several legal and institutional shortcomings were identified, including fragmented regulatory mandates, absence of statutory recognition of drone-generated cadastral surveys, inadequate privacy safeguards, and limited professional regulation of drone surveyors. The article argued that without legal modernisation, Tanzania risks undermining land tenure security, investment confidence, and effective dispute resolution, and concluded that comprehensive legislative reform, institutional

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coordination, technical standardisation, and specialised professional regulation are essential for integrating drone technology into transparent and legally certain land governance.

Keywords: Drone Technology; Unmanned Aerial Systems (UAS); Land Surveying; Land Administration; Cadastral Mapping; Geospatial Information; Land Governance; Tanzania; South Africa; Rwanda; Kenya.

1. Introduction

Land surveying constitutes one of the fundamental pillars of land administration and governance, providing the technical foundation upon which land registration, boundary demarcation, valuation, spatial planning, infrastructure development, environmental management, and the protection of property rights depend.[2] Accurate cadastral surveys promote legal certainty in land ownership, facilitate secure land transactions, reduce boundary disputes, support sustainable land use planning, and enhance investment confidence.[3]Consequently, an effective surveying system is indispensable for achieving sound land governance and sustainable socio-economic development.

In Tanzania, the legal framework governing land surveying is principally established under the Land Survey Act, the Land Act, the Village Land Act and the Professional Surveyors (Registration) Act.[4] Collectively, these statutes regulate cadastral surveying activities, prescribe professional standards, establish licensing requirements for surveyors, and assign supervisory responsibility to the Director of Surveys. While these legislative instruments have historically provided an effective legal framework for conventional surveying techniques, they were enacted before the emergence and widespread adoption of drone technology and therefore provide little guidance regarding the legal status of drone-assisted surveying within Tanzania's cadastral system.[5]

Traditionally, cadastral surveys in Tanzania have relied upon conventional ground-based techniques involving total stations, Global Navigation Satellite Systems (GNSS), terrestrial measurements, and manual boundary verification conducted by licensed surveyors.[6]Although these methods continue to provide reliable survey results, they are frequently associated with high operational costs, prolonged fieldwork, limited accessibility to remote or environmentally sensitive areas, and considerable human resource requirements. As Tanzania experiences rapid urbanization, population growth, infrastructure expansion, industrial development, and increasing demand for secure land tenure, conventional surveying methods alone are becoming insufficient to meet the growing need for efficient land administration services.

[2]As per Article 24 of the Constitution of the United Republic of Tanzania of 1977 Amendment of 2005.
[3] As per Section 22(1) and section 25 of the Land Act [Cap 113 Revised Edition 2023].
[4] The Land Survey Act [Cap 324 R.E. 2023], the Land Act [Cap 113 Revised Edition 2023], the Village Land Act [Cap 114 Revised Edition 2023], Professional Surveyors (Registration) Act [Cap 270 Revised Edition 2023]
[5] As per section 4 and 5 of the Land Survey Act [Cap 324 Revised Edition 2023], as its read together with Section 8 of the Professional Surveyors (Registration) Act [Cap 270 Revised Edition 2023].
[6] As per Section 7 and 13he Land Survey Act [Cap 324 Revised Edition 2023].

The emergence of drone technology, commonly referred to as Unmanned Aerial Systems (UAS) or Unmanned Aerial Vehicles (UAVs), has significantly transformed surveying practice worldwide. Equipped with high-resolution cameras, LiDAR sensors, Global Positioning Systems (GPS), and sophisticated photogrammetric software, drones enable surveyors to produce highly accurate orthophotos, digital terrain models, three-dimensional spatial models, and detailed cadastral maps within considerably shorter periods than conventional surveying techniques,[7] Consequently, drone-assisted surveying has become an integral component of modern land administration systems, supporting cadastral mapping, land registration, infrastructure planning, agricultural management, disaster risk reduction, environmental conservation, and land dispute resolution.

Globally, numerous jurisdictions have incorporated drone technology into official cadastral systems through comprehensive legal frameworks regulating aviation safety, professional accreditation, geospatial data management, evidentiary standards, privacy protection, and operational procedures. Rwanda has successfully integrated drone-assisted mapping into its national land tenure regularisation programme, while Kenya has adopted regulatory reforms facilitating the use of remotely piloted aircraft systems in geospatial data collection and land administration. [8]These experiences demonstrate that technological innovation can substantially improve land governance when supported by coherent legal and institutional frameworks.

In contrast, Tanzania's legal framework remains fragmented and institutionally inadequate for regulating drone-assisted land surveying. Although the Tanzania Civil Aviation Authority (TCAA) regulates the operation of remotely piloted aircraft systems from an aviation safety perspective, existing land legislation neither expressly recognises drone-generated cadastral surveys nor establishes procedures for validating, approving, and integrating drone-generated spatial data into official land administration systems. [9]Likewise, the Professional Surveyors (Registration) Act does not prescribe competency standards or certification requirements for surveyors utilising drone technology, while the Evidence Act[10] provides limited guidance regarding the admissibility of drone-generated geospatial information in judicial proceedings.

The absence of harmonized legislation has generated significant legal uncertainty concerning the ownership of drone-generated geospatial information, professional liability arising from drone-assisted surveys, institutional mandates governing drone operations, and the evidentiary reliability of aerial imagery in land disputes. These regulatory gaps have become increasingly significant as government institutions, private surveying firms, development partners, and investors continue to adopt drone technology in cadastral mapping, infrastructure development, mining, agriculture, environmental conservation, and urban planning.

[7]As per section 2 and 5 of the Civil Aviation Act [Cap 80 Revised Edition 2023].
[8]National Land Commission Act (Kenya), 2012; the Land Registration Act (Kenya), 2012.
[9]Spatial Data Infrastructure Act 54 of 2003 (South Africa).
[10]The Evidence Act [Cap 6 Revised Edition 2023]

Furthermore, drone technology raises important constitutional and human rights concerns. The collection of high-resolution aerial imagery frequently involves the capture of private property, residential premises, agricultural activities, and personal information, thereby engaging constitutional principles relating to privacy, dignity, property rights, and data protection. Although Tanzania has enacted the Personal Data Protection Act of 2022, the legislation does not specifically regulate the collection, storage, processing, and dissemination of geospatial information obtained through drone technology, thereby creating uncertainty regarding the lawful management of aerial data used in land administration.

Judicial decisions in Tanzania have consistently emphasised the importance of accurate surveying and the protection of land rights. In *Attorney General v Lohay Akonaay & Another*[11], the Court of Appeal affirmed that secure land administration depends upon legally recognised procedures capable of protecting constitutional property rights. Nevertheless, Tanzanian courts have yet to develop comprehensive jurisprudence specifically addressing the admissibility and evidentiary value of drone-generated cadastral information, leaving significant uncertainty regarding the legal treatment of technologically generated spatial evidence.

Using a comparative legal methodology, this article evaluated Tanzania's regulatory framework alongside the experiences of South Africa, Rwanda, and Kenya, all of which have made significant progress in integrating drone technology into official land administration systems. Through this comparative analysis, the article identified legislative and institutional reforms capable of strengthening Tanzania's regulatory framework and proposes a comprehensive legal model for the governance of drone-assisted land surveying that promotes technological innovation while safeguarding constitutional rights, professional accountability, and sustainable land governance.[12]

2. Materials and Methods

This article employs a qualitative doctrinal legal research methodology, supported by comparative legal analysis. The primary sources examined include relevant Tanzanian statutes principally the Land Survey Act, the Professional Surveyors (Registration) Act, the Civil Aviation Act and the Evidence Act[13] as well as subsidiary legislation issued by the Tanzania Civil Aviation Authority (TCAA). Tanzanian case law, including decisions of the Court of Appeal and High Court relating to land rights and technical evidence, is also analysed.

Secondary sources consulted include academic journal articles, policy reports from international organizations such as the World Bank and OECD, national geospatial policy

[11]Attorney General v Lohay Akonaay & Joseph Lohay [1995] TLR 80 (CA).
[12]World Bank (2019): *Land Tenure Regularisation in Rwanda: Lessons from a Nationwide Cadastre Project*, World Bank, Washington D.C; OECD (2021): *Drone Technology in Public Sector Applications*, Paris; El-Mowafy A (2020): *Modern Surveying and Geospatial Techniques*, Springer.
[13]The Land Survey Act [Cap 324 Revised Edition 2023], the Land Act [Cap 113 Revised Edition 2023], the Village Land Act [Cap 114 Revised Edition 2023], Professional Surveyors (Registration) Act [Cap 270 Revised Edition 2023], the Civil Aviation Act [Cap 80 Revised Edition 2023], Evidence Act [Cap 6 Revised Edition. 2023]

documents, and comparative legal materials from Rwanda, Kenya, and South Africa. Comparative legislation examined includes Rwanda's land tenure regularization framework, Kenya's Survey Act and Land Registration Act, and South Africa's Spatial Data Infrastructure Act and Professional and Technical Surveyors Act.

The comparative analysis is structured to identify regulatory models, assess institutional coordination mechanisms, and draw normative insights applicable to the Tanzanian context. The study is limited to the civil law dimensions of drone-assisted land surveying and does not engage with criminal law, tax law, or sector-specific environmental regulatory frameworks beyond their intersection with land surveying practice.

3. Findings and Analysis

3.1 Conceptual Framework: Drone Surveying Technology

Land surveying is a technical and legal process involving the measurement of land parcels for the purpose of determining size, shape, and boundary demarcation. Traditionally, it is conducted by registered land surveyors through physical ground-based inspections and measurements. The output of this process includes cadastral maps, survey plans, and technical reports depicting land boundaries, land use patterns, and infrastructural features. These outputs also assist in identifying public utility reservations such as road reserves, schools, hospitals, and other designated public spaces.[14]

In Tanzania, conventional cadastral surveying is often time-consuming, typically requiring several days or weeks depending on terrain conditions, accessibility, and technical complexity. This traditional approach, while legally recognized, is increasingly challenged by technological advancements in geospatial data acquisition.

Drone technology, also referred to as Unmanned Aerial Systems (UAS), represents one of the most significant innovations in modern surveying. It refers to remotely piloted aircraft systems used to capture high-resolution aerial imagery and geospatial data through photogrammetry, LiDAR, and remote sensing techniques. In land administration, drones are used for cadastral boundary mapping, topographic surveys, land-use planning, infrastructure monitoring, and spatial analysis in dispute resolution.[15]

Compared to traditional surveying methods, drone-assisted surveying provides faster data collection, reduced operational costs, and higher spatial accuracy. It is particularly effective in inaccessible, hazardous, or environmentally complex areas. However, despite these advantages, drone technology introduces emerging legal challenges relating to privacy rights, data ownership, evidentiary admissibility, and regulatory oversight.[16]

The legal framework governing surveying practice is primarily established under the Land Survey Act, which regulates surveying procedures, approval of survey plans, and

[14]El-Mowafy A (2020): *Modern Surveying and Geospatial Techniques*, Springer.
[15]*Ibid.*
[16]OECD (2021): *Drone Technology in Public Sector Applications*, Paris; World Bank (2022): *Drone Applications in Land Administration Systems*, Washington D.C.

maintenance of survey standards. Section 18 of the Act requires that all cadastral surveys be conducted or supervised by licensed surveyors.[17] Additionally, section 8, 9, 10 and 11 of the Professional Surveyors (Registration) Act together with the section 30 and 31 of the Land Survey Act establishes the registration regime for professional surveyors and provides disciplinary mechanisms for misconduct.[18]

Judicial recognition of modern geospatial and digital evidence is also evolving. In *Trust Bank Tanzania Ltd v Le-Marsh Enterprises Ltd & Others*, the Court of Appeal emphasized the importance of reliability and authenticity of electronic and technical evidence in commercial disputes.[19] Similarly, in *Mbeya Cement Co. Ltd v Attorney General*, the High Court underscored that expert technical evidence must meet standards of accuracy and procedural integrity before being admitted in court proceedings.[20]These principles are relevant to drone-generated spatial data, which must satisfy evidentiary thresholds of reliability, authenticity, and chain of custody.

3.2 Legal and Institutional Framework and Practice of Drone Surveying in Tanzania

The regulation of drone technology in land surveying and land administration in Tanzania is characterised by a complex interaction between statutory land law, professional regulation, aviation control, and evidentiary rules. However, rather than forming a coherent regulatory system, these legal regimes operate in parallel silos with limited institutional coordination. This fragmented structure has resulted in uncertainty regarding the legal status of drone-assisted surveying and its integration into cadastral administration.

3.2.1 Statutory Land Survey Framework and Technological Silence

The Land Survey Act remains the principal legislation governing cadastral and topographic surveying in Tanzania. It regulates licensing of surveyors, approval of survey plans, maintenance of national surveying standards, and protection of survey infrastructure such as boundary beacons.21The Act vests technical oversight in the Director of Surveys, whose approval is required before any survey plan is accepted for cadastral registration.

Despite its relatively comprehensive institutional structure, the Act is technologically static. It is largely premised on conventional ground-based geodetic surveying methods and does not expressly recognize drone technology, photogrammetry, or remotely sensed data as valid surveying instruments. This legislative silence is particularly significant in the context of rapid technological transformation in geospatial data acquisition.

From a doctrinal perspective, this silence creates a form of “regulatory lag”, where statutory frameworks fail to evolve in step with technological innovation. The consequence is that drone-generated survey outputs exist in a legally ambiguous category they are technically reliable and increasingly used in practice, yet lack explicit statutory recognition within the cadastral system.

[17]The Land Survey Act [Cap 324 Revised Edition 2023].
[18]The Professional Surveyors (Registration) Act [Cap 270 Revised Edition 2023]; The Land Survey Act [Cap 324 Revised Edition 2023].
[19]Trust Bank Tanzania Ltd v Le-Marsh Enterprises Ltd & Others [2000] TLR 41 (CA).
[20]Mbeya Cement Co. Ltd v Attorney General [2017] TLR 210 (HC).
[21]The Land Survey Act [Cap 324 Revised Edition 2023].

This gap has several practical implications. First, the admissibility of drone-derived spatial data in cadastral registration is not governed by clear legal rules but rather depends on administrative discretion by surveying authorities. This undermines legal certainty and may lead to inconsistent acceptance standards across different regions or projects. Second, the absence of statutory recognition creates uncertainty regarding the evidentiary status of UAV-generated maps22 in land disputes, particularly where conflicting boundary data arises.

Third, the Act does not provide technical standards or certification requirements for drone-based surveying methodologies, such as accuracy thresholds, calibration procedures, or data validation protocols. This contrasts with conventional surveying methods, which are governed by established geodetic and procedural standards under the supervisory authority of the Director of Surveys.

Furthermore, the absence of UAV-specific provisions also affects professional accountability. Since drone-assisted surveying typically involves multiple actors licensed surveyors, UAV pilots, and geospatial analysts the lack of statutory guidance complicates liability allocation in cases of error or dispute. The law presumes a single responsible surveyor model, which is increasingly incompatible with modern multi-actor geospatial workflows.

Comparatively, jurisdictions such as Rwanda and South Africa have addressed this gap by embedding geospatial technologies within broader land administration frameworks, thereby ensuring that technological innovation is supported by legal recognition and institutional integration. Tanzania, by contrast, continues to operate within a conventional cadastral paradigm that does not yet formally accommodate remotely sensed surveying technologies.

Accordingly, the current legal framework results not in prohibition of drone technology, but in a condition of silent tolerance, where UAV-derived survey outputs are used in practice but lack explicit statutory anchoring. This creates uncertainty for regulators, practitioners, and courts, and ultimately weakens the predictability and uniformity of land administration processes.

3.2.2 Professional Regulation and the Question of Liability

The Professional Surveyors (Registration) Act establishes the regulatory framework for registration, discipline, and professional conduct of surveyors through the National Council for Professional Surveyors (NCPS).[23] The Act ensures that cadastral surveying is undertaken by qualified and licensed professionals, thereby safeguarding technical and ethical standards.

[22]For the purposes of this article, the terms **Unmanned Aerial Vehicle (UAV)** and **Unmanned Aerial System (UAS)** are used interchangeably unless the context requires otherwise. Strictly speaking, a UAV refers to the aircraft itself, whereas a UAS encompasses the aircraft together with its associated ground control station, communication systems, sensors, and other supporting components.

[23] Section 3, 4, 5 and 6 of the Professional Surveyors (Registration) Act[Cap 270 Revised Edition 2023]

However, the Act does not engage with the evolving technological reality of surveying practice. In particular, it does not define the professional status of drone operators involved in geospatial data acquisition, nor does it clarify whether such individuals fall within the category of regulated surveyors. This omission creates a significant accountability gap. In drone-assisted surveying projects, multiple actors are typically involved: licensed surveyors supervising the project, UAV pilots conducting aerial data capture, and data analysts processing geospatial outputs. Yet the law does not clearly allocate liability where errors arise in drone-generated cadastral data.

3.2.3 Aviation Regulation and Functional Disconnect with Land Law

Drone operations in Tanzania are governed by the Civil Aviation Act and subsidiary regulations issued by the Tanzania Civil Aviation Authority (TCAA).[24]The regulatory framework is primarily designed to ensure aviation safety, airspace control, and operational risk management. Under this regime, drone operators are required to obtain registration, import permits, and operational authorisation, and must comply with restrictions relating to altitude limits, restricted airspace zones, proximity to airports, and general flight safety protocols.

However, the aviation regulatory framework is fundamentally designed as an airspace governance system, not a geospatial or land administration framework. Its primary objective is to prevent accidents, protect national security, and regulate the safe integration of unmanned aircraft into national airspace. As such, it does not extend to regulating the downstream use of drone technology for cadastral mapping, land surveying, or land administration functions.

In particular, the Civil Aviation Act and TCAA regulations do not establish standards governing geospatial accuracy, cadastral validity, data calibration, or spatial referencing systems required for land registration purposes. There is also no legal framework specifying how drone-generated outputs such as orthophotos, digital elevation models, or photogrammetric maps should be validated, certified, or integrated into the national land information system.

This creates a clear functional and normative disconnect between aviation regulation and land law. Compliance with aviation requirements ensures only that a drone operates safely within national airspace; it does not guarantee that the data produced meets the legal or technical standards required for cadastral registration or evidentiary use in land disputes. In effect, a UAV operator may be fully compliant with aviation law, yet their outputs may still be rejected or questioned under land administration procedures due to the absence of statutory recognition.

This disconnect generates legal uncertainty at multiple levels. First, it undermines the interoperability between aviation governance and land administration systems, which are both essential for modern geospatial infrastructure. Second, it places excessive reliance on administrative discretion by land authorities when determining whether drone-derived data is acceptable for cadastral purposes. Third, it creates inconsistencies in practice, where

[24]As per section 35 of the Civil Aviation Act [Cap 80 Revised Edition 2023].

similar drone outputs may be accepted in some jurisdictions but rejected in others due to the absence of uniform legal standards.

Comparatively, more integrated systems such as those emerging in Rwanda and South Africa demonstrate the importance of aligning aviation regulation with spatial data governance frameworks, ensuring that UAV operations are not only safe in airspace but also legally functional within land administration systems.

Accordingly, Tanzania's current framework reflects a dual-regulatory structure without functional integration, where aviation law governs flight operations while land law governs cadastral outcomes, with no bridging legal mechanism connecting the two regimes.

3.2.4 Evidentiary Framework and Judicial Uncertainty

The admissibility of drone-generated spatial data in Tanzania is primarily governed by the Evidence Act, which provides for the reception of electronic evidence subject to requirements of authenticity, integrity, and reliability. However, while the Act broadly accommodates electronic records, it does not expressly contemplate or regulate geospatial data generated through Unmanned Aerial Systems (UAS), such as orthophotos, photogrammetric models, digital elevation models, or GIS-based cadastral outputs.25

This legislative silence creates interpretive uncertainty regarding the evidentiary status of UAV-derived data in land-related disputes. Unlike conventional documentary or testimonial evidence, drone-generated spatial data is technically complex, requiring specialised knowledge to verify its accuracy, calibration, metadata integrity, and spatial referencing systems. As a result, courts are increasingly required to evaluate evidence that lies at the intersection of law, engineering, and geospatial science without explicit statutory guidance.

Judicial practice in Tanzania has consistently emphasised that technical and electronic evidence must meet stringent standards of reliability and authenticity. In *Trust Bank Tanzania Ltd v Le-Marsh Enterprises Ltd*,[26] the Court of Appeal held that electronic evidence must be properly authenticated and shown to be reliable before it can be admitted and relied upon by the court. Similarly, in *Mbeya Cement Co. Ltd v Attorney General,*[27] the High Court underscored that expert technical evidence must be properly verified and grounded in established methodology to be admissible in proceedings involving technical disputes.

However, neither of these decisions specifically addresses UAV-generated geospatial evidence, and consequently Tanzanian courts have not yet developed a coherent doctrinal framework for assessing the authenticity of drone-captured spatial datasets, the chain of custody for geospatial files, the calibration and accuracy standards of UAV-derived maps, or the admissibility of photogrammetric outputs as proof of boundary location.

[25] Evidence Act [Cap 6 R.E. 2023], ss on electronic evidence admissibility (general provisions on authenticity and reliability).
[26]Trust Bank Tanzania Ltd v Le-Marsh Enterprises Ltd & Others [2000] TLR 41 (CA).
[27] Mbeya Cement Co. Ltd v Attorney General [2017] TLR 210 (HC).

This absence of jurisprudential guidance creates a doctrinal gap in evidentiary law, particularly in land disputes where conflicting spatial datasets may arise from conventional surveys and drone-based mapping technologies. In such cases, courts are left to rely heavily on expert testimony, which may vary significantly depending on methodological approaches and technological sophistication.

Comparatively, jurisdictions with more developed geospatial legal frameworks increasingly treat UAV-generated data as a distinct category of scientific and technical evidence, requiring predefined standards for validation, metadata verification, and expert certification prior to admission in judicial proceedings.

Accordingly, the current Tanzanian evidentiary regime reflects a state of partial technological adaptation, where general principles of electronic evidence exist, but specific rules governing UAV-derived geospatial data remain undeveloped. This results in legal uncertainty, inconsistent judicial approaches, and increased reliance on judicial discretion in technologically complex land disputes.

3.2.5 Institutional Practice and Regulatory Reality

Despite the existence of a formal legal and regulatory framework, actual institutional practice in Tanzania reveals significant operational and administrative challenges in the use of drone technology for surveying purposes. In practice, drone surveying equipment is frequently subject to delays, inspections, or detention at points of entry where operators have not obtained prior clearance from the Tanzania Civil Aviation Authority (TCAA), reflecting an aviation-focused compliance regime that does not fully accommodate geospatial applications.

In major development corridors, including urban expansion zones and infrastructure investment areas, developers increasingly rely on drone-based mapping due to the inadequacy, incompleteness, or outdated nature of existing cadastral records. However, despite the technical superiority and higher spatial accuracy of drone-generated outputs, such data often encounters administrative resistance when submitted for official land registration. This resistance is largely attributed to the absence of standardized legal and technical criteria for the acceptance, validation, and integration of UAV-derived spatial data within the cadastral system.

Similarly, in peri-urban and rapidly urbanising settlements, overlapping land claims remain prevalent, partly due to outdated or incomplete cadastral maps. In response, private actors have increasingly turned to drone surveys to generate alternative spatial datasets. However, these privately generated outputs frequently lack formal recognition within official land administration processes, creating a parallel system of spatial information: one official but often outdated, and another technically accurate but legally uncertain.

This duality has significant implications for land governance, as it undermines uniformity in land information systems and contributes to inconsistencies in decision-making across administrative levels. The situation reflects a broader institutional coordination problem in which technological innovation outpaces regulatory adaptation.

Judicial observations have indirectly highlighted the importance of institutional coherence in technical regulatory environments. In *Tanzania Electric Supply Company Ltd v Independent Power Tanzania Ltd,* the court emphasised that regulatory compliance and inter-agency coordination are essential in technical and infrastructure-related disputes, noting that fragmented regulatory frameworks can undermine legal certainty, accountability, and effective dispute resolution.[28]

Accordingly, the institutional reality of drone-assisted surveying in Tanzania demonstrates a clear gap between formal legal regulation and practical implementation, where administrative discretion and fragmented oversight continue to shape the acceptance and use of UAV-generated geospatial data in land administration.

3.3 Key Legal Challenges in Drone-Assisted Surveying in Tanzania

3.3.1 Fragmented Institutional Framework

One of the most significant challenges is the fragmented institutional structure governing drone-assisted surveying. Regulatory authority is distributed across the Ministry responsible for lands, the TCAA, and professional regulatory bodies. This institutional division creates overlapping mandates without a coordinating legal mechanism.[29] In practice, a drone survey project may require aviation clearance from TCAA, professional supervision under surveying regulations, and subsequent approval of outputs by land authorities each applying different standards and objectives.

3.3.2 Absence of Drone-Specific Surveying Legislation

A further challenge lies in the absence of dedicated legislation governing drone-assisted surveying. Current land and aviation statutes do not explicitly recognize drone-generated cadastral maps as legally valid surveying outputs. The Land Survey Act is silent on UAS, photogrammetry, and remotely sensed geospatial data, [30]while the Civil Aviation Act regulates drone operation from an air safety perspective but does not address their application in land administration. As a result, there is no statutory framework that recognizes drone-generated cadastral outputs as legally binding survey documents, establishes technical standards for UAV-based cadastral surveying, or integrates drone-derived spatial data into the official land registration system.

3.3.3 Privacy and Data Protection Concerns

Drone-assisted surveying introduces a complex intersection between geospatial technology and privacy regulation, as unmanned aerial systems routinely capture high-resolution imagery of private residences, agricultural land, commercial activities, and human movement patterns. Unlike traditional ground surveying, which is spatially limited and typically consent-based in practice, UAV operations enable wide-area, persistent, and often incidental collection of data that may relate to identifiable individuals or households.

[28]Tanzania Electric Supply Company Ltd v Independent Power Tanzania Ltd [2018] TLR (HC).
[29]The Civil Aviation Act [Cap 80 Revised Edition 2023]
[30]The Land Survey Act [Cap 324 Revised Edition. 2023]

In Tanzania, privacy and data protection are primarily governed by the Personal Data Protection Act, 2022 (PDPA).[31]The Act establishes a general legal framework for the processing of personal data grounded in core principles of lawfulness, fairness, transparency, purpose limitation, data minimisation, accuracy, storage limitation, integrity, and confidentiality. It further provides for data subject rights, obligations of data controllers and processors, and the establishment of a regulatory authority responsible for oversight and enforcement.

Importantly, the PDPA adopts a technology-neutral regulatory approach, meaning that its application is not determined by the method of data collection but by whether the information relates to an identified or identifiable natural person. On this basis, UAV-generated geospatial data may fall within the scope of the Act where individuals, households, or patterns of activity can be directly or indirectly identified from aerial imagery or when such data is linked with cadastral, administrative, or ownership records.

However, despite this broad and flexible statutory design, the PDPA does not expressly regulate geospatial data processing, aerial surveillance practices, or drone-based data acquisition in land administration contexts. This omission creates a significant interpretive gap, particularly in determining when spatial imagery transitions from non-personal geospatial data into legally protected personal data.

A further legal uncertainty arises in relation to the threshold of identifiability. While the Act defines personal data broadly, it does not provide specific guidance on whether spatial representations of land parcels absent direct identifiers constitute personal data. In UAV surveying contexts, this becomes particularly complex because geospatial datasets often become identifiable only through linkage with cadastral records, ownership registries, or contextual environmental markers.

Additionally, the absence of UAV-specific guidance creates uncertainty regarding compliance obligations such as lawful basis for processing, consent requirements, and public interest justification. This is particularly relevant in cadastral surveying, where aerial data collection is wide-ranging and not practically suited to individual consent mechanisms.

Accordingly, while the PDPA provides a foundational framework for personal data protection, its lack of sector-specific rules for geospatial technologies results in regulatory ambiguity, inconsistent compliance interpretation, and operational uncertainty in the application of drone-assisted surveying within land administration systems.

3.3.4 Evidentiary Admissibility and Judicial Uncertainty

Drone outputs such as orthophotos, digital elevation models, and georeferenced maps are increasingly used in land disputes, yet their legal status remains uncertain under the Evidence Act, while the Act allows electronic evidence subject to authentication and reliability requirements,[32] it does not specifically address geospatial evidence derived from UAV systems. This raises three interrelated legal issues: the lack of standardized authentication procedures for drone data; uncertainty regarding chain of custody for digital

[31]The Personal Data Protection Act Chapter 44 of 2022 (Tanzania).
[32] As per section 70 of the Evidence Act [Cap 6 Revised Edition 2023].

geospatial files; and the absence of statutory criteria for evaluating spatial accuracy in cadastral disputes.

3.3.5 Professional Licensing and Regulatory Classification Gaps

Drone-assisted surveying exposes significant gaps in professional regulation and institutional coordination within Tanzania's land governance framework. The Professional Surveyors (Registration) Act establishes the regulatory framework for the registration and discipline of licensed surveyors; however, it does not recognise UAV operators, drone pilots, or geospatial data analysts as distinct professional categories within the surveying ecosystem.[33]

In practice, drone-based surveying is inherently multidisciplinary, involving a hybrid structure of actors including licensed surveyors responsible for legal certification of cadastral outputs, UAV pilots responsible for aerial data capture, and geospatial analysts responsible for processing and interpreting spatial datasets. Despite this functional differentiation, the legal framework does not clearly define the respective professional roles, responsibilities, or liability structures of these actors. This creates uncertainty in determining accountability in cases of technical error, inaccurate spatial outputs, or disputes arising from drone-derived cadastral information.

The absence of UAV-specific licensing regimes or competency-based certification frameworks further limits professional standardisation and weakens quality assurance in drone-assisted surveying practices. As a result, the regulatory system continues to operate on a traditional single-profession model, which is increasingly misaligned with the collaborative and technologically complex nature of modern geospatial surveying.

This professional regulatory gap is compounded by broader institutional fragmentation in the governance of UAV-derived geospatial data. Although Tanzania's Personal Data Protection Act (PDPA)[34] establishes a general regulatory framework for data protection, it does not provide sector-specific implementation rules, technical standards, or interpretive guidance tailored to geospatial and UAV-derived datasets. Consequently, its application to drone-assisted surveying remains indirect and inconsistent.

From an institutional perspective, although the PDPA establishes a supervisory authority, its mandate remains general in scope and not specifically designed for geospatial governance, and there is no designated institutional coordination mechanism linking the key regulatory actors involved in UAV-assisted land administration, namely the data protection authority under the PDPA, the Ministry responsible for lands, the Tanzania Civil Aviation Authority (TCAA), and professional surveying regulatory bodies.

The absence of such coordination results in fragmented enforcement, where drone-generated geospatial data is simultaneously subject to aviation safety regulations, land administration procedures, professional surveying standards, and general data protection principles, without a unified compliance framework or harmonised regulatory guidance.

[33]The Professional Surveyors (Registration) Act [Cap 270 Revised Edition 2023].
[34]The Personal Data Protection Act Chapter 44 of 2022 (Tanzania).

This regulatory fragmentation creates uncertainty for practitioners and institutions alike, particularly in relation to compliance obligations, professional accountability, and admissibility of UAV-derived outputs in cadastral and legal processes. Ultimately, it reflects a broader structural weakness in Tanzania's legal framework, where technological innovation has outpaced institutional integration and regulatory harmonisation.

3.3.6 Technical Standardization and Geospatial Integration Deficits

Unlike conventional surveying, which is regulated through established geodetic and cadastral standards under the Land Survey Act, drone-based surveying in Tanzania lacks uniform calibration, validation, and integration protocols. There are currently no nationally prescribed standards governing UAV data accuracy thresholds for cadastral use, calibration requirements for drone mapping systems, or formal procedures for integrating drone-derived outputs into the national land information system.[35]

The absence of these technical standards results in considerable variability in the quality, precision, and reliability of drone-generated survey outputs across different operators and projects. Consequently, administrative consistency is undermined, interoperability between spatial datasets is compromised, and legal certainty in land registration processes is weakened, particularly where drone-generated maps are relied upon for boundary determination, urban planning, infrastructure development, and the resolution of land disputes.

Furthermore, the lack of nationally recognised technical specifications creates challenges in ensuring methodological consistency in photogrammetry, LiDAR data processing, georeferencing, and spatial referencing systems. Without standardised procedures for validating and certifying UAV-derived datasets, discrepancies may arise between drone-generated information and conventional cadastral records, increasing the likelihood of conflicting spatial interpretations and reducing confidence in the use of drone technology for official land administration purposes. Comparative experience from jurisdictions such as Rwanda and South Africa demonstrates that the successful integration of drone technology into cadastral systems depends not only on technological capability but also on the existence of clear technical standards and institutional mechanisms that ensure the consistency, accuracy, and legal reliability of geospatial information.[36]

3.4 Comparative Legal Analysis: South Africa, Rwanda and Kenya

3.4.1 South Africa: Mature Geospatial Regulation and Survey Integration Standards

South Africa provides a comparatively more structured and mature regulatory environment for geospatial data governance, where the surveying profession is regulated under the Professional and Technical Surveyors Act, while the management of spatial information is governed through the Spatial Data Infrastructure Act, which establishes comprehensive

[35]The Land Survey Act [Cap 324 Revised Edition 2023]; El-Mowafy A, *Modern Surveying and Geospatial Techniques* (Springer, 2020).
[36]World Bank, *Drone Applications in Land Administration Systems* (World Bank, Washington D.C., 2022); Organisation for Economic Co-operation and Development (OECD), *Drone Technology in Public Sector Applications* (OECD Publishing, Paris, 2021); Spatial Data Infrastructure Act 54 of 2003 (South Africa).

standards for the collection, storage, management, sharing, and dissemination of geospatial data across public and private institutions.37Within this framework, spatial data is treated as a strategic national resource, and regulatory mechanisms are designed to ensure interoperability, accuracy, and institutional coordination across different levels of government and technical agencies.

Unlike jurisdictions where aviation and land administration operate in separate regulatory silos, South Africa has developed clearer institutional linkages between aviation regulation and geospatial governance, allowing UAV-derived outputs to be more systematically integrated into national spatial data infrastructure systems under defined technical and administrative standards. As a result, drone-generated data is increasingly accommodated within formal geospatial workflows, reducing ambiguity regarding its legal status and improving its usability in cadastral surveying, infrastructure planning, and land administration processes.

This integrated approach reflects a more advanced stage of regulatory maturity, where UAV technology is not treated as an isolated innovation but as part of a broader spatial governance ecosystem, thereby enhancing consistency in data standards, improving institutional coordination, and strengthening legal certainty in the use of drone-derived geospatial information.

3.4.2 Rwanda: Integrated Digital Cadastre and UAV-Friendly Land Governance

Rwanda represents one of the most advanced examples of integrated land administration in Africa, particularly through its nationwide Land Tenure Regularisation Programme, which relied heavily on geospatial technologies, including aerial imagery, satellite mapping, and UAV-assisted data collection, in the systematic adjudication and registration of land rights across the country, thereby significantly improving efficiency, reducing boundary disputes, and accelerating the formalisation of land ownership.38The Rwanda Land Management and Use Authority (RLMUA) operates within a fully digitised cadastral system that enables the integration of remotely sensed data into official land registration processes, ensuring that geospatial technologies are not treated as external tools but are embedded within the core land administration infrastructure.

In this framework, drone and aerial mapping technologies are functionally integrated into cadastral decision-making processes rather than being regulated solely as aviation devices, thereby allowing geospatial data to serve both administrative and evidentiary functions in land governance. Consequently, the Rwandan legal and institutional approach reflects a shift towards geospatially integrated land governance, where UAV and remote sensing technologies are incorporated into a unified system that supports faster adjudication, improved spatial accuracy, and enhanced transparency in land administration processes.

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[37]Spatial Data Infrastructure Act 54 of 2003 (South Africa); Professional and Technical Surveyors Act 40 of 1984 (South Africa).

[38]World Bank (2019): *Land Tenure Regularisation in Rwanda: Lessons from a Nationwide Cadastre Project*, World Bank, Washington D.C;Rwanda Land Management and Use Authority (RLMUA), *Land Administration and Geospatial Systems Report* (Government of Rwanda publications).

3.4.3 Kenya: Progressive Geospatial Regulation and Partial UAV Integration

Kenya presents a hybrid regulatory model that combines conventional land law with emerging geospatial governance and partial UAV integration frameworks, where the Survey Act and the Land Registration Act provide the foundational legal basis for cadastral surveying, while the National Land Commission plays a central institutional role in land administration, management, and policy coordination.39Although Kenya does not yet have a fully dedicated statutory framework specifically governing drone-based cadastral surveying, regulatory developments under the Kenya Civil Aviation Authority, together with evolving national geospatial policies, have progressively created an enabling environment for the use of UAV technology in mapping, spatial data collection, and land-use planning activities.

In practice, UAV technology in Kenya is increasingly utilised in public-sector geospatial projects, including urban planning, infrastructure development, environmental monitoring, and land-use mapping, reflecting a gradual institutional acceptance of drone-derived spatial data despite the absence of complete legislative harmonisation between aviation regulation and land administration law. This has resulted in a regulatory environment characterised by partial integration, where UAV systems are functionally embedded in geospatial practice but remain only indirectly regulated within cadastral law frameworks.

The key distinction between Kenya and Tanzania lies in Kenya's more advanced level of institutional experimentation and regulatory adaptability, where UAV technology is increasingly incorporated into operational land administration systems despite the lack of a single consolidated legal framework governing drone-assisted surveying. Consequently, Kenya demonstrates an evolving transitional model in which regulatory gaps are mitigated through policy development and administrative practice rather than comprehensive statutory reform, thereby allowing gradual but uneven integration of drone technology into land governance systems.

3.4.4 Comparative Insight and Tanzania's Position

A cross-jurisdictional analysis reveals three distinct regulatory trajectories in the integration of drone technology into land administration systems. First, Rwanda demonstrates full institutional integration, where drone technology and other geospatial tools are embedded within a digitised cadastral framework that enables the systematic incorporation of remotely sensed data into formal land adjudication, registration, and administration processes. Second, Kenya reflects partial regulatory evolution, where UAV technologies are increasingly utilised in practice for mapping, planning, and spatial analysis, yet without full statutory integration into cadastral law, resulting in a system where practice has advanced faster than legislative harmonisation. Third, South Africa illustrates structured regulatory maturity, where geospatial governance frameworks, supported by defined institutional linkages and spatial data infrastructure standards, provide clearer technical and

[39]Survey Act (Kenya), Cap. 299; Land Registration Act (Kenya), 2012; National Land Commission Act (Kenya), 2012; Kenya Civil Aviation Authority Regulations (UAS Regulations, as applicable).

legal parameters for the controlled integration of UAV-derived data into surveying and land administration systems.

In contrast, Tanzania remains at an earlier stage of regulatory development, characterised by sectoral fragmentation, institutional silos, and legal silence on the integration of drone technology into cadastral surveying and land governance processes. While aviation regulation is administered under the Tanzania Civil Aviation Authority (TCAA) and land surveying is governed by established statutory frameworks, there is no bridging legal or institutional mechanism that connects UAV technology with cadastral validation, approval, and integration processes within the land administration system. This absence of regulatory linkage results in uncertainty regarding the legal status of drone-generated spatial data and limits its systematic use in official land governance functions.

This comparative divergence demonstrates that Tanzania's central challenge is not technological readiness or operational capability, but rather a deficit in legal harmonisation and institutional coordination, particularly in adapting existing aviation, land, and professional regulatory frameworks to accommodate emerging geospatial innovations such as UAV-assisted surveying.

3.5 Discussion

The analysis of Tanzania's legal and institutional framework reveals a system that is partially functional but increasingly misaligned with the operational realities of modern geospatial technology. Although the existing legal framework regulates both aviation safety and traditional cadastral surveying, these areas are governed through separate, sector-specific, and largely disconnected legal regimes. Consequently, the current regulatory architecture lacks an effective legal and institutional interface for integrating drone technology into land administration systems.

The consequences of this fragmentation are evident across several interconnected aspects of land governance. First, in land ownership verification, the absence of explicit legal recognition of drone-generated spatial data means that UAV-derived information is frequently treated as supplementary rather than authoritative evidence. This limits its potential to improve the accuracy of boundary identification, particularly in rapidly urbanising and peri-urban areas. Second, in infrastructure development, the lack of formal integration of drone-derived maps into cadastral systems compels developers and planning authorities to rely on inconsistent or non-standardised spatial datasets. This increases the likelihood of planning conflicts, project delays, and inefficient land-use planning.

Third, in investment land allocation, uncertainty regarding the legal status and admissibility of drone-generated geospatial data undermines investor confidence, particularly where reliable spatial information is required for due diligence, land valuation, and risk assessment. Fourth, in land dispute resolution, courts are increasingly confronted with conflicting survey plans and privately generated geospatial evidence. However, there is currently no developed judicial doctrine or statutory framework specifically governing the admissibility, authentication, and evidentiary value of UAV-generated spatial data.

The findings of this study therefore demonstrate that the principal challenge is not the absence of legal regulation, but the absence of regulatory integration. Existing legislation regulates drones primarily as aviation devices under airspace law, while land legislation continues to regulate surveying through conventional cadastral procedures. There is no comprehensive legal framework that recognises drones as instruments of land governance capable of producing authoritative geospatial information for cadastral registration, land administration, and judicial proceedings. As a result, technological innovation has advanced more rapidly than the legal and institutional framework designed to govern it.

The comparative analysis further demonstrates that jurisdictions such as Rwanda, Kenya, and South Africa have made greater progress in integrating drone technology into land administration through stronger institutional coordination, clearer technical standards, and more coherent regulatory frameworks. Tanzania can draw valuable lessons from these experiences by developing a harmonised legal framework that integrates aviation regulation, cadastral surveying, professional standards, evidentiary rules, and data governance. Such reforms would improve legal certainty, strengthen institutional coordination, and promote the effective adoption of drone technology in support of efficient, transparent, and sustainable land governance.

4. Recommendations

4.1 Enactment of Dedicated Drone Surveying Regulations

Tanzania requires a dedicated regulatory instrument specifically governing drone-assisted surveying within the land administration system, as the current fragmented framework does not adequately address the legal status, technical standards, and institutional use of UAV-generated geospatial data in cadastral processes. Such a framework should expressly recognise drone-derived geospatial outputs as legally valid inputs in cadastral surveying and land registration procedures, thereby removing the current ambiguity that results in reliance on administrative discretion rather than clear statutory authority.

In addition, the proposed regulatory framework should establish minimum technical standards governing spatial accuracy thresholds, data resolution requirements, calibration procedures, and methodological consistency in UAV-based surveying, in order to ensure uniformity and reliability of drone-generated datasets across different operators and projects. It should further define standardized procedures for data validation, quality assurance, and certification of drone-derived cadastral outputs before their integration into official land information systems.

Moreover, the regulation should provide clear legal guidance on the evidentiary and administrative status of UAV-derived cadastral data, including its admissibility in land registration processes and dispute resolution mechanisms, while also specifying the roles and responsibilities of licensed surveyors, UAV operators, and geospatial analysts within the cadastral workflow. By doing so, the framework would ensure legal certainty, improve

institutional coordination, and facilitate the safe and effective integration of drone technology into Tanzania's land governance system.

4.2 Establishment of an Integrated Institutional Coordination Mechanism

The current fragmentation between land administration authorities, aviation regulators, and professional surveying bodies necessitates the establishment of a structured institutional coordination framework to ensure coherent governance of drone-assisted surveying within Tanzania's land administration system. A joint institutional mechanism involving the Ministry responsible for lands, the Tanzania Civil Aviation Authority (TCAA), and the surveying regulatory authority should be formally established to provide a unified platform for policy alignment, regulatory interpretation, and operational oversight of UAV-based surveying activities.

Such a mechanism would facilitate harmonised decision-making across the key sectors involved in drone governance, thereby reducing duplication of regulatory procedures, conflicting administrative requirements, and procedural delays that currently affect UAV deployment in surveying practice. It would also ensure alignment of technical and operational standards relating to drone operations, cadastral data production, and geospatial data integration into national land information systems.

Furthermore, the coordination framework would enhance consistency in the approval, validation, and acceptance of drone-assisted survey outputs by establishing shared guidelines and inter-agency protocols for evaluating UAV-derived geospatial data. In doing so, it would strengthen institutional accountability, improve regulatory efficiency, and promote interoperability between aviation safety regulation and land administration systems, ultimately supporting a more integrated and legally coherent approach to geospatial governance in Tanzania.

4.3 Reform of Data Governance and Geospatial Information Law

Tanzania requires a comprehensive and coherent legal framework governing geospatial data ownership, access, use, and sharing, particularly in the context of rapidly expanding drone-assisted surveying practices, as the current legal regime does not sufficiently regulate the lifecycle of UAV-generated spatial data from collection to processing, storage, dissemination, and integration into land administration systems. Such a framework should clearly define ownership rights over drone-captured geospatial data, establish safeguards for privacy and data protection, and set out structured protocols for inter-agency data sharing in order to ensure that geospatial information is not only technically usable but also legally regulated, securely managed, and institutionally coordinated within national systems.

Although Tanzania does not lack a general data protection framework, the Personal Data Protection Act, 2022 provides only baseline principles governing the lawful processing of personal data, including requirements of lawfulness, purpose limitation, and data minimisation, yet it does not contain UAV-specific provisions or detailed regulatory guidance on geospatial data governance, particularly in relation to cadastral mapping, aerial surveillance, or drone-based land information systems.

Accordingly, reform efforts should focus on the development of sector-specific regulations or subsidiary guidelines under the PDPA that operationalise its general principles in the context of geospatial technologies, including defining the circumstances under which aerial imagery constitutes personal data, establishing technical and legal standards for anonymisation, aggregation, and spatial masking of geospatial datasets, regulating cross-border transfer and processing of UAV-derived geospatial information, and clarifying lawful bases for the use of drone technology in cadastral surveying and land administration activities.

Such targeted reforms would strengthen the practical implementation of the PDPA within emerging technological contexts without necessitating wholesale legislative overhaul, while simultaneously ensuring that drone-generated geospatial data is governed in a manner that balances innovation, privacy protection, institutional accountability, and legal certainty in land governance systems.

4.4 Amendment of the Evidence Act to Accommodate Drone-Based Evidence

The Evidence Act should be amended to explicitly recognise drone-generated imagery, photogrammetric outputs, LiDAR datasets, and GIS-based mapping products as admissible categories of electronic and scientific evidence, given that the current legal framework only provides a general basis for the admissibility of electronic evidence without addressing the unique technical and methodological characteristics of geospatial data generated through Unmanned Aerial Systems. In its present form, the Act does not sufficiently account for the scientific processes underlying UAV-derived outputs, including spatial calibration, georeferencing, metadata integrity, and post-processing methodologies, all of which are essential for determining reliability and probative value in judicial proceedings involving land disputes.

Express statutory recognition of UAV-generated geospatial evidence would enhance judicial certainty by providing clear admissibility standards, reduce interpretive inconsistencies among courts when dealing with technically complex spatial data, and improve the overall reliability and evidentiary weight of drone-based mapping outputs in land adjudication processes. It would also facilitate the development of standardized judicial approaches to issues such as authentication of digital spatial datasets, chain of custody for geospatial files, and expert verification of UAV-derived maps used in boundary determination and cadastral disputes.

Furthermore, such reform would strengthen the interface between law and geospatial science by ensuring that courts are equipped with clear legal parameters for evaluating technologically advanced forms of evidence, thereby reducing over-reliance on discretionary judicial interpretation and promoting consistency, predictability, and fairness in land-related litigation involving drone technology.

4.5 Reform of Professional Regulation and Capacity Frameworks

Professional regulation of surveying practice in Tanzania should evolve to incorporate drone-based competencies as an essential component of modern cadastral and geospatial practice, given that the increasing use of Unmanned Aerial Systems in land surveying has transformed the technical, operational, and methodological requirements of the profession beyond traditional ground-based surveying techniques. In this regard, the current regulatory framework should be restructured to include formal certification schemes for UAV survey operators, alongside the integration of drone technology, photogrammetry, remote sensing, and geospatial data processing into the core licensing and continuing professional development requirements for licensed surveyors.

Such reform would ensure that practitioners are adequately equipped with both legal and technical competencies required to operate within technologically advanced surveying environments, while also strengthening professional accountability in cases involving drone-generated cadastral outputs. It would further enable the establishment of clear competency standards distinguishing between roles such as licensed cadastral surveyors, UAV pilots, and geospatial data analysts, thereby reducing ambiguity in responsibility allocation and improving quality assurance in surveying outputs.

Additionally, the integration of drone-related training into professional licensing frameworks would enhance the capacity of regulatory institutions to evaluate, supervise, and standardise UAV-assisted surveying practices, ultimately ensuring that technological innovation is matched with appropriate professional oversight, ethical compliance, and adherence to technical standards within Tanzania's land administration system.

5. Conclusion

This study has critically examined the legal and institutional framework governing drone-assisted land surveying in Tanzania and established that, although multiple relevant statutes exist, they operate in a fragmented, sectoral, and largely uncoordinated manner, as the Land Survey Act, the Professional Surveyors (Registration) Act, the Civil Aviation Act, and the Evidence Act collectively regulate different dimensions of drone-related activities, yet none provides a unified legal structure for the integration of drone technology into cadastral surveying, land administration, and geospatial governance systems.

The analysis demonstrates that this regulatory fragmentation generates significant legal uncertainty in key areas of land governance, including land ownership verification, infrastructure development, investment land allocation, and dispute resolution, while judicial practice further reflects the absence of a developed doctrinal framework for assessing and evaluating drone-generated geospatial evidence, particularly in relation to issues of authenticity, reliability, and admissibility, whereas comparative jurisdictions such as Rwanda, Kenya, and South Africa illustrate more advanced stages of regulatory and institutional integration of UAV technology into land administration systems.

Ultimately, the study concludes that the core challenge is not the absence of legal regulation, but rather the absence of legal and institutional integration across existing sectoral frameworks, and unless coordinated reforms are undertaken to harmonise aviation law, land law, professional regulation, data protection law, and evidentiary standards,

Tanzania risks continued inconsistencies in land administration practice, evidentiary uncertainty in judicial proceedings, and inefficiencies in geospatial governance, thereby underscoring the need for a comprehensive, harmonised legal and institutional framework that ensures drone technology strengthens rather than destabilises land governance systems.

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