The Role of Digital Transformation for Integrated Land Management: Insights from Latin America

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Key words: land administration, digitalisation, integrated land management

SUMMARY

Land rights, restrictions and responsibilities are closely linked to land management in general and spatial planning in particular. Both systems - land tenure and land use planning - involve the distribution, regulation and use of land resources, but they usually operate through different processes and are influenced by different policies, institutions and legal frameworks. In many contexts, institutions that document and disseminate information on land tenure, typically cadastral offices and land registries, and institutions that deal with land use planning, typically planning authorities, operate in silos. Weak governance structures and poor institutional coordination of land tenure and land use planning can lead to inefficient processes, ineffective enforcement and poor community support, and even conflict due to inconsistencies. The advent of digital transformation offers significant opportunities to overcome these silos and strengthen linkages, improving efficiency, transparency and decision-making processes. The paper hooks onto earlier works of the joint FIG Commission 7 and Commission 8 Working Group 7.6/8.4 on Integrated Land Management and refers to the previously presented conceptual framework to assess these linkages and to identify the role of digitalisation and digital transformation in this context. The main categories relate to I) Institutions and governance; II) Legal framework and policy; and III) Data and technology.The case studies from Mexico and Brazil are contextualised and evaluated alongside general developments on the Latin American continent. Data were collected through a literature review and semi-structured interviews with key experts in both countries. The findings shed light on the three lenses of the conceptual framework and emphasise the relevance of digitalisation in implementing integrated land management. The preliminary results show that in practice digitisation is a balancing act between internal and external forces on the one hand and gradually manoeuvring between what is technically possible and operationally feasible on the other hand. Internal forces hindering major transformations in day-to-day workflows concern vested interests of professional standards and practices, as well as internal territorial or functional mandates. External influences generally concern advocacy agencies with their own information systems and indicator systems which are largely incompatible with existing internal ones. This paper concludes with a discussion on potential use cases and different user perspectives on integrated land management.

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1. INTRODUCTION

Land rights, restrictions, and responsibilities are intrinsically linked to land management in general and spatial planning in particular. Both systems of management—managing land tenure and managing and planning land use —involve the distribution, regulation, and use of land resources, yet they typically operate through separate processes and are influenced by different policies, institutions, and legal frameworks. In many cases, institutions that document and disseminate information on land tenure, such as cadastral offices and land registries, and those responsible for land use planning, such as planning authorities, function in silos. This fragmentation often leads to weak governance structures, poor institutional coordination, and inefficient processes, resulting in ineffective enforcement, limited community support, and even conflicts due to inconsistencies between land tenure, cadastral information and planning systems.

Examples of the effect of these discontinuities and disconnections are the three use cases of integrated land management systems in Germany discussed by Sommer & Vries (2023). While properties in Germany are accurately measured and registered, and while the procedures of registration follow well-defined and long-standing standards, what one can actually do with the information in these registers, besides checking individual property ownership for particular locations, is limited. It remains difficult to control or steer the land market despite the potential wealth of data on land transfers; it remains difficult to check if land concentrations are occurring and if and where accumulations of property ownership take place, and the link of ownership information to environmental and public restrictions is not embedded in the property registration systems. Hence, for an individual owner or specific location, it is extremely cumbersome to obtain a full picture of the current legal status quo of a plot of land or an area. This makes both land use planning and broader land governance complicated.

The advent of digital transformation presents significant opportunities to overcome these silos, enhancing the linkages between land tenure and land use planning. By improving efficiency, transparency, and decision-making processes, digital tools and technologies have transformed how integrated land management systems respond to disruptions, enhance service delivery, and support sustainable development. Innovative technologies and digital infrastructures ensure that land administration systems become more resilient, efficient, and inclusive. Thus, it is not a surprise that (technically supported) integrated land management gains attention at national as well as international level.

However, much focus has been placed on the technical infrastructures and technological drivers behind these developments. This paper takes a broader perspective by zooming out to examine the role of practice and practitioners in processes of digitalisation and digital transformation for integrated land management. By better understanding in which environment and with which opportunities practitioners are operating and making day-to-day decisions on adopting and enhancing digitalisation and integration, it is better possible to comprehend it beyond its mere technical aspects and support the development of a conceptual framework for a more holistic assessment pertaining to the institutional, legal and technology lens.

FIG WG 7.6/8.4 addresses both aspects and explores if and how digital transformation improves the integration of land management and administration by creating opportunities for cross-sectoral synergies that have hardly been exploited so far. The working group wants to expose best practices the bridge land administration, land management, land use planning and spatial governance.
The paper is structured around six main parts. Contextual background about the region as well as integrated land management is provided in section two, before section three illuminates on the methodologies used to collect data for this contribution. The fourth section elaborates the country cases of Brazil and Mexico before the fifth section of this paper puts the examples into international context. The last section concludes with the main findings and outlines the way forward.

2. BACKGROUND

2.1 Integrated Land Management and Digitalisation

In the land management paradigm (Enemark 2005), land administration functions are essential for regulating how land and its resources are managed, used, and distributed. These functions ensure that land-related activities are conducted efficiently, equitably, and sustainably. The key land administration functions include land tenure, land valuation, land use planning, and land development.
Enemark (2005) emphasises the importance of integrating land management functions, noting that many countries tend to separate managing land tenure rights from managing land use rights. This separation creates a gap in both information provision and designing practical land management and land governance solutions, as there is no effective institutional mechanism to link planning and land use controls with land values and the land market's functioning. These challenges are further exacerbated by inefficient administrative and management practices that fail to provide essential services. Back then, Enemark (2005) further outlined that investments in new technology can offer some improvements, they only address part of the problem—the broader issue lies in the inability to manage land and its resources as an integrated, cohesive system. Still, however, some of the promises of technological changes are not yet fulfilled, as some of the basic public sector information and land governance objectives are not properly aligned (Scanlan et al., 2025).
Undoubtedly, technology has advanced tremendously, offering ways to address siloed systems, challenging the status quo and providing opportunities for integrated land management. Previous work on digital transformation in land administration emphasises the shift from traditional, manual processes to digital systems, leading to significant improvements in efficiency, transparency, and service delivery. This transformation involves digitizing data and redesigning business processes to accommodate digital tools, with countries adopting technologies like blockchain, GIS platforms, cloud processing, and satellite data for land registration and property transactions. The COVID-19 pandemic accelerated this shift, highlighting the importance of digital infrastructure in maintaining service continuity during disruptions. Global frameworks, including the Voluntary Guidelines on the Responsible Governance of Tenure (VGGT), as well as the Framework for Effective Land Administration (FELA) provide policy guidance and support for countries in adopting digital strategies. Overall, digital transformation is recognised as a crucial step in improving service delivery and achieving broader development goals through modern technology and process reengineering.

Use cases demonstrating different stages of digitisation, digitalisation and digital transformation can be found across the globe. In this context, significant progress in digitally accelerated land administration is frequently reported and presented at international conferences, addressing various aspects such as technological infrastructure, legal and regulatory frameworks, data management, interoperability, service delivery, and user experience (FAO, UNECE, FIG, 2022). Despite these advancements, risks and challenges remain, particularly with regard to the digital divide, digital literacy, and inequalities in access to digital infrastructure, particularly in rural areas.
In this vein, earlier work in the working group provides insights into stakeholder perspectives from 23 countries, focusing on both the opportunities and challenges of digital transformation by investigating and categorising the different social perspectives, beliefs and values on preferred and non-preferred (technical and non-technical) practices, fears and opportunities related to digital technologies (Lindner et al. 2024). Key benefits include improved efficiency, security of tenure, and enhanced spatial planning, while concerns centre around job loss, privacy issues, and the exclusion of vulnerable groups especially in the discourse of digital versus analogue data. The study underscores the importance of balancing innovation with inclusive strategies to ensure equitable access and minimise risks.

2.2 The Context of Latin America

Most countries in Latin America follow a dual structure inherited from the Roman Law, where the cadastre and the land registry are managed by separate entities. Only 43% of Latin America and Caribbean (LAC) countries have integrated registry and cadastre systems, a figure notably lower than in other regions such as Eastern Europe and Central Asia (ECA). This lack of integration increases transaction costs and reduces data reliability (Deininger et al., 2025), while also complicating coordination and digital integration (Ribeira et al., 2025). The systems are often fiscally oriented, focusing primarily on property valuation for taxation purposes, whereas legal security is handled independently, leading to data duplication and inefficiencies.
In terms of progress towards digital transformation of property institutions, Deininger et al. (2025) reflect that the LAC region has made only moderate advances. While about 78.6% of LAC countries surveyed have a digital land registry with national scope and 64.3% have more than half of their private land registered, only 35.7% have more than half of their cadastral data mapped, and just 21.4% have mapped more than half of their public land (Deininger et al., 2025). This indicates limited spatial coverage, which restricts the potential for effective land governance, taxation, and planning. Digitalization is increasingly recognised as a key driver for those developments making land administration more efficient, transparent, and accessible. Digital tools support cadastral surveys, regularization, registration, territorial planning, disaster risk management, and sustainable rural development. However, many countries face weak institutional coordination, insufficient funding, and a lack of technical capacity, especially at the municipal level, which limits the ability to maintain and update digital land records, particularly in rural areas (FAO, ABC/MRE & INCRA, 2022).
There is a growing push for multipurpose cadastres, serving legal, fiscal, planning, and environmental needs, and for adopting “fit-for-purpose” and social mapping methodologies, especially in rural and informal areas (Beccera et al., 2021; Flores-Rozas et al., 2023). The literature recommends moving toward a single, unified digital system for cadastre, registry, and regularization, with open data standards and interoperability between institutions (FAO, ABC/MRE & INCRA, 2022).

3. METHODOLOGY

3.1 Institutional, Legal, Technological Setup

This paper uses a threefold analytical framework to assess these linkages and to identify the role of digitalisation and digital transformation in this context.
The main categories relate to:

- I) Institutions and governance: Governance structures should facilitate partnerships and collaboration between land management agencies, planning authorities and community stakeholders, and provide opportunities for digital transformation;
- II) Legal framework and policy: A strong legal framework that aligns land tenure laws with land use planning regulations promotes coherence between how land is owned and how it can be used, as well as its support for digital technologies;
- III) Data and technology: Harnessing technological advances and digitalisation efforts provides the necessary infrastructure to bridge siloed institutional arrangements.

The preliminary findings from Brazil and Mexico are based on a literature review and consultations with two experts from each country. Semi-structured interviews were organised around five thematic sections to explore the current state and prospects of integrated land management, with a focus on the role of digitalisation. The first section about integrated land management investigates the general country context and extent of integration between land tenure and land use planning, practical examples at various governance levels, and the role of strategic development plans. Secondly, the technology lens assesses the technological tools used in land management, their effectiveness, and barriers to adoption such as cost, training, and infrastructure. Thirdly, the institutional lens explores the roles of different institutions, their coordination mechanisms, and how digital processes support collaboration. It also seeks suggestions for improving inter-institutional cooperation. Fourthly, the legal lens evaluates whether integration is supported by legislation or policy frameworks and how these laws facilitate or hinder digitalisation in land management. The interviews closed with an outlook towards future developments to gather insights on expected changes over the next decade, the role of digital transformation, and key enablers and barriers to progress.

3.2 Enabling and Disabling Design Features for Integrated Land Management

While there is a fundamental overlap between secured land rights and integrated land management, there are also differences. Legal certainty of land rights requires clear property boundaries and a timely, centralised, unique, and harmonised registration of landowners. As the systematic and effective implementation of land administration system takes time and is capital intensive, integrated land management should not be seen as an add-on to existing land administration infrastructure. Rather, the consistency of strategies for providing secured land rights with integrated land management should be explored from the start. The approach considers that digitisation practices and their outcomes are built on the interplay between lock-in effects of past decisions and on current political and economic agendas and interests. At the same time, the prioritised implementation of land right security could create future lock-ins that disable use cases of integrated land management. It is noteworthy that integrated land management goes beyond merging cadastres and land registers and can include linking land rights and restrictions information, information on landowners and corporate ownership, land acquisitions and concentration as well as levers of control and enforcement. Thereby, emphasis is not on secure property transactions alone but on various land management use cases.

How legal, technical and institutional architectures of land information and planned digitisation strategies enable or disable certain functions and use cases of integrated land management needs to be understood. Clear property boundaries are not necessarily the first priority as would be the case for a single focus on property transactions and secure land rights. From this angle, use cases like land concentration assessment, land market control and enforcing land rights restrictions could lead to additional digitisation requirements. The mentioned use cases instead emphasise clear links between land rights and restrictions as well as transparent, unambiguous, correct, complete and timely data on land transactions as well as landowners and purchasers:

- For land concentration assessment: need for unique identifiable direct owners and data access regarding ultimate beneficial owners, harmonised measures, classifications and thresholds for land values or parcel sizes - link between owners to all parcels of one owner
- For land market regulation: timely identification of direct property transactions or indirect purchases via share deals
- For control of land rights restrictions: link between property right and land restriction via common spatial or direct links between right and restriction

4. RESULTS

4.1 The Understanding of Integrated Land Management and Digitalisation

Integrated land management has emerged as a central theme in Latin America's efforts to promote sustainable development, territorial justice and environmental protection. These efforts are increasingly supported by digitalisation and data-driven governance, aligning with broader global frameworks such as the Sustainable Development Goals (SDGs). The Montevideo Consensus on Population and Development (UN ECLAC, 2014) provides a foundational policy framework for the region, emphasizing human rights, equality, and the strategic use of digital tools to enhance land-related governance and integrated territorial planning.

Historically, land administration systems in Latin America have been shaped by the legacy of the Roman Law and the Spanish legal tradition, which separated land registration from cadastral mapping. In many countries, cadastral agencies were only established in the last 20 to 30 years, whereas land registries have existed for much longer, primarily focused on legal documentation of ownership. As a result, the concept of integrated land management is often narrowly interpreted as the technical integration of cadastre and land registry systems. However, contemporary approaches increasingly advocate for a multipurpose cadastre—a broader construct that links territorial information, rights, restrictions and responsibilities to cadastral properties, enabling more holistic and inclusive land governance (Lopez-Rivera, 2024).

Despite growing recognition of the importance of integration, progress remains uneven across the region. Institutional fragmentation, legal pluralism, and disparities in digital infrastructure continue to hinder the development of coherent land administration systems (FAO, ABC/MRE & INCRA, 2022). Many countries operate multiple land information systems in parallel, often without interoperability, and responsibilities for land use planning and tenure management are distributed across different levels of government.

4.2 The Case of Mexico

Land management practices in Mexico are shaped by historical legacies, institutional fragmentation, and the uneven adoption of digital technologies. The country's land administration system reflects a complex interplay between federal, state, and municipal authorities, each operating under distinct legal frameworks and data infrastructures. This complexity is further compounded by Mexico's dual land tenure system, which distinguishes between ejido and communal lands managed by the Registro Agrario Nacional (RAN), and private property overseen by municipal cadastral offices. The decentralization reforms of 1983, which granted municipalities strong autonomy over land use planning and cadastral mapping and registration of private property, were intended to empower local governance but have also contributed to fragmentation and inconsistent planning practices across the country.

Efforts to modernise land governance began in earnest during the 1990s, particularly through the PROCEDE program (Ejido Rights Certification Programme), which aimed to formalise ejido land rights using geographic information systems and digital cadastral mapping. This initiative significantly improved tenure security and facilitated the emergence of land markets (INEGI, 2006). However, many Ejidatarios, the owners of the ejido land, continue to face barriers to accessing and managing their land rights due to digital illiteracy, limited internet connectivity, and dependence on intermediaries (Hoekema et al. 2009, Barnes, 2014).

The legal framework underpinning land governance is anchored in the Ley General de Asentamientos Humanos, Ordenamiento Territorial y Desarrollo Urbano, which mandates integrated planning and coordination across government levels. Despite this, only a minority of federal entities have fully harmonised their legislation with the national law, leaving most states with partial or outdated regulatory structures (SEDATU, 2025).

Institutional fragmentation remains one of the most significant obstacles to integrated land management. Key federal institutions such as SEDATU (Secretaría de Desarrollo Agrario, Territorial y Urbano), INSUS (National Sustainable Land Institute), RAN, and INEGI (National Institute of Statistics and Geography) each play vital roles in land administration, housing policy, land regularization, and geospatial data provision. However, coordination among these entities is limited, and their respective data systems are often incompatible. Municipalities, which are responsible for land use planning and cadastral management and the management and updating of land administration data, vary widely in their technical capacity and resources. While some urban centres like Guadalajara have developed advanced digital platforms, many smaller municipalities lack even basic digital infrastructure. According to recent assessments, only 18 percent of municipalities possess the capacity to maintain digital cadastral systems (PNOTDU, 2025). This fragmentation, outdated information and lack of interoperability between municipal cadastres and public registers generates uncertainty about land ownership and use ultimately limiting legal certainty, reducing property tax collection and hindering territorial planning. Legal pluralism, discrepancies between cadastral and legal data, especially in ejido areas and a lack of integrated urban planning frameworks, especially in the ejidos which cover more than 50% of total Mexican territory, lead to tensions, particularly in peri-urban areas where there is a high degree of informality in land transactions (Schumacher et al. 2019).

In response to these challenges, land management in Mexico is undergoing a transformative shift as the Mexican government via SEDATU is introducing two major national projects aimed at reforming land governance: the Proyecto del Programa Nacional de Ordenamiento Territorial y Desarrollo Urbano (PNOTDU) 2025-2023 and the Lineamientos del Programa de Modernización de los Registros Públicos de la Propiedad y Catastros 2025. The modernization guidelines set forth a comprehensive strategy to digitise and harmonise property registries and cadastral systems. Their objectives include strengthening institutional coordination, implementing interoperable digital platforms, harmonising legal frameworks, formalising

informal settlements, and enhancing citizen access to land-related services. These reforms are designed to replace outdated paper-based systems with transparent, efficient, and inclusive digital infrastructures (SEDATU 2025) allowing for efficient land services and public access to land data.
The project PNOTDU went through the National Council lately but its final publication in the Diario Oficial de la Federación is still pending. In essence, it outlines Mexico's territorial development strategy for 2025–2030, representing a paradigm shift in land governance. It conceptualises territory as a common good and positions planning as both a technical and ethical responsibility. The program emphasises substantive equality, particularly for historically excluded territories, and promotes public participation through forums and consultations. It also advocates for affirmative action in housing, mobility, infrastructure, and access to services, aligning its goals with international frameworks such as the Sustainable Development Goals (SDGs), the Paris Agreement, and the 2030 Agenda. PNOTDU seeks to reverse the effects of neoliberal reforms that weakened public institutions and to restore the state's capacity to manage land equitably and sustainably (PNOTDU, 2025).
Despite these promising initiatives, significant challenges remain. The coexistence of multiple land registries and legal systems continues to generate conflicts and uncertainty, especially in peri-urban areas where informal settlements proliferate. Discrepancies between cadastral maps and legal property titles are common, and the process of converting ejido land to private property is often discretionary and opaque. Municipal resistance to data sharing and collaboration further impedes integration efforts. Moreover, the digital divide exacerbates inequality, as wealthier municipalities benefit from advanced technologies while rural municipalities and marginalised communities are left behind.
Nevertheless, emerging opportunities are beginning to bridge these gaps. Participatory GIS and community-driven mapping initiatives, for example, are empowering local stakeholders and improving data accuracy (Salgado Montes et al., 2017). Academic institutions are increasingly collaborating with government agencies to support evidence-based planning and policy development. The SITU (Land and Urban Information System) refers to a centralised database that is currently being created to integrate all planning information in one place. Combined with the strategic frameworks provided by the central government, these innovations offer a pathway towards more coherent, inclusive and sustainable land management in Mexico.

4.3 The Case of Brazil

Brazil's land administration system is historically fragmented, shaped by colonial legacies and institutional silos. Urban and rural land governance are managed separately, with urban cadastres under municipal control and rural cadastres under the federal institution INCRA. Land registration, however, is handled by private notaries and registrars under the juridical control at state level, creating a disconnect between cadastral mapping and legal ownership. This fragmentation has long hindered integrated land management, but recent digitalisation efforts and changing institutional mandates for integrated land information offer a promising path forward. Developments are also pushed by a recent Supreme Court decision[1] calling for integrated information of land rights and environmental aspects of land.
Land tenure in Brazil is categorised into several types, each governed by different regulatory frameworks, marking Brazil, besides Mexico, as one of the only countries with independent legal frameworks for both rural and urban lands (FAO, ABC/MRE & INCRA, 2022). Rural land, primarily used for agricultural purposes, is subject to specific federal regulations. Urban

[1] See: https://www.conjur.com.br/wp-content/uploads/2025/03/ATA-ADPF-743-1-3.pdf

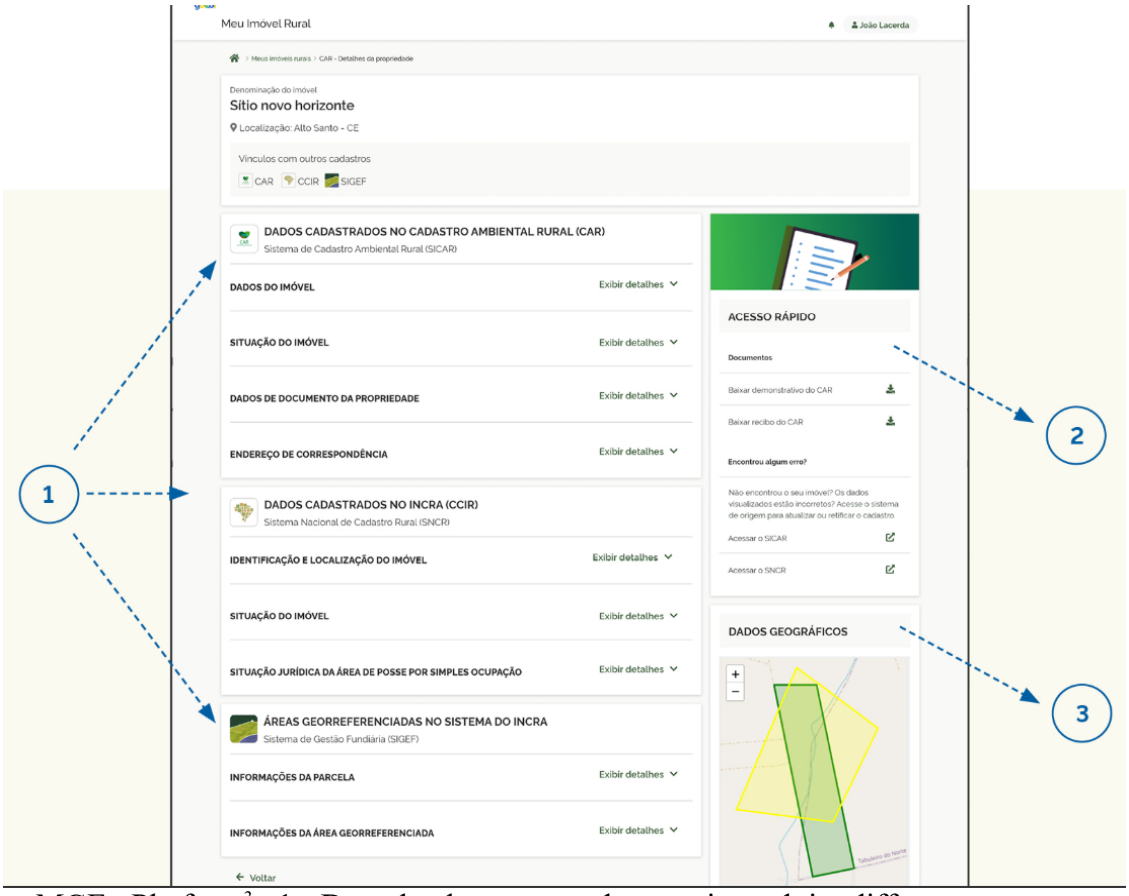
land falls under the jurisdiction of municipal authorities and is regulated through local planning instruments. Public land may be owned by federal, state, or municipal governments, while private land is held by individuals or corporate entities.

Brazil's land governance landscape is shaped by two major databases, the Cadastro Ambiental Rural (CAR) and the Sistema de Gestão Fundiária (SIGEF). Developed by the Ministry of Environment, CAR is a geospatial registry that maps land use and possession across rural areas. Although CAR plays a crucial role in environmental monitoring and planning, it is not legally linked to formal land rights. This has led to problematic situations where CAR maps are used as de facto evidence of ownership, even when mapped parcels overlap indigenous territories or protected lands. Furthermore, CAR mostly relies on crowdsourced data, which is often submitted without spatial validation, impacting data quality. It has been reported that data quality varies significantly across states, with some regions showing coherent data and others showing topologically inconsistent data with significant overlaps.

Launched by INCRA in 2013, SIGEF is a cadastral system that manages over 2 million land parcels, with more than 800,000 parcels linked to the land registry. It is publicly accessible and widely utilised, including by large corporations. The system's significance was underscored when it went offline for several weeks, prompting widespread complaints from across the country. Despite its importance, SIGEF faces low political prioritisation and is impacted by limited human and financial resources. Nevertheless, ongoing modernization efforts are underway, focusing on standardised data formats and enhanced interoperability to improve system efficiency and integration such as with the National Rural Cadastre System (SNCR)[2].

The Ministry of Management and Innovation in Public Services (Ministério da Gestão e da Inovação em Serviços Públicos - MGE), established 2023 plays a pivotal role in bridging the gap between distinct databases on properties Brazil by integrating information from SNCR, CAR and SIGEF, in a unified interface. The application was designed to simplify the management of these records for small and medium-sized farmers, as its goal is to provide easy, user-friendly and intuitive access to data and documents.

[2] See: https://geocracia.com/sigef-sncr-novo-sistema-de-regularizacao-de-imoveis-rurais-entrou-em-vigor/



Source: MGE, Platform[3]. 1- Download property data registered in different government databases, 2 - Download property documents, 3 - View CAR polygon and georeferenced area

Efforts to integrate are further fuelled by private sector actors who are increasingly pushing for better land governance. International buyers such as PepsiCo demand legal certainty in supply chains, as mandated by directives such as the EU Corporate Sustainability Due Diligence Directive (CSDDD). This creates market pressure for land regularisation.

Despite notable technical advancements in Brazil's land information systems, several institutional and structural challenges continue to hinder full integration. One major obstacle is institutional resistance, particularly from registrars and legal professionals who often oppose integration efforts, citing legal mandates and jurisdictional boundaries. Additionally, political instability—including budget cuts under previous administrations—has significantly weakened the operational capacity of INCRA who reportedly lost 40% of its staff leaving only 100 employees across 30 regional offices. The current administration is rebuilding capacity aiming to hire more than 700 new employees with the support of international donors such as the UK Foreign Office, the World Bank and GIZ. However, the next elections are in 2026, so the next year is critical for laying the foundations of reform before priorities may shift again.

Another critical issue is legal ambiguity. Conflicting laws and the absence of harmonised legal frameworks make system interoperability difficult, creating confusion and inefficiencies across institutions. MGE laid the foundation with a harmonised data platform creating a single point of information, but also showing overlapping land claims as well as conflicting institutional

[3] See: https://www.gov.br/gestao/pt-br/assuntos/meu-imovel-rural

mandates which require reform. Furthermore, the digital divide poses a substantial barrier: many rural communities lack reliable internet access and digital literacy, limiting their ability to engage with and benefit from digital land management tools. Especially for those communities who could benefit from adverse possession legislation, it remains often unclear how and where their legal claims are registered.
Looking ahead, the next one to two years are considered pivotal for laying the groundwork for an integrated and inclusive land administration system. Achieving this vision will require political continuity and sustained support, alongside legal reforms aimed at harmonizing existing frameworks. Capacity building at both municipal and federal levels is essential to ensure that institutions are equipped to manage and implement integrated systems effectively. Equally important is collaboration among stakeholders, including the state level as well as indigenous and traditional communities, whose participation is vital for equitable land governance.

5. DISCUSSION

Efforts to digitalise and integrate land management functions in Latin America face a range of complex and interrelated challenges. A key barrier is the legal pluralism and diversity of land tenure arrangements, which include both communal and private property systems. These coexist with varying degrees of formalisation and digital availability of land tenure data. Brazil, for example, still lacks complete cadastral coverage. In many countries, multiple land information systems operate in parallel, often without interoperability, further complicating efforts to unify data and processes, and thus preventing reliance on land data and associated land indicators as a basis for unified land governance objectives.
Land management responsibilities are also distributed across different institutions and levels of government. This creates a clash between territorial (area-based) and functional (topic, theme, or sector-based) mandates. Typically, land use planning is handled at the municipal level, while land tenure is managed at regional or national levels. Additionally, environmental or societal concerns connected to land tenure or land use planning may be the responsibility of sectoral ministries and associated lower-level organizations. Brazil and Mexico exemplify this complexity, with both countries maintaining separate legal frameworks for rural and urban land, creating complexities and uncertainties particularly in peri-urban areas. This legal disconnect poses significant obstacles to developing unified and integrated land (information) governance solutions (FAO, ABC/MRE & INCRA, 2022).

5.1 Integrated Land Management in Mexico and Brazil

Comparing Brazil and Mexico reveals that while developments are highly context-specific, both countries face similar structural challenges. Technology itself is not the main issue, land use and tenure data are largely available, but integration remains limited due to institutional fragmentation, legal pluralism, and uneven digital infrastructure. In Brazil, urban and rural land are governed separately, with cadastral and registration functions split across federal, municipal, and private entities. Mexico similarly divides land governance between ejido/communal lands and private property, managed by different institutions at various levels.
Over the past two decades, both countries have made significant strides in digitalisation. Brazil has developed systems such as CAR and SIGEF, while Mexico has initiated reforms through

the PROCEDE programme and, more recently, national modernisation strategies. However, issues with data quality, limited municipal capacity and digital divides persist, particularly in rural and peri-urban areas, hindering the full potential of these systems. Integration efforts are underway in both contexts, albeit at different levels. Brazil is capitalising on technology and enhanced processes, with a strong focus on data integration. This is evident in the Meu Imóvel Rural platform, for example, development in harmonised data modelling with LADM standards (Marra, 2024) and in the recent integration of SIGEF and SNCR. In contrast, Mexico is taking a legal and governance approach, paving the way for enhanced integration with programmes and strategies for national territorial planning and modernisation. These aim to harmonise data, improve interoperability and give citizens better access to land-related services.
As both Brazil and Mexico are experiencing rapid changes in both the formal and informal settlements, and have customary as well as formal tenure systems, managing land use and securing land rights legally and legitimately remains a major challenge. This also involves managing interests of large-scale investments and large-scale acquisition in land and setting proper restrictions for environmental concerns. Scenarios of land development need to rely however on proper land intelligence, i.e. which expansions are likely to happen and how this will affect or fundamentally alter current land claims, rights or interests. As Mexico has a strong separation in processes and institutional set-ups of land use planning and land administration, such land intelligence can act as a technical boundary object - uniting both systems despite their different operations. Showing scenarios of change and prioritizing or classifying land management options is a practical way of showing how land rights and land use are connected in the past and in the future. This does not need a major change in the legal framework as this largely exists already and is also perceived as adequate by the practitioners, neither does it require a fundamental change in the mandatory procedures. It ‘only’ needs additional technical and managerial capacity in designing and operating land intelligence systems. For Brazil setting up land intelligence effectively is probably different, as the institutional complexity is larger. Finding or deriving optimal land managerial solutions and scenarios will therefore yield multiple and comparable options, which will largely be dependent on local land tenure situations and land use planning idiosyncrasies. Nevertheless, the interviews with the Brazilian experts showed that there is no lack of informational expertise or technical infrastructure. Instead, constructing acceptable institutional and political imaginaries such as preferred or desired outcomes or priorities of land use or land ownership changes may be the biggest hurdle to overcome.

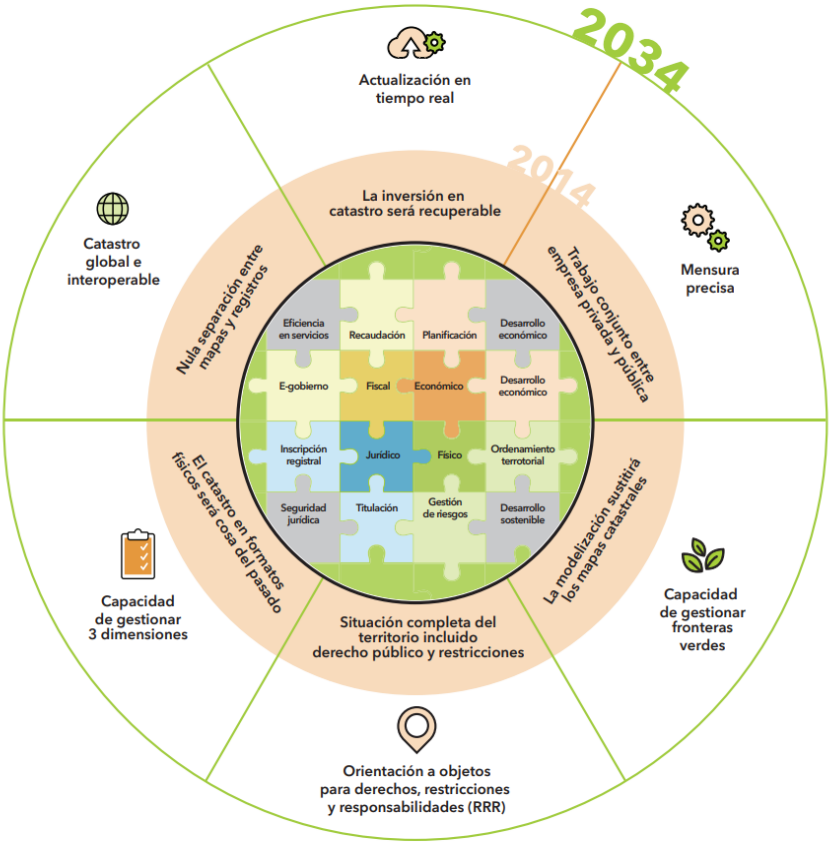
5.2 Evaluation of Use Case Examples

From a land governance perspective, the current systems in Mexico and Brazil are not effective in achieving spatial justice, land reform or land redistribution, or in selecting and restricting areas and owners of environmentally sensitive zones. Land tenure security in itself is not a necessary prerequisite for integrated land management and can instead be implemented alongside advancements in land administration systems including land registries and cadastral coverage. Strategies for the integration of various use cases of integrated land management are presented in the following.
The first example is land market control and land concentration assessment. The current institutional and informational systems in both Brazil and Mexico do not allow a rapid and transparent assessment of how much land remains in the hands of a few (individuals, corporates, of States - federal or regional or municipal). While an assessment of the total land distribution would require the complete digitisation and centralisation of land administration information,

an identification of the largest landowners and land purchasers per region does not require the complete digitisation of land register entries or the recordation of survey-grade parcel boundaries. Instead, it requires unique identifiers for (corporate) landowners and information on the corporate heads and global ultimate beneficial owners of directly registered entities. The reason is that corporate entities (legal persons) registered as owners often are controlled by corporations owning 51% of the shares of these registered entities. Ownership concentration assessments require new forms of collaboration between land registries and commercial or corporate registers. Yet, this function should be established alongside the digitisation and harmonisation of existing land registry entries. Otherwise, data architectures oriented towards land registration only will not be able to provide the necessary functions for iterative processes of identifying concentration dynamics and developing normative concentration measures and thresholds. The registers could not provide the evidence required for addressing or mitigating accumulation of capital and ownership as can be seen in Germany, where sanctions against undesirable landowners are practically impossible (see also Sommer & Vries 2023).
The other case example addresses the aspect of land rights restrictions. Reasons for lacking enforcement of land right restrictions against illegal activities cannot be discussed here in detail. Yet, an integrative land management approach can link registers and data bases that support public scrutiny and enforcement of restrictions, like public databases that validate sustainability certification and corporate sustainability reporting information. Again, the interconnection between land rights and land restrictions information can be developed alongside land administration modernisation like correct and granular identification of property boundaries, as long as information of the proximity to land conservation areas is registered and connected to landowner information. The accountability of landowners can be increased through two strategies: creating (spatial) data linkages between land use rights and property transfers and providing detailed information on property owners and the ultimate beneficial ownership of registered companies, as well as land rights restrictions stemming, for example, from land use or environmental protection instruments. And secondly, by increasing the efforts of identifying current owners in areas with ongoing illegal activities. Transparent and accessible land administration information in nature conservation areas or in areas with illegal logging activities could increase public awareness and support the integration of relevant information in corporate ESG ratings.

5.4 Future developments

FAO, ABC/MRE & INCRA, 2022, advocate integrated land management systems as a key requirement for future territorial development in the LAC region (based on a study developed through a collaboration between the Food and Agriculture Organization (FAO), the Brazilian Cooperation Agency (ABC), and the National Institute of Colonization and Agrarian Reform (Incra).) This study advocates modernization of the current systems by better integration, better electronic services and standardization of models. Cadastro 2034 is a visionary framework proposed for Latin America that aims to transform land administration systems into modern, inclusive, and interoperable platforms. Moving beyond traditional centralised models, it emphasises legal and institutional reform, digital transformation, and the development of a multi-purpose cadastre. The initiative envisions a technically robust, socially inclusive, and institutionally integrated system capable of supporting equitable development and adapting to the diverse territorial realities of the region. By aligning land governance with broader social needs and technological advancements, Cadastro 2034 seeks to empower communities, enhance transparency, and foster sustainable land use.



Cadastro 2034 - New vision and future roles of the cadastre in the LAC countries. Source: G. Álvarez in (FAO, ABC/MRE & INCRA, 2022).

6. CONCLUSION

The key objective of this investigation was to unveil the current status quo of digitisation and integrating endeavours in land administration and land use planning, rather than creating a theory, guidelines or framework of digital integrated land information management. In this paper, we focused our investigation on current practices and the daily work of practitioners, and how they operate (or can operate) within the current operational and institutional environments. The preliminary results show that in practice digitisation is a balancing act between internal and external forces on the one hand and gradually manoeuvring between what is technically possible and operationally feasible on the other hand. Internal forces hindering major transformations in day-to-day workflows concern vested interests of professional standards and practices, as well as internal territorial or functional mandates. External influences generally concern advocacy agencies with their own information systems and indicator systems which are largely incompatible with existing internal ones. Finding a middle ground requires thus finding a platform or organisation which is not perceived as a threat, major disruption of fundamental change of present mandates and workflow yet one which can be easily connected to existing (information) systems and adopted to ongoing workflows. Finding a good balance between what is desired and possible and what is practically feasible and achievable remains a major challenge. It often resembles playing chess on multiple chessboards, shuffling between

disjointed political, (inter-)organizational and (inter-) personal priorities. This process is slow, but necessary to make progress.
From a user or citizen perspective, there is not much interest in how public land information repositories are digitising or integrating, as it is often seen as a black box back-office system. Instead, they would be interested in how the adjustments of this system offer easier points of access (preferably digital and online), provide direct time and regulatory reductions and have better livelihoods.
We are obviously aware that relying on a small number of in-depth interviews and a relatively limited, yet crucial, amount of documented evidence does not generate a full picture and insight into current realities. Nevertheless, the vignettes we presented in this paper offer a first step towards more in-depth investigations into the nudging and adaptation efforts of practitioners towards better integration and digitisation. From the interviews, a picture emerged that practitioners in both land use planning and land administration are very aware of the potential of further digitisation and integration for their daily work and are therefore also looking for multiple informal ways of looking for pragmatic solutions - either in the form of modifications of the data models, or inter-organisational work flows and person-to-person networks. A further investigation should thus rely on a more longitudinal data collection and data analysis strategy, which can better map how information management processes change.
For any digitisation process to be successful in the long run, one can either opt for a radical change of government structures (disassembling all structures and starting a new one) or gradually adapting the existing ones. Given the gradual progress that has been made in both Mexico and Brazil, we argue that the gradual adaptation option is probably going in the right direction. Hence, changing existing institutions, or simply adding a new one with the integration or digitisation mandate in a principal-agent structure with existing institutions, is likely to be counterproductive. Instead, such an institution should act more like a neutral service-oriented platform enabling information exchange and integration. This will also avoid inter-organisational vested interests and politics. The information itself is not value-neutral, as it relates to organisational mandates and reductionist land information perspectives, but the sharing and exchange could be neutral, if all institutions are convinced of mutual benefits, both for themselves as well as for their customers/citizens. From a broader perspective on the governance of land information, it is important to start discussions on how to bring together territorial and sector- or theme-based mandates and the associated information collections.

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