A systematic literature review on blockchain-based titles registries for transparent land administration

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ABSTRACT

Traditional land registration processes in many countries are vulnerable and lack transparency, resulting in fraud, delays, and costs, especially in developing countries, and blockchain integration has been proposed as a potential solution in land administration systems. This paper addresses the challenges of the conventional system in its examination of this integration. Sweden stands out for its successful implementation of blockchain in land registry, owing to its advanced digital landscape. In contrast, developing countries such as Namibia face limited internet access, particularly in rural areas, which can hinder blockchain adoption. Georgia, Honduras, and Ghana have had success combating corruption through blockchain in land titling, while Kenya, Dubai, and several other countries are all actively exploring various blockchain applications in land administration. Despite its potential, this systematic literature review identifies a few challenges, such as identity verification, contract legality, co-ownership management, and adaptation to legal frameworks, that must be addressed before widespread blockchain implementation. The successes of Sweden, Georgia, Honduras, and Ghana illustrate both the potential and limitations of utilizing blockchain technology for land registry purposes. This study concludes that while blockchain's potential in land administration is evident, its realization requires careful consideration of legal, technological, and governmental complexities.

1 Introduction

According to Moerkerke (2017), a land title is a legal document that grants ownership rights to a property owner, who can use it and modify it how they see fit, or transfer interest or any portion that they own to others via a deed which is the legal document stating the rights of ownership. The title system goes together with the causal legal system and always results in several obligations for both the alienator and the acquirer when changing property ownership (Hendrik , Aart, & Jaap , 2005). For example, for every deed one must ask the question if the alienator is entitled to act as the owner and if they as well have the legal authority to sell the property.

According to Zimmermann (2008), effective public land management plays a crucial role in ensuring good governance in a country's land administration which is considered a

fundamental aspect that supports economic growth and sustainable development (Salfarina, 2011). The complexity of the subject requires professionals with experience in the matter to complete a widespread process that reflects the truth, at least as long as the parties involved are honest which indisputably indicates that the guarantees the traditional titles system should deliver such as transparency, timeliness, and accessibility are limited (Moerkerke, 2017).

This paper focuses on conducting a systematic literature review about the integration of blockchain technology in title registries for land administration and issues associated with the traditional system. The review aims to identify primary topics, evaluate the advantages and limitations of blockchain technology, and offer valuable insights for future research and practical application.

2 Methodology

The approach used in this study follows the guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) as discussed by (Moher, Liberati, Tetzlaff, Altman, & PRISMA Group, 2009). Figure 1 shows the adapted PRISMA flow diagram, which details the processes of study identification, screening, eligibility, and inclusion in the final analysis. This framework provides a systematic and structured approach to literature reviews, ensuring comprehensive reporting of findings while also increasing the reliability of results by defining key procedural steps.
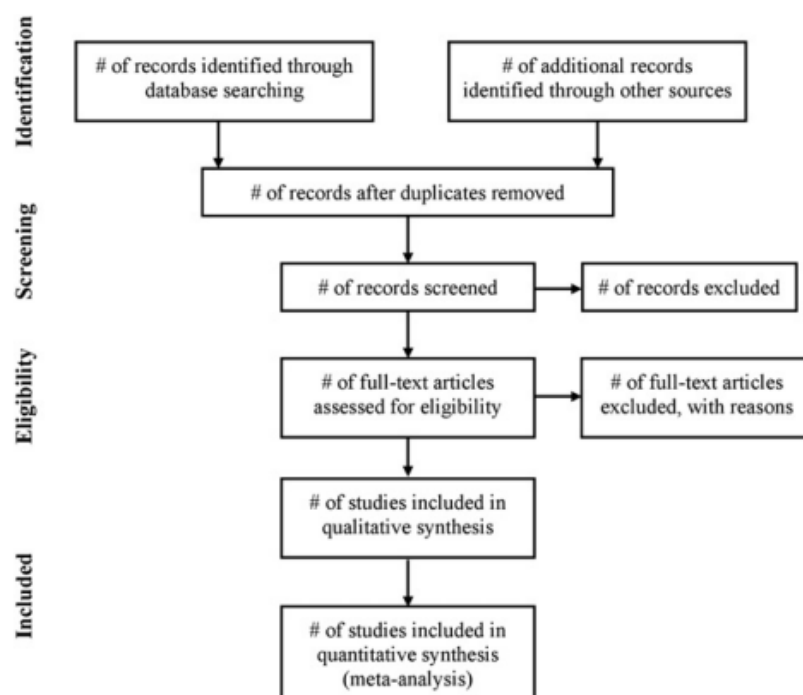

Figure 1 Flow of information through the different phases of a systematic review.

2.1 Research Questions

The following questions serve as a guide for determining the scope and focus of the review:

- o What are the key requirements and features that should be incorporated into a blockchain-based land titles registry to effectively preserve land rights?

- What are the different types of blockchain networks and their characteristics?
- How does the implementation of a blockchain-based land titles registry impact the timeliness of land transactions and the issuance of land titles?

2.2 Inclusion and Exclusion Criteria

The inclusion and exclusion criteria were established to identify studies relevant to the research questions following the PICOS framework outlined by Amir-Behghadami and Ali (2020). Since Blockchain is an emerging technology, with limited literature on its application in land administration systems, this study covered the review of various studies that discuss the design, implementation, and impact on land transactions dating back to 2008. Additional criteria were also set for the reviewed studies, they must be (1) a book or book section, published in journals or conference proceedings, (2) written in English and (3) have its complete text accessible in at least one of the utilized databases. The study excluded blockchain articles not related to land title registries, lacked details on features and practical uses of public, private, and consortium blockchains, and lacked empirical evidence on blockchain's impact on transaction timeliness in land title registries.

2.4 Search Strategy

The following online scientific databases were used for the study: Association for Computing Machinery (ACM), Central and Eastern European Online Library (CEEOL), Institute of Electrical and Electronics Engineers (IEEE) Xplore, ScienceDirect, SpringerLink, and Google Scholar. Researchers from diverse disciplines frequently utilize these widely recognized databases to gather relevant and credible information to support their studies. To ensure a thorough and impartial literature review, appropriate keywords together with Boolean expressions were utilized to combine terms and identify relevant studies from diverse databases and sources. A total of 185 papers were retrieved through the employment of the search criteria to discover studies pertinent to the objectives of the paper. The selected terms included "blockchain AND land administration OR titles solutions", "blockchain registry implementation AND transparency", and "blockchain networks AND land registries, OR land administration".

2.5 Data Extraction and Analysis

After retrieving studies that align with the search strategy criteria, a two-step process was employed to filter the studies. The initial step, abstract reading and skimming, entailed reviewing titles and abstracts, which led to the exclusion of over half of the studies deemed unrelated, including tutorials and duplicated titles. Most of the technical reports and online presentations were also not considered for review due to their absence of a peer-review process. The remaining studies underwent a second-level trimming by reading the whole article to assess their suitability for inclusion in this study based on their quality, leading to the inclusion of 23 studies for review. Figure 2 shows the distribution of selected papers over the publication years.
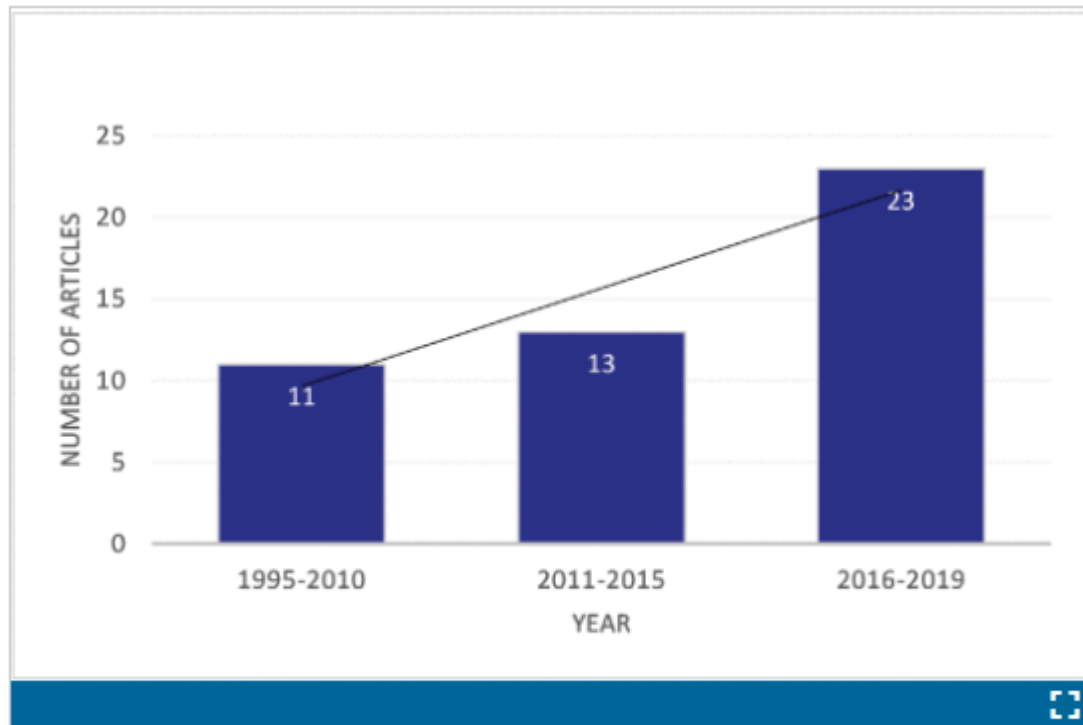
Fig 2 Distributed of selected papers over the publication years.

3 Literature review

This section provides an overview of challenges in traditional land administration, introduces blockchain technology, outlines blockchain solutions for land administration, and emphasizes the benefits and implications of using blockchain-based title registries.

3.1 Issues with the Traditional Land Administration System

As indicated by a training package on transparency in land administration by the Global Land Tool Network (GLTN) in 2023, weak governance has been identified as a primary factor contributing to corruption in land occupancy and administration in over sixty-one countries (GLTN, 2013). Numerous studies also show that most land in suburb areas of developing countries is undocumented or unregistered due to the frail titles data management system in place and the lengthy and excessive costs associated with property registration (Krishnapriya & Greeshma, 2020; Biraro et al., 2021).

The current land registration process in most countries contains lots of vulnerabilities and loopholes for fraud (Krishnapriya & Greeshma, 2020). Vinay et al. (2020) highlighted minimal transparency, accountability, delays, and costs associated with land registration as well as the incoherent data sets with different parties involved in an international journal of information management. Nir and Jeffrey (2018) agree with the previous researchers by testifying that it is common for government officials to alter titles of registered properties, and there are cases where government officials have allocated properties with altered titles to themselves, which can lead to uncountable title administration misdeeds.

In another far-reaching study by Nir (2018), a 2010 earthquake in Haiti left farmers fighting over land as all the municipal buildings that stored documents confirming land ownership were

destroyed. In his 2019 study, he conferred that various initiatives such as Blockchain have been undertaken in countries like Ghana, where 78 percent of the land is unregistered. Despite the initiative purveyed since 2014 by private actors like Bitland and BenBen, its effective output is yet to be seen and further results have not been published yet (GEORG , 2019).

3.2 Overview of Blockchain Technology

According to (Tiana, 2019), blockchain technology was initially introduced by Satoshi Nakamoto in the Bitcoin white paper as a decentralized time-stamp server operating on a peer-to-peer network. In his work, Satoshi presented the concept of "blocks" and "chains" as a means of organizing and securing records such that by using a shared database, entries could be verified as accurate and unaltered through mathematical proof. Müller and Markus (2019) describe blockchain as an ever-growing collection of interconnected records known as blocks that are secured through encrypted data exchange. In general, each block consists of transaction data, a timestamp, and a reference to the proceeding block. This guarantees a secure transaction in any untrustworthy environment as the blockchain network depends on the consensus algorithm, agreed upon by all entities involved in validating new transactions, making it very popular to apply in different sectors including land administration (Namasudra & Akkaya , 2023).

3.3 Blockchain Solutions for Land Administration

Several countries, according to Sladić et al. (2021), have launched (pilot) projects to investigate the applicability of blockchain technology in land administration. Brazil, Dubai/UAE, Georgia, India, Kenya, Ghana, Ukraine, Sweden, Honduras, and other countries have such projects. Driven by its dedication to augmenting and enhancing the transparency, security, and efficiency of its land registry system, Sweden has emerged as one of the innovators in adopting blockchain-powered land registry systems (Marinos, 2018). According to (Proskurovska & Dörry, 2022), Sweden's level of digitalization is among the most advanced in the Organization for Economic Co-operation and Development (OECD) countries. Coupled with its high internet penetration, this advanced digital landscape paved the way for the successful implementation of its hybrid public-private blockchain land registry solution. On the other hand, Namibia's digital divide and limited internet access, particularly in rural areas, might hinder the effective implementation of such a land registry system.

During the mid-2000s, the Republic of Georgia embarked on a mission to combat corruption in its land registry system (Qiuyun & Price, 2019). Through the utilization of Blockchain technology, the Georgian government aspired to take a pioneering role in bolstering governance, ensuring security, and reinstating public confidence in both institutions and government agencies. The pivotal role of Georgia's political stability and proactive approach to enacting legal and administrative reforms is evident in the success of its blockchain-based land titling system. In contrast, the Namibian government's hesitancy in this regard stands as a potential obstacle that could impede the achievement of a comparable solution (Ben & Scoones, 2010).

Similar to the situation in Georgia, where for numerous years, Honduras's public officials with malicious intent could infiltrate the land register and improperly alter property ownership records, the country had to adopt a blockchain-based land registry system (Marinos, 2018). This innovative solution was put in place to eradicate fraudulent land title activities and ensure a secure and streamlined safeguarding of property ownership records. Like in Georgia, the Honduran Government played a crucial part in establishing a strong system for land and property rights. This was achieved through the Land Registry Reform, backed by the World Bank, which introduced a modernized approach to title management (Colindres, Regan, &

Panting, 2016). By digitizing titles within a unified registry framework, this initiative laid the foundation for the effective adoption of their blockchain-based land registry solution.

The process of acquiring land in Ghana can be classified into two main categories: Customary land, which accounts for approximately 80% of the total land, and statutory or public land, which makes up the remaining portion (Donkor & de Vries, 2021). This adoption of a divergent approach to land acquisition leads to the emergence of multiple conflicts within the realm of land administration. In response to the aforementioned issue, Ghana has implemented the utilization of blockchain smart contracts as a means to digitize and protect land records. This implementation serves to enhance transparency and reduce conflicts about land ownership and transactions (Samuel & Tahiru, 2020). The successful implementation of this initiative in Ghana can be attributed to a comprehensive land tenure reform and a high level of commitment from the government. The complexities of land tenure in Namibia, as well as their historical contexts, have been examined by scholars such as Walter and Lewis (2009) as well as John et al. (2012). These studies highlight distinct differences, indicating the need for a tailored approach that extends beyond mere technological implementation.

Similar to Ghana, which shares a colonial history with Britain, Kenya maintains two central registries for all land-related data: the Nairobi land registry, also known as the Inland Registry, and the Coast Registry (Land Layby Kenya, 2018). In Kenya's historical context, the majority of the land was governed by community leaders through customary tenure systems. These systems were retained by the Kenyan government during the post-colonial era. Notably, the Kenyan government, as highlighted by the Land Layby Group, assumed direct control over community lands, resulting in conflicting land claims nationwide. This situation led to political and social unrest, displacing numerous individuals from their land and fostering an environment conducive to corruption and chaotic land registries. In contrast to developed countries like Sweden, where the primary aim of introducing blockchain into real property transactions is to enhance transaction speed, reduce costs, and minimize errors, Kenya has embraced blockchain technology to augment transparency in property dealings and combat corruption, a choice underpinned by the intrinsic immutability of blockchain technology (Sladić , Milosavljević, Nikolić, Sladić, & Radulović, 2021). Kenya's blockchain-based land registry operates on the Ethereum blockchain network, establishing a single, unmodifiable record of land ownership. Sladić et al. further note that while the ledger is publicly accessible, it incorporates multiple permission levels to safeguard specific transaction details, such as sales prices and sensitive personal information, ensuring their confidentiality.

Dubai, as one of the constituent emirates of the United Arab Emirates (UAE), has experienced significant growth across diverse economic sectors in recent times. This necessitated the regular modernization of conventional procedures to uphold efficiency and expediency, thereby safeguarding the nation's standing among potential investors (Bishr, 2019). The current economic expansion is bolstered by a robust and efficient government sector that has embraced technological advancements and is dedicated to upholding elevated standards of performance. The Dubai Land Administration has initiated various projects, including the "Blockchain in Real Estate Strategic Plan," which was introduced in October 2016 to facilitate real estate transactions by leveraging blockchain technology (Alsuwaidi, 2018). This involves the utilization of blockchain technology to effectively optimize the procedure of buying, selling, and transferring property titles, consequently mitigating the potential for fraudulent activities and conflicts. According to Alsuwaidi, the land administration in Dubai has implemented blockchain technology as a means to decrease the reliance on paperwork, remove intermediaries, enhance transaction efficiency, and establish

transparent transaction histories for all stakeholders. The adaptation experience of blockchain for land registry is claimed to be actively working well in Dubai by Graglia and Mellon (2018).

Graglia and Mellon (2018) correspondingly posit the existence of eight distinct theoretical steps that can be identified for the integration of blockchains into society. These steps range from the utilization of public blockchains for document recording to the eventual achievement of interoperability, wherein various blockchain-based registries are merged. Instances of the integration of blockchain technology in land administration can be observed at the primary level. Numerous nations, such as Brazil, have initiated the practice of documenting land transaction-related records and workflow processes by leveraging the Bitcoin blockchain to authenticate property sales and by utilizing smart contracts, to minimize the occurrence of fraudulent activities and errors for all data recorded within the decentralized ledger. Nevertheless, it is worth mentioning that the extensive implementation of blockchain technology in land administration applications within Brazil has not yet materialized, as observed by Krigsholm et al. (2019). The outcomes of ongoing pilot programs, including both existing and yet-to-be-implemented initiatives, will determine the future role of blockchain in land administration.

Some countries, Estonia being one of them, have successfully integrated blockchain technology into their land registers as a component of a broader e-government initiative aimed at running various governmental functions on a blockchain-based platform. Estonia is notable for its pioneering approach to digital governance, wherein blockchain technology has been extensively employed within its governmental infrastructure (Sladić , Milosavljević, Nikolić, Sladić, & Radulović, 2021). The Estonian government has developed an extensive infrastructure based on blockchain technology, encompassing various registries such as the business registry, property registry, health registry, digital court documents, and official announcements. Sladić et al. (2021) argue that this technological framework enables not only the effective identification of data modifications but also guarantees the utmost level of record integrity. The land administration system in Estonia is a prominent example of the utilization of blockchain technology. This system is effectively incorporated into the broader "e-Residency" initiative, which was initiated in 2014 through a partnership with Bitnation (Sullivan & Burger, 2017). Sullivan and Burger (2017) further stated that the primary objective of this system is to enhance the facilitation of secure and efficient land registration and management. The implementation of blockchain technology in Estonia has resulted in the optimization of its land registration procedure, leading to enhanced levels of transparency, security, and confidence in property-related transactions (Josip & Lenac, 2020). Josip and Lenac (2020) assert that Estonia's successful integration of blockchain technology into its government infrastructure, particularly in the domain of land administration, exemplifies the potential advantages of digital innovation in governance and the modernization of administrative procedures.

Vinay et al. (2020) as well as Bal (2017) noted that despite the considerable economic growth experienced by India in recent years, the land administration system in the country has traditionally been characterized by complexity and inefficiency. This has been attributed to challenges such as incomplete and damaged records. According to Vinay et al., the implementation of digitization of land records and computerization of property registration offices in most states has been successful. However, the computerized systems currently operate independently, without a reliable ecosystem for managing transactions and updating records. This is because various departments within the land administration system store their copies of records, leading to incomplete records. Andhra Pradesh, an Indian state, has partnered with ChromaWay, a blockchain-based startup, to address the aforementioned obstacles by

establishing a blockchain-powered land registry, following the examples set by countries like Estonia (Bal, 2017). The integration of blockchain technology as a backend, along with the utilization of a web application as a frontend, has facilitated enhanced data transparency for citizens. This implementation has effectively decentralized land registries to the village level, thereby contributing to the mitigation of corruption. In contrast to the prior centralized digital solution, this decentralized approach has proven advantageous by ensuring that small farmers are not disadvantaged in favor of large- and middle-scale farmers who benefited from the centralized system (Saari, Vimpari, & Junnila, 2022).

In Serbia, the Real Estate Cadastre serves as a vital register for property information, including data on ownership rights and the individuals or entities that hold such rights. Nonetheless, there are flaws in the current system's immutability and tamper-proof capabilities. As a result, data validation is heavily reliant on supporting documents (Stefanović, Pržulj, Ristić, Stefanović, & Vukmanović, 2018). Discrepancies in the land register and cadaster data are resolved in the absence of supporting documents by assuming the accuracy of the data stored in the land register (Sladić , Milosavljević, Nikolić, Sladić, & Radulović, 2021). This land register comprises cadastral records and maps containing two kinds of data: alphanumeric data about property transactions and geospatial data about cadastral changes. Although the presence of numerous blockchain networks and services, according to Sladic et al. (2021), does not currently adhere to a standardized method for encoding geospatial information, blockchain preservation has the potential to provide significant benefits to both types of data. As a result, the Open Geospatial Consortium has launched initiatives to address this shortcoming, and it is confident that exploring the potential of blockchain technology in geospatial data maintenance holds promise for future advancements, especially given its relatively early stage of development in the non-financial domain, Sladic et al. (2021) concluded.

Based on the evaluation conducted by the United Nations in 2020, Haneem et al. (2020) proclaim that Cyprus is one of the countries that has achieved a notably high E-Government Development Index (EGDI). Consequently, the blockchain initiative undertaken by Cyprus has the potential to enhance understanding and establish standards for other countries. The country has emerged as a prominent hub for academic research, education, training, and practical development of applications focused on fourth-generation technologies, specifically blockchain (Giaglis, 2018). Since 2014, the University of Nicosia has held the distinction of being the pioneering institution to provide a comprehensive academic curriculum centered on Blockchain technology. This program, known as the Master of Science in Blockchain and Digital Currency, has established the University of Nicosia as the global leader in offering such specialized education, Giaglis (2018) affirmed. Based on existing literature, it is evident that numerous pilot projects have been conducted to explore the application of blockchain technology in land registration. However, further advancements are necessary to fully harness the potential of blockchain as a means to document land interests. In this context, Cyprus presents a noteworthy prospect for leveraging blockchain technology to facilitate the establishment of peace on the island (Yapicioglu & Leshinsky, 2020). Yapicioglu and Leshinsky (2020) also assert that further investigation is necessary, specifically regarding the potential applications of side chains in documenting conflicting land interests and contested land ownership assertions.

In 2019, a project based on Distributed Ledger Technology (DLT) was launched in Afghanistan by UN organizations (UNOICT and UN-Habitat) in collaboration with the LTO Network and the Afghan government. This project was launched after these stakeholders signed a memorandum of understanding (Kaczorowska, 2019). Its primary goal was to promote the development of cities that are inclusive, secure, resilient, and sustainable. By December

2020, the UN announced the creation of a new digital land registry dedicated to informal urban settlements within Afghanistan's Ministry of Urban Development and Land. This registry aimed to address the issue of secure land rights, which is a major source of conflict in the country. The hybrid blockchain platform LTO Network was used for this endeavor, which includes both a public blockchain network and a suite of tools that allow users to create private chains within the network. This platform, known as 'goLandRegistry' was created to manage property records on the blockchain, including at least one million individually registered land parcels, as well as the issuance of occupancy certificates. However, Shah et al. (2023) expressed reservations about the viability of the 'goLandRegistry' solution, citing Afghanistan's formal land administration system's limited capacity. This limitation highlighted the reliance of all such deployments on governance capacity that Afghanistan lacked. Given that approximately 80% of the Afghan population lives in rural areas, Bustamante et al. (2022) expressed similar concerns and argued that simple, community-based information recording using basic technology can often provide greater certainty in land registration within local communities.

In another far-reaching case, both Niloy et al. (2022) and Alam et al. (2022) emphasized the significance of land as a valuable asset in densely populated developing countries like Bangladesh. Consequently, investing in land assets has emerged as the most prudent means of deploying capital. Nonetheless, Niloy et al. (2022) argue that acquiring land is a time-consuming process due to the necessity of extensive communication among buyers, sellers, and various government agencies to secure the requisite documentation and approvals. On the contrary, Alam et al. (2022) put forward that the primary issue with the current system lies in the fragmentation of information across multiple government offices that lack synchronization, creating opportunities for corrupt bureaucrats to modify legal documents and assert false ownership claims. These authors, along with Islam et al. (2020) and Biswas et al. (2021), have proposed blockchain-based solutions as a remedy to these challenges. These solutions promise data synchronization, transparency, accessibility, and the management of immutable records, all accomplished swiftly and cost-effectively. Among these proposals, LANDCHAIN stands out, as it automates the land administration process while upholding security and transparency standards. According to Niloy et al. (2022), LANDCHAIN's lightweight nature facilitates effortless deployment and automatic scalability. The model has undergone testing on the Ethereum Virtual Machine (EVM), demonstrating superior reliability, security, efficiency, and scalability compared to conventional database management systems (Shithy, Pipash, Elme, & Mahmud). Consequently, LANDCHAIN not only addresses existing land administration issues but also aids the government in optimizing the processes identified by Niloy et al. (2022).

Over the years, countries with limited land areas have invested substantial funds in land reclamation projects. However, some countries, like Japan, have undertaken even larger land reclamation undertakings (Stefanović, Pržulj, Ristić, Stefanović, & Vukmanović, 2018). Japan has been at the forefront of blockchain-based developments, including pioneering blockchain assessment methodologies and forms. These innovations mark the first attempts to evaluate blockchain-based systems while considering their compatibility with existing systems and comprehensibility. Furthermore, Japan has conducted extensive surveys on blockchain technologies, collaborating with universities and research institutes to explore the potential applications of blockchain in various sectors, including land administration (Haneem, et al., 2020). According to Müller and Markus (2019), Japan had plans to migrate its state-owned real estate databases onto a blockchain platform, which would encompass proprietary and sales data. The initial testing phase was scheduled for 2018. In a parallel effort, González (2018) identified Japanese companies that have been actively involved in the creation of a public system for land transactions since 2018, with notable participants being the Nomura Research

Institute and Fujitsu. Lastly, Müller and Markus (2019) claim that Japan's long-term goal is to merge all of its local government agencies' property registers and real estate companies' databases into a single blockchain database.

According to Haneem, et al. (2020), South Korea's government is a global leader in providing online services, with the highest EGDI value in Asia. However, Veeramani and Jaganathan (2020) highlight that, despite service modernization, there is still a lack of transparency. To address this issue, e-governance requires a robust underlying technology that ensures record integrity and effectively eliminates corruption. This explains why the central and local governments of South Korea have actively embraced blockchain technology, positioning the country as a potential leader in the blockchain market (Soomin, et al., 2022). For instance, in 2020, the Ministry of Science and ICT and the Korea Internet Security Agency (KISA) selected 24 companies to launch ten blockchain-based pilot projects worth up to 5.3 million US dollars. One of these initiatives, as reported by Soomin, et al. 2022), took place in the Ministry of Land, Infrastructure, and Transport, with a specific focus on documentation and certification processes. This innovation meant that citizens no longer had to endure the time-consuming bureaucratic procedures of visiting multiple offices and navigating various steps to secure a mortgage for the purchase of a home.

Following the country's independence in 1960, Nigerians, like those in many other African countries, took control of the management and governance of the country's territories and resources (Ibrahim, Daud, Azmi, Noor, & Yusoff, 2021). Land management systems in Nigeria, like those in Kenya, remained largely unchanged from the colonial era during the early years of independence, with the state taking charge of land administration as a public service. This approach, however, has been hampered by a slew of challenges and limitations, exemplified by the country's lack of formal, documented, and registered land titles (Obamehinti & Eguavoen, 2022). As a result, a sizable portion of the population is denied access to secure land titles, as well as the economic opportunities and potential benefits associated with land title utilization and trade. As a result, researchers have been investigating potential solutions, with many pointing to blockchain technology. All of the aforementioned authors have emphasized the benefits of blockchain over the traditional land titling system in Nigeria, which could serve as a solution to the land title issues if adopted. It is also noteworthy that a study conducted by Omole, et al. (2019) using a pragmatic approach to understand the perspectives of Nigeria's professionals regarding their awareness, acceptance, feasibility, and readiness to embrace innovations in land administration revealed that there is an awareness level exceeding 50%, complete acceptance, and a readiness level exceeding 95%. However, the study predicts that the technology will take 5 to 10 years to become mainstream, but this timeline may vary depending on regulatory developments and technological advancements.

An example of a government that is progressively adopting blockchain technology to address common challenges in land administration is Ukraine. The country is incorporating blockchain technology into the State Land Cadaster as the second pilot project in the public sector, starting in September 2017 (Bachynskyy & Radeiko, 2019). This system records all cadaster transactions systematically on the blockchain, following a predefined algorithmic protocol. Government support is vital for the adoption of blockchain technology, as emphasized by Ansah et al. (2023). Christopher et al. (2019 additionally suggest that early adopters of blockchain technology typically have greater political stability, which is crucial for safeguarding the system against potential cyber threats, as explained by Graglia and Mellon (2018). Unfortunately, the blockchain land registry project in Ukraine encountered significant challenges due to political unrest, primarily stemming from Russian interference. These disruptions ultimately led to the project's abandonment during its early stages, as documented

by Konashevych (2020). Nevertheless, Graglia and Mellon maintain that a glimmer of hope remains for the Ukraine project, as they speculate that Bitfury's involvement, given its prior experience in implementing blockchain technology for land rights registration in Georgia, could lead to its revival. Moreover, Bitfury's skilled Ukrainian programmers are well-positioned to enhance government operations within the e-government system, potentially paving the way for the project's recovery and future success.

In Germany, Müller and Markus (2019) cite several difficulties in the country's land transfer process, including its complexity and lack of transparency, which can take 5-6 months to complete and result in a 6-8-week delay between intention and transfer. Bureaucratic procedures involving paper documents further slowed the process. Müller and Markus (2019) propose using blockchain technology to upgrade the electronic land registry to address these issues. This could reduce the process time by 1-2 weeks, improve security with digital signatures, prevent document loss with decentralized data management, and increase transparency. Similarly, Müller and Markus (2019) note that the British Land Registry is eager to investigate blockchain technology and envisions that implementing blockchain for registration could result in a government-backed property guarantee. Beznosov et al. (2021) also identified the United Kingdom as a global leader in the use of blockchain technology for land management, citing the successful Digital Street project. This initiative allows buyers to acquire properties almost instantly and allows the Land Registry to maintain more comprehensive and detailed data records.

In their publication, Muller and Markus (2019) also shed light on Russia's stance on the integration of blockchain technology into land administration. According to their 2019 report, Russia intends to investigate a Blockchain-based land registry system, with a test planned for later that year. The Ministry of Economic Development and the State Cadastral and Cartographic Organizations are collaborating on this project. According to the Russian government, such a system could significantly reduce the operational costs associated with land registration. The project's administrators plan to evaluate the results of the initial pilot project later that year to determine whether to proceed with the full-scale implementation of the Blockchain-based Land Registry system.

The inaugural IBM Blockchain Innovation Centre, established in partnership with the Singapore Economic Development Board and the Monetary Authority of Singapore (MAS), stands as a pioneering hub for the start-up of blockchain projects spanning diverse sectors such as finance, cross-sector partnerships, education, and supply chain management (Haneem, et al., 2020). In Singapore, the Land Registry serves as the custodian of a comprehensive land register, acting as the primary and authoritative repository of land ownership information. It is critical to understand that registered land titles take precedence and can only be challenged under certain predefined conditions (Ooi, Peng, & Soh, 2022). The Singaporean government has proactively implemented digital signature legislation, eliminating the need for handwritten signatures in real estate transactions. This legal framework is supported by a transparent ledger that is accessible to all relevant stakeholders (Rohaidi, 2019). It is also worth noting that China has emerged as a major investor in land reclamation projects in Asia, particularly in the use of blockchain technology for e-government. According to Heng (2017), land administration is an integral component of national land policy in China, exerting significant influence on both economic development and societal stability.

According to a report on the size of the blockchain market, the United States, specifically North America and Canada, accounts for approximately 40% of the global blockchain market (Grand View Research, 2021). Additionally, in 2018 a survey conducted by PricewaterhouseCoopers (PwC) (2018) identified the United States as the current leader in

blockchain technology. Further research into how the United States is adopting and utilizing blockchain technology revealed that the city of South Burlington, Virginia, has launched a pilot project in partnership with the Propy blockchain startup. This pilot project is viewed as a possible step toward using blockchain technology to replace the city's real estate registration system. Similarly, in collaboration with the retailer Overstock, the state of Wyoming is actively incorporating blockchain systems into regional governance, particularly within the land registration mechanism (Beznosov, Skvortsov, & Skvortsova, 2021). Müller and Markus (2019) reported in 2022 that the Chicago Cook County Recorders of Deeds (CCRD) piloted the use of blockchain registries for real estate. This project investigated the integration of physical properties with digital assets in approximately 2,000 vacant properties in Chicago. Along with the CCRD, the International Blockchain Real Estate Association (IBREA) worked with the startup company "Velox.RE" on this project.

3.4 Advantages of Blockchain-Based Titles Registries

Blockchain has evolved from its initial conception and is now utilized to store records across a wide range of systems including land administration systems (LAS) (Stefanović, Pržulj, Ristić, Stefanović, & Vukmanović, 2018). Even though the potential for implementing the entire LAS on the blockchain remains a subject of ongoing debate, Stefanović et al. highlighted that certain processes could surely benefit from the implementation of blockchain technology's inherent characteristics like its distributed ledger, immutable record of transactions, and speed through smart contracts. Both (Kaczorowska, 2019) and (Borse, Ahirao, Chawathe, & Patole, 2022) agree with Stefanović et al. that the underlying distributed ledger technology of blockchain holds the potential to revolutionize land registration systems by leveraging its secure architecture and cryptographic protocols to provide numerous advantages such as enhanced trust, improved processing efficiency, and cost reduction. A study by Shang and Price (2019), distinctively discusses the benefits of blockchain-based title registries such as improved efficiency, security and transparency of land administration Georgia is reaping from the more dependable Ethereum blockchain land registry. According to an estimation of Swedish government project partners, Sweden which is the most advanced country regarding the integration of blockchain in land registry, the system will save the government 106 million US dollars annually as it eliminates paperwork and speed up transactions.

Moreover, Müller and Markus (2019) highlighted key goals for implementing blockchain in land administration: faster transactions, automated change notifications, enhanced transparency and security, and digital contract archives.

3.5 Implications of Blockchain-Based Title Registries

Despite all the benefits, Sweden and Georgia's blockchain land registries can only serve as a blueprint for other countries due to different ICT infrastructures, laws, and land reforms about land issues per country. In 2020, UN-Habitat, OICT, and LTO Network announced the release of an open-source land registry solution slated to debut in December 2020 in Central Asia (UN-Habitat & OICT and LTO Network , 2020). Even with this magnificent effort, like the previously discussed solutions, this solution must be further built or customized based on countries' specific land laws and policies.

Rosa (2020) conducted an in-depth investigation into the potential hurdles blockchain technology poses, focusing on issues like verifying participants' identities, ensuring contract legality due to the lack of independent verification of the transactions, dealing with co-ownership and property rights in smart contracts, and evaluating the feasibility of changing blockchain records. This is important because legal frameworks can sometimes enable property

ownership changes or modifications to rights without prior owner consensus, under certain circumstances.

4 Discussion

Traditional land registration processes in many countries are vulnerable to fraud due to inherent vulnerabilities and a lack of transparency. This challenge is exacerbated by the delays, costs, and lack of accountability associated with land registration, particularly in developing countries. Blockchain initiatives have been launched to address these concerns. Notably, Sweden has emerged as a pioneer in the adoption of blockchain-based land registry systems, owing to its commitment to transparency, security, and efficiency. Sweden's success in implementing a hybrid public-private blockchain solution can be attributed to its advanced digital infrastructure and high internet penetration. However, countries such as Namibia face challenges due to limited internet access, particularly in rural areas, which could stymie the effective implementation of public blockchain-based land registry systems.

Georgia is a success story in using blockchain to combat corruption in its land registry system. Political stability and a commitment to legal and administrative reforms were critical to its successful implementation.

Similarly, Honduras collaborated with the World Bank to implement blockchain, digitizing titles within a unified registry framework to eliminate fraudulent land title activities.

Ghana's adoption of blockchain technology addresses conflicts in land administration caused by complex land tenure systems. Government support and a commitment to land tenure reform were critical to its success.

Kenya uses blockchain on the Ethereum network to improve transparency and reduce corruption in its land registry, particularly in community-led land governance contexts.

Dubai's initiatives, such as the "Blockchain in Real Estate Strategic Plan," demonstrate the city-state's commitment to modernizing real estate procedures and reducing fraudulent activity.

Estonia stands out for its extensive use of blockchain technology in government infrastructure, including land administration, resulting in increased transparency and confidence in property transactions.

In India, Andhra Pradesh's adoption of blockchain aims to simplify land administration by providing data synchronization, transparency, and immutable records, ultimately reducing corruption and inefficiency.

Afghanistan's project to create a digital land registry using hybrid blockchain technology focuses on securing land rights in informal urban settlements, though challenges remain regarding the capacity and governance of the formal land administration system.

Bangladesh is investigating blockchain-based solutions to address land administration issues such as information fragmentation and corruption, with LANDCHAIN providing a lightweight and efficient solution.

By migrating real estate databases onto a blockchain platform, Japan hopes to modernize processes, improve security, and increase transparency.

South Korea actively embraces blockchain technology in e-governance, reducing bureaucratic procedures and increasing citizen convenience in documentation and certification processes.

Nigerian professionals demonstrate a willingness to embrace blockchain-based solutions for secure land titles and economic opportunities while addressing land administration challenges.

Ukraine's adoption of blockchain in its State Land Cadaster aims to reduce operational costs associated with land registration, with success dependent on political stability and government support.

Germany proposes using blockchain to improve its electronic land registry to address complexity, transparency issues, and document-based delays. Similarly, the UK's Digital Street project aims to create government-backed property guarantees using blockchain.

Russia is investigating blockchain-based land registry systems to reduce operational costs, but political stability and external factors may have an impact on their success.

In the United States, particularly in North America and Canada, various pilot projects in states such as Virginia and Wyoming reflect efforts to investigate blockchain applications in land administration.

Singapore's advanced land registry system, along with digital signature legislation and transparent ledgers, serves as a model for efficient land administration. China invests in land reclamation projects while researching blockchain technology for e-government.

Blockchain-based title registries provide benefits such as distributed ledgers, immutable records, and smart contract efficiency. However, due to differences in ICT infrastructure, legal systems, and land reforms, Sweden and Georgia's successes cannot be directly replicated.

The challenges include participant identity verification, contract legality, co-ownership management, and adapting blockchain records. Future research should focus on addressing these challenges to develop holistic solutions that can accommodate complex legal frameworks.

In conclusion, blockchain technology has the potential to transform land administration by increasing transparency, efficiency, and security. Different countries have faced distinct challenges in their approaches, necessitating careful consideration of legal, technological, and governmental factors to realize their full potential. The successes of Sweden, Georgia, Honduras, and Ghana highlight both the possibilities and limitations of using blockchain for land registries.

5 Conclusion

This paper provided an overview of the literature on integrating blockchain into land administration title registries, alongside traditional system issues.

Traditional land registration's vulnerabilities and lack of transparency, particularly in developing nations, have prompted blockchain adoption as a solution. Successful instances in Sweden and Georgia showcase blockchain's transparency, security, and efficiency benefits, combating corruption and fraud. These models inspire but also reveal the need for context-specific strategies due to varied ICT infrastructure, legal systems, and land reforms. Challenges like participant verification, contract legality, and co-ownership management require focused attention for comprehensive integration. While blockchain's potential in land administration is evident, its realization depends on careful consideration of legal, technological, and governmental complexities.

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