Blockchain in Land lease and Mortgage Management System: Benefits, Trends, and Challenges

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Abstract. The Land lease and mortgage management system (LLMMS) is the crucial part of land administration, since it is essential for investment, resource allocation and economic growth of any developed or developing country. However, LLMMS has problems like fraud vulnerability, inefficiency, and a lack of transparency. By digitizing land records, although efficiency was enhanced however, problems like double-spending, centralized databases, and manipulation were not resolved. Further issues with traditional lease and mortgage administration systems are complexity, mistakes, and a lack of real-time confirmation. Due to frequent, minute-by-minute events like document verification ,land transfers, acquisitions, and leasing/mortgaging transactions, there is currently a large volume of data generated that can be categorized as big data. In this regard, Blockchain-based LLMMS provide distributed data management in addition to addressing the problems of alteration and double-spending in conventional systems. Using knowledge from previous studies, this analysis explores the integration of blockchain with the traditional LLMMS in order to offer a thorough grasp of the opportunities, problems, and potential solutions that can resolve the existing issues.

Keywords: Landlease , Mortagage , Blockchain, Decentralization

1 Introduction

1.1 System Overview

A land lease system refers to a legal agreement where the land owner (lessor) sells a right to the other party (lessee) to use the land within a given time frame, to pay periodical lease payments, but does not part ownership of the land. It starts with the establishment of a lease agreement which explicitly stipulates the lease term, rent or lease fee, allowed land usage, and rights and liabilities of both parties. When the agreement is concluded, it will then be registered by the relevant land or government authority and official land records adjusted to indicate the lease. As the lease is running, the lessee pays periodic payments and utilizes the land per the terms agreed. The regulatory authority or lessor can oversee compliance to make sure that the land is not used illegally. The agreement can be renewed at the expiry of the lease period with new terms, or it can be returned to the owner, and the lease comes to the formal finish [1].

A land mortgage system operates by enabling the landowner (borrower) to visit a lender (may be a bank) that can provide them with a loan and keeping the land

S. Bhalerao et al. (eds.), *Proceedings of the 2nd International Conference on Recent Advancement and Modernization in Sustainable Intelligent Technologies & Applications (RAMSITA-2026)*, Advances in Intelligent Systems Research 207,
https://doi.org/10.2991/978-94-6239-678-4_27

as a security. Once the lender confirms the ownership and legal documents, the value of the land is evaluated and a loan is approved with agreed terms of interest rate, tenure and schedule of repayment. A deed of mortgage is then drawn and registered to the relevant authority which gives a legal charge on the land. The borrower proceeds to use the land in the whole loan period as he/she is making regular payments. When the borrower pays off the loan the full loan is discharged and the charge levied on the land discharged. Yet, the lender legally can seize the land or sell it to get back the loan in case the borrower defaults [2]. Fig 1 shows the conventional Land Lease and mortgage system.

Land records, which have been digitized in the past ten years, have made the transactions more efficient; yet, they do not resolve issues of manipulation, the centralized databases featuring one point of failure, the participation of users, transparency, and the elimination of double-spending [3]. The inefficiencies in the traditional lease and mortgage management system, absence of transparency and vulnerability to fraud have been persistent. The large section of sub units (departments) is autonomous and this presents the problem of information redundancy and inaccurate data. The property can be transferred to too many parties that is attributed to the absence of real time data confirmation process. Therefore, there is duplication of expenditure. One issue that stands out as being persistent in most transactions is that legitimacy verification of property ownership and in the same manner that of the authority of the concerned parties is a slow process.

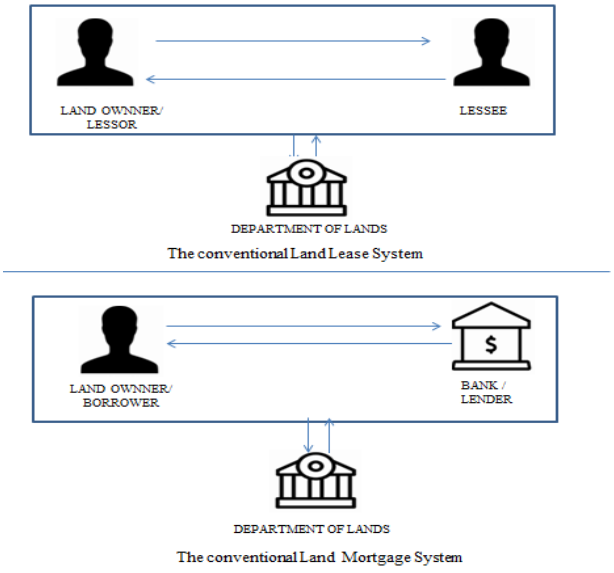

Fig. 1. Conventional Land Lease and Mortgage system.

1.2 Challenges in LLMMS

1. Inefficiencies and Lack of Transparency: The traditional land lease systems suffer from lack of transparency and inefficiencies, which results in disputes and underutilization of land [4].
2. Complexity and Fraud: The LLMMs systems suffer from intricacy of lease agreements and their vulnerability to fraud. By adopting the technology like Blockchain can help address these problems.
3. legislative and Policy Barriers: The absence of a thorough legislative framework for mortgage financing of land contractual management rights is one of the major barrier of all issues related to LLMMS[3]. The lenders, this has made it more difficult to get mortgage security.
4. Limited Financing Channels and High Risk: Financial institutions face difficulties because of the limited financing channels .In addition there is high risk involved in mortgage financing of rural land. This has made it necessary to investigate novel funding schemes and risk-reduction techniques [5].

2 Related Work

Various digital and conventional technologies have been employed for land and mortgage systems before the adoption of blockchain technology. However, these technologies frequently failed to guarantee transparency, confidentiality, and immutability despite their best work to digitize documents, expedite procedures, and increase accessibility like Centralized Databases, Geographic Information Systems (GIS), Relational Database Management Systems (RDBMS), Web-Based Portals, Artificial Intelligence (AI) and Machine Learning (ML), Natural Language Processing (NLP).

The key features of blockchain technology enabled it to completely transform the administration, recording, and transfer of property ownership and transactions has attracted a lot of interest in the fields of land registries and mortgage systems. Lam and Lee (2020) [6] suggested a system with decentralized land registry and used Hyperledger Fabric, a private blockchain network, so as to increase security and control. This permissioned blockchain, saves critical data of land ownership while guaranteeing transparency. As per the study, access permission setting can be made on private blockchains, which can be important for governance and legal compliance.

M. B. Nirmala et al. [7] proposed a blockchain-based land registry system using Ethereum platform that uses smart contracts .The system could manage property transfers , record land ownership**.** It also ensured that once a transaction is validated, it becomes tamper-proof part of the blockchain ledger.
To solve acceptance problems, Solanki et al. (2021) [5] proposed hybrid models that integrate blockchain technology with conventional land registries. The research emphasizes how hybrid solutions can be used to preserve blockchain's benefits, such transparency and immutability, while allowing smooth integration

with legacy systems. Kumar et al. (2022) [8] emphasized on the integration of smart contracts with mortgage repayment systems. Via their system monthly payments are taken out of a borrower's account automatically and applied to the loan's interest and principle. This low downs the possibility of administrative burden and missed payments. Gonzalez et al. (2022) [9] explained the use of Delegated Proof of Stake (DPoS) to increase blockchain systems' scalability for mortgages and real estate. By choosing a group of reliable delegates and without compromising security , DPoS makes it possible to quickly generate blocks .

Another work suggested by R. Sidharthan et al. [10] for decentralized document storage is the integration of blockchain with the InterPlanetary File System (IPFS)**.** The authors proposed a distributed ledger–based land transaction system in which large land documents are stored off-chain in IPFS, while cryptographic hashes are stored on the blockchain. Their contribution highlights how this hybrid approach improves scalability, reduces storage costs, and ensures document integrity while maintaining tamper-proof land records.

Laila Junaid (2024) [11] suggested a blockchain-based architecture that incorporates user involvement, transparency, immutability, and the avoidance of double-spending into mortgage and lease procedures .In her work Laila Junaid used Ethereum blockchain with smart contracts for lease and mortgage and also ensured user involvement by involving all stakeholders: landowners, banks, and financial institutions. In addition ,it implemented double-spending prevention by validating if a property is already leased or mortgaged before processing a new request. A comparative study of all the blockchain based technologies used for LLMMS is shown in table 1.

Table 1. Comparison of different Blockchain based technologies used for LLMMS

S. No	Technology/Approach	Work Done / Application	Key Features	Limitations
1	Blockchain-Based Land Registry	Blockchain based land registry system to prevent fraud and duplicate ownership	decentralized verification , Tamper-proof records	regulatory hurdles , Integration with legacy databases
2	Blockchain with Smart Contracts (Ethereum)	Use of Ethereum smart contracts to automate land transfer and registration	transparency , no intermediaries , Immutability, automation	high gas fees ,Scalability issues, legal recognition challenges
3	Consortium / Private Blockchain	Consortium blockchain for departmental coordivation	Controlled access, consistent records across departments	partial centralization ,Coordination overhead

4	Permissioned Blockchain (Hyperledger Fabric)	Use of Hyperledger Fabric for securely sharing land records among government agencies	Access control, privacy, high throughput	less decentralizatio n , multi-party governance required
5	Blockchain + IPFS (Decentralized Storage)	Combined blockchain and IPFS to secure document integrity	Scalable document storage, reduced blockchain load	complex in retrieval ,Dependency on IPFS availability
6	Blockchain + Digital Identity (DID)	Integrated land ownership verification with decentralized identity	Strong owner authentication, reduced impersonation	Privacy challenges

3 Benefits of Blockchain in Land Lease and Mortgage Management

Blockchain technology has become a viable way to deal with the problems associated with managing mortgages and land leases. The efficiency and security of land administration systems can be improved by Blockchain, which offers a decentralized, transparent, and unchangeable record of transaction [12, 13].Under a blockchain-based system of land administration, ownerships, lease and mortgage deals are stored as irrevocable digital records minimizing fraud, inaccurate records and unauthorized alterations (Fig 2). The blockchain is decentralized and, as such, removes the importance of one central authority, raising the degree of trust among the stakeholders, including land owners, government agencies, banks, and courts. Smart contracts also contribute to efficiency because processes such as the transfer of ownership, enforcement of leases, and release of mortgage under specific conditions are automated to reduce delays and human interference. Moreover, it is possible to combine blockchain with such off-chain storage as IPFS and ensure the safe processing of extensive land documents without losing the integrity of the data.

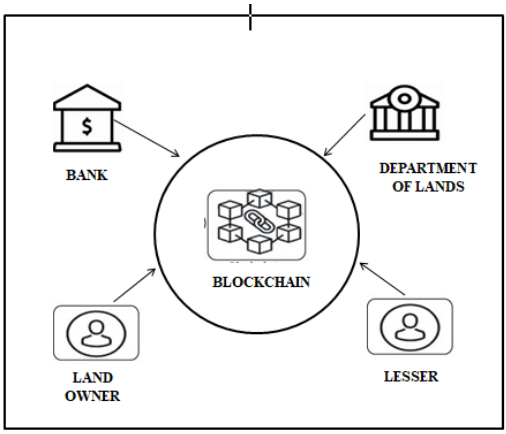

Fig. 2. Blockchain based LLMMS

The benefits of implementing the Blockchain technology in mortgage and land lease administration include the following:

- Improved Security: In the light of the decentralized design of blockchain , transactions and land records are not susceptible to hacker attacks and manipulation [14].
- Higher Productivity: Land lease and mortgage dealings consume less time and cost since the process of automation through smart contracts and distributed data management reduces these costs.

- Transparency and Immutability: Blockchain reduces the fraud and conflicts risk as all transactions were stored in an unchangeable and transparent way.

- Smart Contracts: Terms and conditions can be tracked without involving the middlemen by automation of lease and mortgage contracts through smart contracts on Blockchain [15].

- Distributed Data Management: Blockchain represents the distributed ledger technology, which can be used to safely and effectively administer land records by preventing cases of double-spending and ensuring real-time validation.

Table 2. Recent trends of Blockchain based LLMMS in different countries

Country / Project	Blockchain Platform	Application	Key Features	Drawbacks / Challenges
Sweden	ChromaWay (Private)	Real estate & mortgage transfer	multi-party validation ,Smart contracts, digital workflows	high onboarding cost ,Limited scalability,non-public blockchain

Georgia	Private ledger + Bitcoin	Land title registration	public audit trail ,Cryptographic timestamping	partially decentralized ,Much dependency on external notary (Bitfury),
India (Andhra Pradesh)	ChromaWay (pilot)	Land registry & lease	Fraud prevention, tamper-proof records	Needed significant infrastructure, slow public sector adoption
USA (Vermont , Propy)	Ethereum-based	Property transfers, mortgages	Smart contracts, tokenized titles	Requires Ethereum gas fees , legal interoperability not clear
Ghana (BenBen)	Proprietary Blockchain	Land transaction system	secure access ,Land digitization, analytics	Centralized elements, lack of local awareness and adoption
Colombia (Pilot)	Ethereum (public)	Land title and registration	ownership auditability ,Immutable public ledger	Issue of Technical illiteracy, digital infrastructure required
China (BOC, ABC)	Private Consortium Chain	Mortgage processing	valuation system ,Full automation, fast settlement	permissioned ledger limits transparency ,Not interoperable with foreign systems

4 Major Challenges and Future Research Directions

Digital or blockchain-based land leasing and mortgage management systems have several major barriers to their implementation. One of the most significant issues is institutional and legal issues, since digital records of lease or blockchain-based lease are not formally legal in most countries, limiting their adoption and enforceability. The quality and consistency of data is a significant challenge; haphazard and ill-kept land records do not allow taking the full benefits of automation and digitization. New systems offering maximum transparency raise privacy concerns, too, because they pose a risk of exposing confidential and sensitive mortgage information to a third party [16].

In the future research, one must focus on a couple of things. Interoperability standards that cut across the borders should be designed to allow the smooth management of mortgage and land systems in most of the countries. Research should also address the ethical use of AI models, namely in ensuring equity and transparency in the definition of eligibility to a mortgage. Moreover, to make digital leases and blockchain-based records of mortgages publicly recognized and approved within jurisdictional systems, the changes in regulations must be involved. In order to ensure that more people and

regions have equal and full access to the advanced land and mortgage management systems, it continues to be important to come up with cheap, expandable technology that will serve regions with fewer resources.

5 Conclusion

The land lease and mortgage management are very important in the effective utilization of land resources and the development of economic growth. One of the innovative technologies is blockchain, which presents new opportunities in terms of further development, and older systems face challenges such as inefficiency, absence of transparency, and high risks. To facilitate a sustainable development and management of land resources, the stakeholders can enhance the security, transparency, and efficiency of land leasing, and mortgage management systems using Blockchain-enabled frameworks.

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