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Current Status, Requirements, and Challenges of Blockchain Application in Land Registry

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ABSTRACT

The land registry system is one of the crucial aspects of any government. Proper and reliable land management is essential for economic growth and governance. The traditional land registry model lacks many essential requirements and is mired with a different type of malpractices and security concerns. Blockchain technology has been proposed as a possible solution to counter these malpractices and security concerns. Even though there are many advantages of using blockchain in the land registry, still there are some concerns and challenges that need to be reviewed and addressed for successful blockchain implementation in the land registry. This paper reviews the current state of blockchain implementation in the land registry and the existing project being implemented in different countries. It further highlights the requirements, implications, and challenges for successfully implementing blockchain in the land registry system. This paper provides a future direction for new implementations.

KEYWORDS

Blockchain, Land Registry, Land Transaction, Record Management, Security

INTRODUCTION

A survey conducted by the world bank states that almost 70% of the people do not possess the land title Weizsäcker et al. (2019) Heider and Connelly (2016). However, the land title is an essential part of the economy and necessary element for citizens' social and economic aspects. The land registry system transfers land ownership that protects the stakeholder's rights, increasing trust and confidence.

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Due to poor coordination between various departments, land title verification requires a physical visit, making it time-consuming and often encourages bribery Krupa and S (2019) B (2018).

The country's available land record system is unclear, mismanaged, and failed to show reality. The other significant land record systems' other significant issues are availability and maintenance and did not guarantee ownership Krupa and S (2019) Thakur et al. (2020). The probable ownership, the transfer of property from generation to generation is not recorded in the land registry system appropriately Panchapagesan (2018). By incorporating land-related information into blockchain, identifying the property can be hastened besides providing the security, trust and accuracy of land transfer by al- lowing every stakeholder the digital tracking of each transaction Krupa and S (2019). It would reduce the expense and time of the land transaction without the intervention of a third party. Themistocleous (2018a) Vos (2017),. Blockchain technology has many advantages like distributed trust, timestamping, shared database and validity of transactions that make it very much suitable for land registry system im- implementations Underwood (2016)– Kempe (2016a). Many blockchain-based land registry systems have been proposed and implemented to counter the limitations of existing land registry systems by different countries like Brazil Allison (2018), Canada Brennan (2020), Ghana L and Bates (2016), India Vari- yar and Bansal (2017), Georgia 975 (2017), United Kingdom Birchall (2018), United States Mirkovic (2019), Honduras Anand et al. (2016), Inc and Inc (2018), Switzerland Wisekey (2019) etc.

The blockchain technology can be used in different domain of land registry like digitisation of land records Pongnumkul et al. (2020) Veeramani and Jaganathan (2020) Matai et al. (2020) Ali et al. (2020), land transaction Kumar et al. (2020) Mashatan and Roberts (2015) Avantaggiato and Gallo (2019) Huh and Kim (2020) Shuaib et al. (2020), peer to peer land trading Madhurya et al. (2020) Norta et al. (2018) S and Sarath (2020), record management Shinde et al. (2019) Ramya et al. (2019) Sahai and Pandey (2020) Thakur et al. (2020), ownership protection Yapicioglu and Leshinsky (2020) Joshi et al. (2020) Kumar and Rohith (2020) Konashevych (2020) Krupa and S (2019) Nandi et al. (2020). Even though there are various advantages of blockchain implementation, there are still a few limitations and considerations in adopting blockchain technology in the land registry system. These limitations need to be taken into consideration while making a legal, secure and reliable land registry system which are consensus on the legal ownership is a pre-requirement condition Barbieri (2017), Portability and interoperability Morena et al. (2020), Mehdi (2020) Legal validity of a digital signature Mcmurren et al. (2018), Verifying the ID of the stakeholders in the land registry system Garcia-Teruel (2020) and Non-compliance with identity or self-sovereign identity principles Mehdi (2020). Ekmekci (2019). To further incorporate blockchain technology in the land registry. This paper highlights the issues while implementing blockchain technology in the land registry, which must be addressed while implementing blockchain-based land registry system. The main contributions of this paper are as follows:

- To identify the pre-requisite for successful blockchain-based land registry.
- To highlight the domains of the land registry where blockchain is applied.
- To study the various blockchain implementation in land registry domain in different countries.
- To find the challenges of applying blockchain technology in the land registry.

The article is organised as follows. Section 2 provides a brief review of the land registry system and the limitations of the current land registry system. Section 3 provides a literature review of blockchain-use in land registry systems and pre-requisite of blockchain adaptation in the land registry. Section 4 provides a detailed explanation of the blockchain application in various domains of land registry. Section 5 provide a detailed review of different land registry project currently undergoing in different countries. Finally, section 6, presents the challenges of blockchain application in land registry system and lastly concludes the paper.

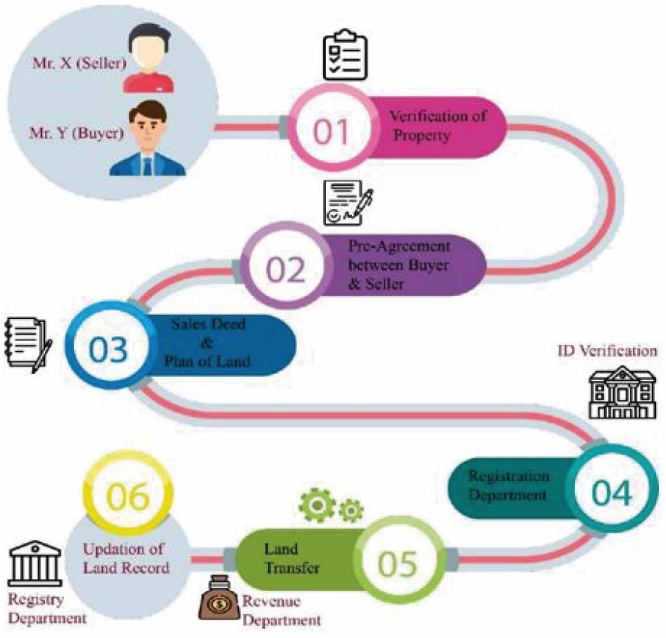
LAND REGISTRY

Process of Land Registry

The updating land record occurs for every piece of land sale or purchase by registration of deeds. The land registration system is divided into two-part,' Deed registration' and' Title registration.' During the deed registration process, the contract is executed between parties and is updated with the registrar's office. However, the deed registration serves as a proof of transaction for every piece of land sale or purchase. The land ownership transfer process contains lots of small steps and conditions to initiate the next step in the process. The process of the land registry has been depicted in Figure 1:

1. Firstly, the legality of the transaction is verified. If the grantor has clear ownership for transfer, then the transfer of the right is initiated.
2. The sale agreement between the seller and the buyer is generally done; generally, the buyer gives the token money to the seller while signing a deal.
3. The buyer pays the registration fees online or offline to the treasury and accounts department.
4. The deed is written on stamp paper. Moreover, the money is transferred from the buyer to the seller on his/her bank account. Further, a drafted deal is approved by both parties in front of two eyewitnesses.
5. The drafted deal is submitted to the registrar's office. The registrar performs the identification seller & buyer and mapping of the property. If all check is successful, the finalised registered deed is collected by the buyer.
6. After getting the original registered title and other necessary documents, the buyer applies to modify the and records at the concerned city/state's land revenue office.
7. The land revenue officer records the statement from both sides and matches with the provided documents. Then it announces inviting any objection. After that, modification is done if no-objection is received.

Figure 1. Land registry



Limitations of Land Registry

The government is struggling to keep land records and to provide up-to-date information. Different departments are monitoring and updating district and village land records. Moreover, poor departmental coordination among department leads to non-synchronised information, resulting in inconsistency and incompatibility. Below are the shortcomings of the existing system of land registry:

- **Centralised control:** The central framework of land registry authorities promotes fraud and corruption. Each Land Registry Department runs independently, resulting in the department's update an obsolete for another Mukne et al. (2019). The buyer reviews the location, coordination and past mortgage history of the property manually, making it more complicated and more prone to theft and the loss of information Krupa and S (2019) Castellanos and Benbunan-Fich (2018) Abhishek (2019).
- **Less secure:** The centralised land registry system creates concern regarding the attack and corruption. It consists of unreliable, sensitive, critical documents, which results in instability to control the system Abhishek (2019) Mehendale et al. (2019b). Moreover, the Land Registry accuracy is a big issue since the documents are not well coordinated Lemieux (2017).
- **Lack of transparency:** There is a lack of transparency in transactions such as lease, purchase and sale in the current land registry system. Additionally, it does not guarantee the security of land record and their validity Lemieux (2017).
- **High time complexity:** In the conventional property registry, property management includes several conceptual phases, including housing evaluation, document compilation, document execution, main contract execution, money transfer and registration, making the entire process complex and ex- pensive Mehendale et al. (2019b).
- **Ownership issue:** There is no established land registry system between the various departments. Land records are kept at the district and village level and need to be appropriately synchronised, re- resulting in differences between land records and fact. Besides, many users claim ownership of the same property. Kumar et al. (2019) Thakur et al. (2020) B (2018).
- **More transaction cost:** Transaction costs in the property market are related to inaccurate knowledge on hidden costs of products Miller and Pogue (2018) Mehendale et al. (2019b) and regulations Cerutti et al. (2015).
- **Third-party involvement:** Many individuals, including mediators, land inspectors, lawyers, notaries and officials are involved in the traditional land registry process, which leads to higher cost, complications and delays Kumar et al. (2019).

BLOCKCHAIN IN THE LAND REGISTRY

Blockchain Types

Satoshi Nakamoto introduces blockchain technology in the research paper titled "Bitcoin: A peer-To peer election cash system" Nakamoto (2008). A blockchain consists of a distributed database contain- ing records or a public database of all the transaction and events among the involved parties within the network Crosby et al. (2016). Blockchain consists mainly of two key features. The first one, blockchain, is public. Anyone within the network can view it. It remains on the network, not with any organisation that can take a price to hold a managing of record. Secondly, the blockchain is encrypted to guarantee security for the public and private keys. A blockchain act as a linked-list in which each block store the hash of the previous block. These hash make it impossible for an attacker to modify the data Miraz and Ali (2018).

Public Blockchain

It allows everyone to build, change and validate the block by tracking and updating data using transactions between participating entities. It is possible to identify which blocks are added to the

blockchain. The real status of a particular plot of land is a matter for the public. This type of blockchain is given in Figure 2 (a).

Private Blockchain

Private blockchain allows only approved participants to alter and create transaction within the ledger, although Reading permissions can be restricted or public. It is given in Figure 2 (b).

Hybrid Blockchain

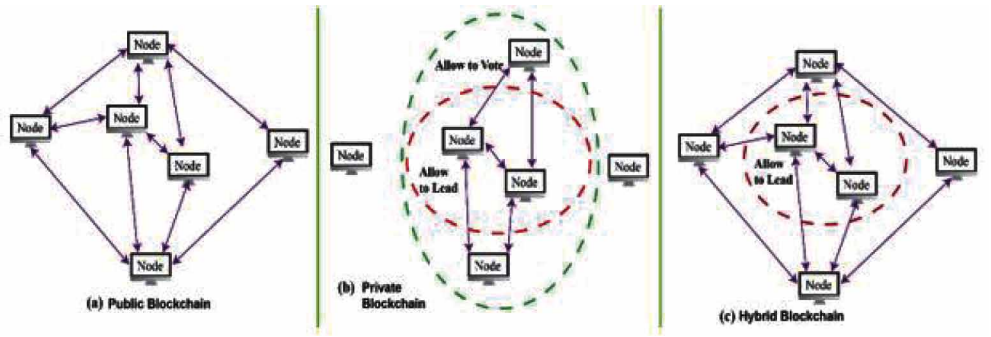
These blockchain models are a mixture of public and private blockchain models that create a balance between these two attributes. Its permissions every node to participate in a consensus mechanism but allows only a few to create a new node explicitly specified for this purpose. This type of blockchain is given in Figure 2 (c).

Characteristics of Blockchain

The blockchain concept contains the following characteristics:

- **Shared database:** In the Land Registry system, one source and one backup database are commonly used. The blockchain is a decentralised ledger which is shared across multiple databases.
- **Several writers:** Each transaction is stored in a blockchain inside each copy of the database. The land registry system records the land transaction and updated into one system; this copy is recorded into the backup system.
- **Distributed trust:** The current land registry systems are where the administrator is trusted, making it pointless to trust the copy database administrator.
- **Disintermediation:** Anyone can keep a copy of the database and make a transaction on it. In the current land registry systems, reliable third parties also update a registration.
- **Timestamping:** In the Blockchain, record or transaction creation and the modification time are securely controlled. And nobody, not the document's owner, can change the document after it's registered, ensuring the timetable facility's credibility.
- **Transaction validity:** Blockchain can check that the transaction is valid to prevent unauthorised transactions. The Trusted Third Party checks transaction validity in conventional land registry systems.
- **Validation:** Blockchain records any sequence of authenticated transactions. It is a public ledger that is unalterable. All transactions are part of a ledger in current land registry systems and validated through an audit trail.
- **Scalability:** Blockchain can be extended easily. Anyone who wants to upload a transaction can do it.

Figure 2. Types of blockchain system: (a) Public blockchain; (b) Private Blockchain; (c) Hybrid blockchain



Advantages of Blockchain in the Land Registry

The decentralised system for recording land registration will eliminate mediators' role, decreasing the time and cost of the process besides fostering trust between the transacting parties. Recording property rights through blockchain will help in annual cost savings and provide a tamper-proof ledger book. It will also assist the judiciary in settling most of the civil cases related to property. The benefits of using blockchain in land registry system are summarised in the following points:

- **Transparency:** Every node has a complete overview of transactions and holds a history of the transactions that can be visible anywhere and anytime Underwood (2016).
- **Increased trust:** Trust build due to immutable recordkeeping and data verification at multiple nodes Fairfield (2015)– Mehendale et al. (2019a).
- **Increase predictive capability:** History stored at multiple nodes can be traced back, which increases predictive capability N (2018).
- **Reliability:** Data is stored in multiple places in the blockchain-based system. Consensus mechanisms ensure that information only changes when all relevant parties agree Krupa and S (2019), N (2018).
- **Increased control:** Consensus mechanism to add transaction increases the control over the database Zyskind et al. (2015).
- **Cost reduction:** Cost decreases as no human third party is involved in conducting and validating the data U and Ølnes (2017), Tapscott and Tapscott (2016).
- **Reduced energy consumption:** Increased efficiency and transaction mechanisms through the network, reduce energy consumption Tapscott and Tapscott (2016), Tapscott (2016).
- **Security:** Data is stored at multiple systems using encryption methods that stop the data from being altered without proper authentication Gervais et al. (2016)– Kempe (2016a).
- **Ease of access:** Information stored at multiple nodes, enhances easy and speedy access P (2015).
- **Privacy:** The information is secured from secret surveillance. Users need private keys or access mechanism to ensure that the information is safe from unauthorised view N (2018), Abhishek (2019).
- **Reducing corruption:** Distributed ledgers storage allows them to prevent land ownership corruption due to the secure and reliable transfer and change of ownership records Themistocleous (2018b), Kshetri (2017).
- **Error reduction:** Automated transactions reduce the chance of human errors N (2018), Cai and Zhu (2016).
- **Data integrity and higher quality:** The originality of the data is maintained since it cannot be easily accessed by hackers or unauthorised users N (2018), Abhishek (2019).

Pre-Requisite of Blockchain Adoption in the Land Registry

While some blockchain technology, in theory, has several positive effects on the land registry process, alternatively, the requirements must also need to be addressed. Thus Graglia and Mellon Graglia and Mellon (2018) list seven requirements for effective blockchain land registry.

An Identity Solution

Current identity management systems do not incorporate blockchain. They, therefore, do not have the requisite KYC regulatory checks.SecureKey in Canada may be the only national ID scheme built using blockchain. Even, it needs to be included in the blockchain land registry trials. It makes absolutely no sense for those operating on blockchain-based registry systems to enforce the new digital ID pre-requisite as this would significantly restrict eligible participants. Instead, an existing identity system must be accepted for several purposes. An established identity management system will lead to better awareness and greater blockchain acceptance in the land registry. The existing identification system is much easier than just creating a new one for the land registry. It is because

identity management is a separate skill set, resulting in greater awareness of consistency through the use of an established system.

Registries Must Be Digitised

Blockchain operates on a computer algorithm to ensure the input information is correct. This algorithmic system is termed as hashing, in which everyone wants the same digital information in the same format to be validated. There is probably no way to generate a hash for a paper document, but perhaps a paper document and hash can be scanned.

However, due to minute copy variations, every scan of the same hard copy would have a different hash from the original. Because hashing enables blockchains to minimise document modification, no paper or digitised document produces a single verifiable data version. Consequently, every registry must be completely digitised before the incorporation of blockchain. Interestingly, Sweden and Georgia have digitised their land registry systems completely.

Multi-Signature Wallets

Current blockchain databases are available via a private key, known to the property's real owner, often stored in a secure online wallet. Problems arise when a particular user's private key or wallet is stolen, lost, misplaced or manipulated by a third party. The encryption used in blockchain guarantees that only the associated key holders can register or transfer property. It means that there must be some way to recover a key-related property in the event of a failure. One solution may be several signature wallets that require testing the minimum number of keys before the transaction is completed. A private blockchain system can also enable the registrar/notary to sign the transaction.

Private or Hybrid Blockchain

Blockchains may be public ledgers, private ledgers, or a combination of two. In the public chain, only two willing parties accept transactions with their public keys. If fraudulent data are regularly entered and identified, the only remedy is another transaction that corrects the previous entry. In the public chain, it is difficult to address land ownership imposition problems in events such as legal proceedings and inheritance. Decisions may be tracked in a private hybrid chain accessible only to registered officials, while hashes of key documents may be reported in the public chain to ensure their validity.

The decentralised structure of public blockchains ensures that the storage space is only limited to a total of combined network computers. The registries shall contain deeds, names, maps, plans, etc. All documents must be preserved somewhere as Public blockchains are unable to hold too much data. The solution is to store records on a dedicated server and to post relevant hashes on a blockchain. If a blockchain-based data record is required instead of the associated hashes, registries may use a private blockchain to handle very demanding data storage requirements. Public blockchains allow anyone with the right keys to broadcast valid transactions, regardless of who or what they are. A private blockchain is important to ensure that only the parties who have verified their identity are satisfied with the authorities' transactions.

Accurate Data

The blockchain's merits are immutability, so it is important to ensure that the blockchain's data is correct. All current registers, whether digital or paper-based, contain inaccuracies. However, the registry should be cleaned and updated before an immutable platform is constructed. Furthermore, when a registry is cleaned up, there is a risk of disputes creating transitional problems over the years.

Digital Registries Require Connectivity and a Tech Aware Population

Blockchain in land registry adoption needs to address costs and support requirements for adopting a digital platform. The initial response may be that such increased costs make the project unattractive. However, the counterpoint is that certain possible maintenance costs need to be minimised with a

new system. Blockchain technology is complex, and hardware requirements are significant. It is not easy to assume that the majority of public institutions can meet these additional responsibilities. While we can see servers being used and software provided on a contractual basis in the future, the registry authorities still bear the ongoing costs of hiring network experts. Network maintenance and troubleshooting costs will be shifted to blockchain providers. In jurisdictions where access is limited, or consumers are dissatisfied towards online transactions, blockchain-based registries are not suitable.

Train the Professional Community That Interacts With the Registry

It is necessary to engage professional groups that communicate with the blockchain registry early.

For example, lawyers need to consider several issues, including how blockchain documents are pre- sented and interpreted and how the rules of proof are consistent with blockchain output. The blockchain's basic principles, skills, and terminology must first be trained to do all these things. While the blockchain registry's technical and structural requirements are clearly presented, a substantial amount of work remains to be done in the form of education and capacity building. Without that, it becomes impossible to incorporate the blockchain.

APPLICATION AREAS OF BLOCKCHAIN IN LAND REGISTRY DOMAIN

Blockchain technology in the land registry will provide transparency, integrity, and security in the land registry system. Also, it will reduce the cost and time for the land transaction without involving a third party. The blockchain technology can be used in different land registries, like digitisation of land records, land transaction, peer to peer land trading, record management, and ownership protection. Table 1 shows the application areas of blockchain in different land registry domains.

Land Transaction

Real estate is a perfect target for blockchain technology, as it has a complex transaction system designed to prevent fraudulent activity and provide strict ownership protection. Blockchain is used to increase transparency by providing infrastructure that allows regulators to collect and prevent fraudulent activity. Blockchain architecture enables immutable record creation, which is not possible with conventional electronic or paper records. Transaction costs can include search costs, land transfer costs, valuation costs, legal fees, official fees, registration fees, certificate fees, notary fees Mountain (2018). Although a blockchain framework does not eliminate all transaction costs, It will simplify the process and automate key elements, that would significantly reduce processing time and cost Spielman (2015).

Record Management

The management of land registries is a key element of land governance, including preparing the record of right (ROR) by surveys, mapping the land plots, the registry of deeds during transfers and the preservation of various forms of land-related records Saif and Hawlader (2018). The biggest issue with the new system is that information is divided between multiple government departments without synchronisation. Fraudulent people can change legal documents. Distributed ledger technology (DLT) like blockchain will solve this issue which makes falsifying by any node or group of nodes incredibly challenging Suciu et al. (2018). The land transition records are stored in a distributed ledger that prevents the system from randomly changing the record and avoiding fault. All records in blockchain are secured by proof of existence Lemieux (2016). However, in each phase of the Land Registry, the blockchain provides security and integrity of the saved record by timestamping.

Peer to Peer Land Trading

A blockchain is comparable to a distributed database that automatically tests for hash values in the form of cryptographic digests Gaetani et al. (2017). It supports electronic peer-to-peer transaction

of commercial property trading Eshuis et al. (2016). Blockchain can increase liquidity, minimise risk, and reduce costs, making real estate investment more favourable. Registration officers or other third parties involved in land trading profit from customers' money wishing to sell the property. The offline way to start a land transaction also leads to the issue of double-spending. Blockchain helps minimise third- party involvement by providing a safe transaction timestamp, which can be stored in the blocks and Sarath (2020). The smart contract on blockchain manages all the detail regarding the transaction, e.g. what is saved, who saves it and who settles disputes. With the use of blockchain, people can trade property without an intermediary on the internet Spielman (2015), Mohanty (2018). In Blockchain-based land registration system, the revenue department can access land title data, including land registration, changes in registration, and record of land ownership, calculate stamp duties, registration charges and collector rate, and update the contents of registrations.

Ownership Protection

Property ownership of land must be clearly registered and defined. There are several disputes of land ownership in legal systems. It is the responsibility of designated advocates to have clear ownership and is issued as a title certificate. Many countries worldwide need intermediaries to verify their transfer of ownership. A corrupt system may also generate several forges and duplicate papers for the same piece of property Nandi et al. (2020). Blockchain technology tackles land ownership trade-offs to tackle these problems. Blockchain technology can reduce the expense and usage of trusted third parties such as notaries, banks and government agencies Konashevych (2020). Incorporating ownership and use of registrations in the blockchain would explain property ownership and eliminate illegal transactions. It will also improve land management and transportation and increase the country's GDP. It will also help reach sustainable development goals (SDGs) Hughes et al. (2019).

BLOCKCHAIN-BASED LAND REGISTRY PROJECTS IN DIFFERENT COUNTRIES

Various Land registry authorities and country are gaining attention to adopt the blockchain technology to the process of land registry. However, BC technology has several applications since 2016. Below are the early adopter's countries using BC Technology to their land registry system. Country-wise land registry project and involved government entities have been summarised in Table 2:

- **Brazil:** A pilot project has been started by a Brazilian real estate register named "Cartorio de Registro de Imoveis" in collaboration with startup company "Ubiquity" to use blockchain technology to store land registry blockChain. This project addresses cadastral zoning, and owner details, followed by mapping with blockchain-based on Colored Coins protocol. During the first phase, the project is being tested in two Brazil municipalities, Pelotas and Morro Redondo, to make land registers and transactions 100% paper-less and transparent. Initially, a parallel system is developed with the current land registry system, and then all records are moved to a blockchain-based system Allison (2018).
- **Canada:** The Blockchain Land Titles and Survey Authority is currently collaborating with the Digital Identity and Authentication Council of Canada (DIACC) and Identity North (IDN) on initiatives to use Blockchain technology for the land transaction and record management throughout Canada. The project aims at analysing the legal and regulatory complications, the functionality of Blockchain in BC Land Titles and Survey Authority. In this aspect, the University of British Columbia launched a project to examine the numerous problems and issues associated with blockchain's land registry application Brennan (2020).
- **Ghana:** In Ghana, more than 80% of landowners are without title deeds since the majority of the land trade is with oral agreements. The Bitland Land Registry System is a partnership between Ghana and Bitland's. Bitland is a non-profit organisation using blockchain to address property-

Table 1. Review of application areas of blockchain in different land registry domains

Ref	Year	Land registry domain	Technique used	Blockchain platform	Blockchain type
(Pongnumkul et al., 2020)	2020	Transactions & record management	Smart Contract	Ethereum	Private
(Yapicioglu & Leshinsky, 2020)	2020	Ownership disputes	Sidechains	NA	Public
(Joshi et al., 2020)	2020	Property ownership	Consensus mechanism	Ethereum	Private
(Konashevych, 2020)	2020	Property rights	Consensus mechanism and smart contract	Private Blockchain	Private
(Arun Kumar & Rohith, 2020)	2020	Ownership right	Markel hash tree	NA	NA
(Krupa & Akhil, 2019)	2019	Real estate ownership	Smart Contract	Ethereum	Private
(Alam et al., 2020)	2020	Title Management	Smart Contract	Ethereum	Hybrid
(Nandi et al., 2020)	2020	Ownership disputes	Smart Contract	Ethereum	Private
(Veeramani & Jaganathan, 2020)	2020	Digitalisation of the land registry system	Smart Contract	Hyper ledger Fabric	Private
(Shinde et al., 2019)	2019	record Management	Smart Contract	Ethereum	Private
(Gupta et al., 2019)	2019	Land property administration	Markel Patricia Tree and SHA256	Ethereum	Private
(Madhurya et al., 2020)	2020	registration system	Smart Contract & SHA256	Ethereum	Public
(Ramya et al., 2019)	2019	record Management	Hash value & Consensus mechanism	Multi-chain	Public-private
(Sahai & Pandey, 2020)	2020	registration management	Smart Contract	Ethereum	Public
(Kumar et al., 2020)	2020	transaction	Smart Contract(buyer seller protocol)	Ethereum	Public
(Mashatan & Roberts, 2017)	2017	transaction cost & time	Colored coin	NA	NA
(Matai et al., 2020)	2020	Digitalisation of the land registry system	Smart Contract, ERC-721	Ethereum	NA
(Avantaggiato & Gallo, 2019)	2019	trust & transparency in the transaction	Smart filters	Multichain	NA
(Fernando & Ranasinghe, 2019)	2019	transaction cost & time	Hyper ledger's chaincode	Hyper ledger Fabric	Public
(Huh & Kim, 2020)	2020	transaction security	quantum-based encryption, Smart Contract	NA	Public
(Ali et al., 2020)	2020	Digitalisation of the land registry system	Smart-contract, Chain code	Hyper ledger Fabric	Private
	2020	transaction security & reliability	Smart contract	NA	Private
(Norta et al., 2018)	2018	commercial-property trading	Smart-contract	Hyper ledger Fabric	Private
(Thakur et al., 2020)	2019	Records Management	Smart-contract	Hyper ledger Fabric	Public-private
(Krishnapriya & Sarath, 2020)	2020	Secure registration system	ECDSA, SHA256, Markle Tree, Pow	NA	NA

related issues. It uses Ghana as a test case to use technology in the African region. Relevantly, this project was piloted in the Kumasi area. BitLand partners with local bodies responsible for issuing land titles and ready to use new technology to address the issues that have been unsolved for decades. BenBen is another organisation working on the same topic in Ghana. BenBen provides a top-of-the-range land registry and verification network to organise the various financial companies and government authorities to update current records and promote electronic property smart land transactions L and Bates (2016).

- **India:** In India, Telangana and Andhra Pradesh are working on a project to update the land registry system, in collaboration with the Advanced Computing Development Center (C-DAC). This system uses blockchain in the backend, and for frontend, the web app is used to provide a higher transparent system for the citizens. The project is currently under review and development and will be implemented as a test case in Hyderabad and nearby before fully implementing Variyar and Bansal (2017).
- **Japan:** In japan different states and their respective governments maintain a separate property register database and real Estate Company maintain their separate database. Japan is planning to combine all these data using blockchain. In 2018 japan has done a test run for the collected data of state-owned ownership database and trading using blockchain. The system has been in pilot testing in few cities and will be introduced nationwide in the next five years once the findings are positive. In addition to the government initiative, a property company called Zweispace has already introduced a proprietary blockchain framework for the assessment and transaction of property which can minimise time and cost of the transaction Tomotani et al. (2017).
- **Republic of Georgia:** The Republic of Georgia was the first government to use blockchain technology in 2017 to store and validate land registry information. The Georgia national agency is working with the company "Bitfury" for storing the land ownership on the private blockchain. Then this information is made available to the public blockchain to verify the transaction information. A blockchain-based time stamping mechanism was initiated during the first phase of the project to ensure the system is verifiable and secure. The second phase allows blockchain and bitcoin technology to facilitate the purchase and sale of land, which reduces the transaction costs to about 0.1% of the property value. All records can be stored online and protected through blockchain networks. Georgia is also planning to use blockchain technology for emergency and authority transfer services 975 (2017).
- **Russia:** Russian started the project to implement blockchain technology in the land registry, significantly reducing the transaction cost. State cadastral organisation and Ministry of Economic Development of Russia is working in collaboration on this project During the first stage; the entire record is transferred to a blockchain system to verify land records, past owners and liability of the property etc. Of and Russia (2018).
- **Sweden:** In June 2016, land registry authority in Sweden named "Lantmäteriet" undertake a project with the startup company name "Chromaway" to use blockchain technology to store transactions of land registry. In this project, the trading of land is done with the help of a smart contract, banks and intermediaries supervise this execution. Use of blockchain technology reduces the fraud, removing paperwork and fastening of transactions and reducing the taxpayer by EUR 100 million per annum by Kempe (2016b). The project is going to be three stages. During the first stage, a test run is performed to test the technical benefits.

Further, in the second stage, a study was released showing the benefits of using smart contracts in land transactions. In the third stage, real transactions are created using digital signatures and a smart contract. The system is currently tested, and it will be implemented once the results are satisfactory Kempe (2016b).

- **Ukraine:** Ukraine current land registry system has lots of challenges related to the ownership issue. As a result, the Ukraine government banned land trading, which makes the country economically backwards. To overcome these challenges, the Ukraine government is planning to make global, transparent and secure blockchain registry to remove the ban on land trading to improve the economy. The pilot project began in 2017 and deals with the problem of record authentication without initially direct land transactions, but is later included in the next phase. It uses Exonum's private blockchain network. Paolo Alto Propy worked with the government to help online property using the Ethereum blockchain Tian (2017).
- **United Kingdom:** The United Kingdom government is funding research and development projects to use blockchain technology in land registry in a combination of various business model, law and financial management to make land registry faster, cheaper and more straightforward. Currently, the UK government working on project name Digital Street to study the modernise effects of using blockchain technology in the land registry Birchall (2018).
- **United States of America (Illinois):** International Blockchain Real Estate Association (IBREA) working in collaboration with the Chicago Cook County Recorders of Deeds (CCRD) on the pilot project "Velox.RE" to use blockchain technology for land registry. This project focuses on over 2000 empty properties and testing of these combinations of properties with the digital assets Mirkovic (2019).
- **Netherlands:** The Netherlands Land Registry organisation, generally referred to as the Kadaster, introduced a land registry project using Blockchain and AI. The Department of Land Registry records, title information and geographical coordinates for accurate classification. This knowledge can be stored accurately with blockchain and time stamping techniques. The project has been in the development stage. This initiative is part of the "Blockchain Pilots" government programme, which aims to implement blockchain on all forms of e-governance Wouda and Opdenakker (2019).
- **Dubai:** In 2016, Dubai blockchain strategy was launched, which combine the Dubai electric and water authority (DEWA) and the transaction detail of land trading and resident visa information. Using blockchain in document processing saves annually around EUR 1.2 billion. Dubai blockchain strategy aimed to achieve all transaction using Blockchain in Dubai up to 2020, making Dubai the world leader in using the blockchain technology for public domain Hochstein (2017).
- **Honduras:** The land title frauds and corruptions are usual in Honduras. The corrupt public servant may enter the land register and illegally alter the land ownership in- formation. By using the blockchain technology for land registry eliminate fraud and provides security and protection for property title. In 2018, the Honduran government signed a contract with Factom, a US startup to handle fraud and corruption to register and manage land records using blockchain Anand et al. (2016), Inc and Inc (2018).
- **Switzerland:** Currently, Switzerland is using a standardised method to implement large-scale digital ecosystems. In cooperation with Microsoft and the Rwandan government to establish a system of land rights. WISeKey, one of Geneva's largest cybersecurity firms, offers the Swiss-based Root Trust (RoT) to authenticate and identify IoT, Blockchain securely and AI in both physical and digital environments Wisekey (2019).

CHALLENGES OF BLOCKCHAIN IN THE LAND REGISTRY

This paper examines existing blockchain-based land registry projects and their implementations to gain insight into how the technology is used. As blockchain is new, there are a few issues to this technology Bal (2017). Various issues related to the blockchain with land registry are addressed and it is shown in Table 3. These issues should be taken into account while applying blockchain technology in the land registry.

Table 2. Country-wise land registry project and involved government entities

Ref	Country	Project Name	Government Entity
(Allison, 2018)	Brazil	Land Title Registry	Property Registry Office
(Joni Brennan, 2020)	Canada	BC Land Titles and Survey Authority's Design Challenge	Province of British Columbia: Land Title and Survey Authority
(L. Chris Bates, 2016)	Ghana	Land Rights/Land Registry	Ministry of Lands and Natural Resources& Bitland
(Mugdha Variyar & Varsha Bansal, 2017)	India	Blockchain-based Land Title Registry	State of Telangana, (C-DAC)
(Nikkei, 2017)	Japan	Blockchain-based Land Registry	Ministry of Justice
(CNN, 2017)	Republic of Georgia	Blockchain-based Land Title System	National Agency of Public Registry
(Russia, 2018)	Russia	Land Title Registration	Ministry of Economic Development
(Kempe, 2016)	Sweden	Blockchain Land Registry	Swedish land registry and Chromaway
(Tian, 2017)	Ukraine	Blockchain-based Land Title System	State Land Cadaster
(Annie birchall, 2018)	United Kingdom	Digital Street	HM Land Registry
(Mirkovic, 2019)	United States - State	Land Title Registry	International Blockchain Real Estate Association (IBREA), Cook County Recorder of Deeds
(Wouda & Opdenakker, 2019)	Netherlands	Blockchain-based Land Registry	Land Registry, Municipality of Eindhoven
(Hochstein, 2017)	Dubai	Dubai Land Department Real Estate Blockchain	Dubai Land Department (DLD)& Dubai Electricity & Water Authority (DEWA)
(Anand et al., 2016; Factom | A Blockchain Innovations Company, 2018)	Honduras	Blockchain-based Land Registry	Honduras government & Fatcom
(Wisekey, 2019)	Switzerland	Digital ID/Land Rights	WISeKey, Microsoft and Rwandan Government

1. **Legal consensus is pre-requisite:** All the property output in the transaction is allocated in the beginning. Details of the output are linked to the original owners as maintained in the land registry system Barbieri (2017).
2. **Portability and interoperability:** The records to be kept separately, in a different location. We must standardise the documentation to increase the authenticity of documents. After the document is validated and accepted, it can be submitted and used in other systems and organisations Morena et al. (2020), Mehdi (2020). To facilitate the cross border implementation of land registries, data protection, and portability regulation are necessary Barbieri (2017).
3. **Legal validity of a digital signature:** The digital signature of the land registry contract requires absolute authenticity, but unfortunately, it is not governed at the Court's legal level Mcmurren et al. (2018). Besides, several technical and implementation preparations are required to allow digital signatures for land records Stefanovi et al. (2018).
4. **Verifying the stakeholders' ID:** The verification of the stakeholder's identity is of great public interest, and it is. Therefore it is necessary to ensure stakeholder verification in the land titling system to secure the property rights Garcia-Teruel (2020).

Table 3. Implementation challenges of blockchain technology in the land registry

Ref	Description	Year	Challenges
(Stefanovi et al., 2018)	Analyse the use of blockchain technology in improving the transaction process in land administration. And presented case studies which may fasten the transaction process and eliminate the double sending problem	2018	1.The technical infrastructure for issuing of digital signatures to stakeholders
(Teruel & M, 2020)	Discusses the challenges, limitations, and opportunities in the real estate sector and explores the implementation challenges of blockchain technology.	2020	1. Verifying the ID of the stakeholders 2.Control the legality and effectiveness of the contract 3. Difficult to translate co-ownership and other rights into a smart contract 4.Irreversible nature of blockchain
(McMurren J et al., 2018)	Minimises the issue of transaction costs and time consumption by using blockchain and identity management system in Swedish Land registry transfers	2018	1. Legal validity of digital signature for land registry contract 2. framework for data governance for the involved stakeholder in the process. (scalability)
(Mehdi, 2020)	An overview of the use case of blockchain in real estate and explored the potentials, its limitations of blockchain in different sectors	2020	1. Portability and interoperability feature not supported 2. non-compliance with ID & SSI principle
(Morena et al., 2020)	Use of blockchain to improving trust in the real estate sector and analyse its main features and characteristics.	2020	1.Standardization of document for data sharing
(Tilbury & Rey, 2019)	Studied the business process model of real estate purchasing in South Africa by implementing blockchain technology also to find its opportunities and challenges in the real estate sector.	2019	1. Possibility of fraud if at the same time, 51% of nodes are in favour.
(Barbieri, 2017)	Discusses the use of blockchain technology in current land registry and find out the risk associated with it.	2017	1. Pre-requirement for consensus on the legal ownership. 2. Unable to prove ownership if a private key is a loss. 3. Legal Framework and data protection law to implement land registry between different cities.

5. **Scalability:** There are many land registries stakeholders such as sellers, investors, trusted third parties, and government agencies. Stakeholders shall ensure that both sides meet the legal conditions during the land transaction Garcia-Teruel (2020). This large number of stakeholders would draw a massive amount of data and bandwidth resources. Therefore, data governance problems and scalability need to be resolved Mcmurren et al. (2018).
6. **Non-compliance with the principle of identity:** Since blockchain is trustworthy, compliance with identity principles is necessary to allow users to manage their own identities. Many of the land registry systems do not support the principles of identity Mehdi (2020).
7. **Private key loss:** The blockchain land registry is based on the private key of the holder, the majority of the holders are less likely to remember or lose their cryptographic keys, which means that they are unable to prove the ownership Barbieri (2017).

CONCLUSION

This paper reviewed the land registry process and limitations of current land registry systems. It further analyses the various blockchain models and application of blockchain in the land registry. Various blockchain-based land registry projects in different countries have been reviewed to analyse such systems' advantages and limitations. Finally, this paper highlights the challenges of blockchain application in the land registry. These challenges are essential to be considered for any new project implementation in the field of land registry, incorporating blockchain technology. Although there are various advantages of using blockchain use in the land registry, but the challenges need to be resolved for effective implementation.

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