

Land registries on a distributed ledger

Introduction

70% of the world's population has no access to formal land registration systems. Globally, only 30 states have a functioning, countrywide land administration that also recognizes local tenure systems. In particular marginalized groups such as women, the poor and indigenous people are the most vulnerable to arbitrary practices in land rights governance. Land tenure is a legal regime which determines who can use land, for how long, and under what conditions. Land tenure security can be legitimately based on individual, household, family as well as community claims. The security of tenure is essential for the development of countries, as it incentivizes land holders to invest in their land, thus generating broader social and economic development.

Problem description

Today, when a purchaser seeks to buy property, he or she must identify and secure the land title or any accepted document, such as existing deeds of sale, and have the lawful owner sign it over. For a large number of residential titleholders in developing countries, flawed paperwork, forged signatures and defects in foreclosure and mortgage documents have marred proper documentation of property ownership. The resulting situation is that the property no longer has a 'good title' attached to it, being no longer legally sellable and leaving the prospective buyer in many cases with no remedies. Besides, agricultural land ownership is often regulated by customary practices without any written documentation.

In addition, many countries struggle to properly register land tenure in the first place. In Africa, for instance, only 10% of the surface

is formally documented. Hereby, the gap between rural and urban areas is particularly noteworthy: while many large cities at least partly record land ownership, rural areas often lack any registry system. This has also to do with the fact that land regularization and land ownership determination can be a costly and lengthy undertaking. In places where land is documented, the registries mostly rely on paper-based documentations, which are usually centrally stored, making them vulnerable to loss, corruption, or misuse. Moreover, natural disasters can affect such single-location paper registries, as the case of Haiti illustrates, where large amounts of documents were destroyed during the earthquake in 2010. The loss or manipulation of land documents creates social conflict and negatively affects the trust in governmental services. Paper-based land registries are likewise plagued by significant inefficiencies. Land transfer processes often require a variety of hard copy documents, manual signatures and third-party verification. These complex and time-consuming procedures obstruct investment as well as the economic use of land.

Blockchain 101

Blockchain is a continuously growing list of records stored in blocks, which are cryptographically secured and linked across a network of computers. Even if 99% of the computers are disabled, the records will remain available and secure on other parts of the network.

Blockchain land registries – quo vadis?

Generally speaking, blockchain serves the same functionalities as the filing system inside a sound land registry: it knows who owns what at a certain time, ensures single-ownership and

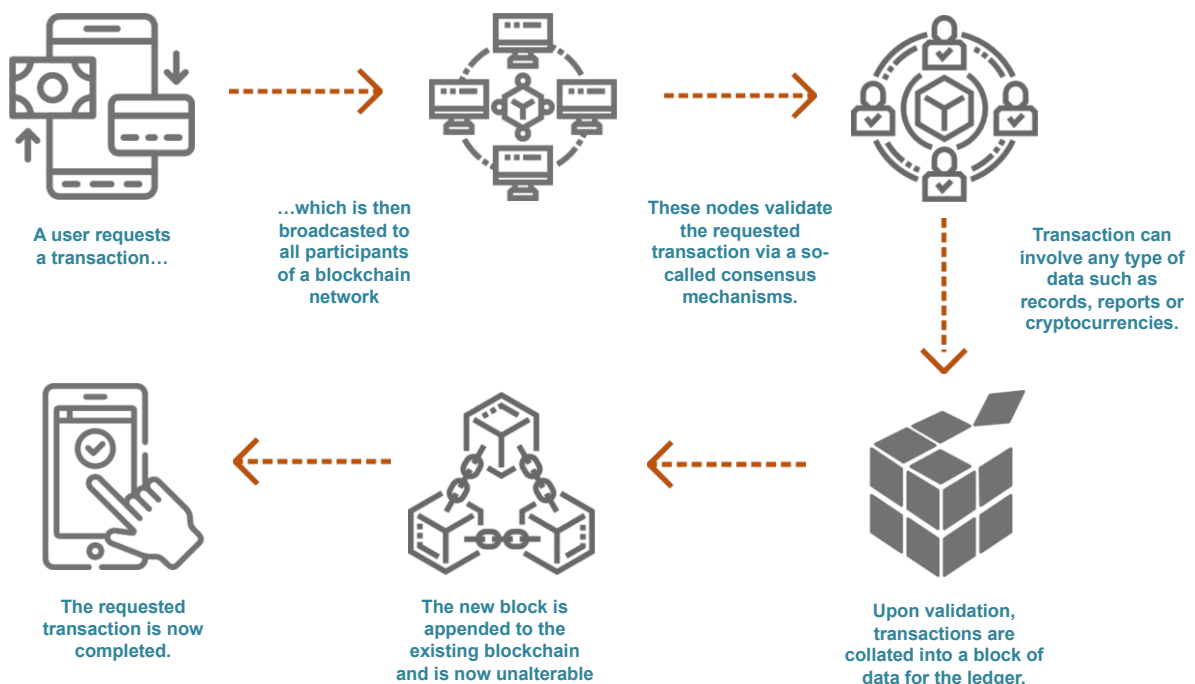
knows when a certain transaction took place. In comparison to a traditional registry, however, blockchain promises to make land documentation more secure, incorruptible and transparent.

From a bird's eyes perspective, the blockchain will capture and permanently store (a hash of) each transaction of land titles, which permits near real-time traceability of ownership change as well as transparency in the state of the property, removing the possibility for manipulation of the titles. More precisely, imagine two citizen who have agreed on the sale of a land parcel and now wish to register the sales contract with their countries land administration. Similar to the registration process in a traditional land registry, the seller and the buyer go to the governmental administrator with the sales contract signed by both parties and enter it into the blockchain-powered land registry database in the form of a cryptographic hash. The public ledger will contain only a reduced privacy-enabled set of data including the fingerprint or hash of the full transaction. Once the transaction is approved by the network and added to the blockchain, the transfer of ownership is

immutably recorded on the ledger which becomes a single-point-of truth, preventing document forgery and corrupt land transfers. If there are doubts as to the validity of a land ownership claim, the public ledger can be used for validation by all relevant stakeholders involved. The user front-end is available for anyone with internet connectivity e.g. via smartphone.

In a more disruptive scenario, the property transfer itself is conducted in the form of a smart contract. This implies to completely digitize and legally effectuate the peer-to-peer sale and purchase of properties, thereby cutting out the role of intermediaries such as banks, notaries and public registry offices. Taken to the extreme, this would mean that a smart contract on a public ledger, digitally signed by the parties, would automatically transfer the land title upon payment in cryptocurrency. This scenario however comes with a number of prerequisites of which some are unlikely to be met in the near future. The digital vanguard country of Estonia has moved almost all government transactions online, except for the procedures of getting married and transferring property. Given that these

Transactions on a blockchain



kinds of transactions require physical presence due to their sensitivity, solely relying on digital signatures appears to be insufficient. Therefore, trusted middlemen performing checks on identities and signatures, are likely to remain in place for the time being. Similarly, governments will most likely continue to act as a verifier of legal preconditions for the transfer of property, as the public ledger would rarely include data on whether the owner is adult and mentally sane, and otherwise legally able to sell a certain piece of land. Therefore, we expect smart contract-based land titles to become legally binding only once these checks and safeguards of trusted middlemen are reliably provided in the form of so-called oracles. These oracles would be digitally representing the required preconditions for land transactions to be executed via smart contracts.

The added value of decentralization

When examining the benefits of a blockchain solution over incumbent systems several benefits can be identified.

Much of the efficiency gains of the blockchain-based land registry can be attributed to processes having digital workflows as opposed to being paper-based. Digital workflows in a land registry can save time, be remotely accessible, avoid certain corruption scenarios, and improve data quality and reliability of storage. Moreover, a decentralized land registry promises to create great efficiency gains in administration-related governmental mandates such as land taxation. Here blockchain adds value through its immutability and resilience. Fraud and corruption scenarios that rely on the forging or disappearing of documents or attempts to sell land twice, are effectively discouraged by a timestamped hash on the public ledger. This would especially benefit marginalized groups in society, such as women or indigenous populations, who are often the victims of land fraud. In addition, while existing backup technologies can provide a good level of reliability for data storage, the reliability of distributed ledgers, with sometimes several thousand copies worldwide,

is unprecedented, and works even in absence of qualified IT personnel on site.

The more disruptive scenario of smart contract-based land transfers provides an occasion and opportunity for a more fundamental reform of institutions and their mandates. Each intermediary along the process is stripped to its core functionality, such as, for instance, verifying identities and signatures. This institutional restructuring based on a clear definition of roles can break up existing inefficiencies, corrupt structures and collusion.

Generally speaking, the increased transparency brought by blockchain-based land registries can therefore contribute to boosting citizens' and companies' trust in public institutions. This, in turn, may translate into growing investments and use of land, spurring social and economic development at a larger scale.

Challenges and limitations

Despite the various advantages of blockchain for land registration, a number of challenges still have to be taken into consideration.

The small-scale solution of timestamping transactions of existing land registries by writing hashes on a public ledger is relatively straightforward and easy to implement. Yet, the more disruptive solution in which land transactions are executed in a fully automated manner through the use of smart contracts, faces significant implementation hurdles for several reasons. Firstly, land titles and obligations are often complex and involve additional information beyond the identity of the land tenant. For instance, mechanisms and procedures have to be defined for land seizure in cases of insolvency etc. Projecting such complex modalities of rules and obligations into a blockchain will require not only careful and thorough coding of smart contracts but also institutions to go through a significant adaptation of their management processes.

Secondly, the legal status of smart contracts still needs to be specified, possibly requiring

legal amendments of contract law, along with the changing role of the institution of the land registry. In addition, questions regarding data sovereignty are likely to arise, particularly with regards to varying privacy and data-hosting laws across different countries. Data privacy concerns may be addressed by employing cryptographic methods such as zero-knowledge proofs.

Oracles

Smart contracts do not know about events that happened outside of the blockchain, i.e. in the real world. Oracles are used to provide information about real world events required for the execution of smart contracts. For instance, an oracle may answer the following questions: Did it rain in Berlin 10969 on 5th December 2018 at 14:25? What is the Amazon's stock price at present (AMZ)?

Furthermore, land registry systems depend on reliable data sources e.g. regarding legal age or eligibility for signing contracts. Hence, governmental authorities would need to serve as an oracle, providing proofs of entered data, in order to allow for automated land transfers. This, in turn, requires a secure and reliable IT environment.

Another hurdle relates to the lack of maturity of blockchain technology. Public blockchains are a phenomenon of the past 10 years, while land titles are meant to be kept for up to 100 years or more. Therefore, we need to assess risks and shortcomings of blockchain architectures. Consequently, data may need to be migrated at some point if the chosen architecture seems no longer suitable. Energy consumption and scalability questions of current blockchain systems add to these technological concerns. It will thus be fundamental to choose a blockchain platform which can accommodate the need for millions of land registry entries. Lastly, digital infrastructure and literacy are pre-requirements

for implementing a blockchain-based land registry system. This applies to both authorities as well as citizens.

In sum, blockchain is unlikely to render trusted middlemen obsolete in the near future. Nonetheless, it holds the potential to create more accountability by creating an immutable audit trail and handing more control over land transactions to citizens. This makes it possible to fend off certain corruption or loss of documentation scenarios. While blockchain does not resolve questions regarding costs and problems arising from land regularization and land ownership determination – two important processes for the generation of quality data – the technology can ensure that the time and effort invested in these processes will not be undermined by fraudulent actors at a later stage.

Public v. private blockchains

Public blockchains are decentralized meaning no actor has control over the network, ensuring the data cannot be altered once validated. In other words, anyone, anywhere, can use a public blockchain to input transactions and data when connected to the network.

Blockchains that are private or permissioned work similarly to public chains, but write permissions are kept centralized to certain entities. Read permissions may be public or restricted to an arbitrary extent.

Ideal application context

Blockchain-based recording of land titles is particularly relevant in contexts where existing land licensing and registration processes are facing fraudulent and corrupt practices, particularly related to document fraud, double selling, or risk of malicious actors within governmental institutions confiscating land. The auditability and transparency introduced by blockchain would significantly increase trust in land registries and management.

Furthermore, if a digitized cadaster or registry already exists, the investment to write respective hashes onto a public ledger is relatively small.

Concerning the more sophisticated solution of a smart contract-based land registry, the complexity of the legal situations can be a challenge for implementation. A comparably simple regulatory environment and a reduction in project scope (not covering all exceptions) is advisable. An additional enabling factor is the existence of a competitive private sector, which pushes for reform in land registries, seeking to benefit from cost-efficiencies. While the technology appears mature enough for the simple use case of timestamping land registration, the more complex use case of smart contract-based land titles will preferably be implemented in the form of a locally, more narrowly targeted pilot project, with possible extension of scope upon success.

Current initiatives

To-date, there are several pilot projects for blockchain in land registration. The arguably most successful pilot was implemented by the start-up Bitfury in Georgia with the support of GIZ where land titles are recorded on the Bitcoin blockchain. Keys to success were the already prevalent digitized land documents as well as political will and feasibility of adopting the regulatory environment. In another successful pilot project in Sweden, a heavily regulated legal environment currently still poses significant hurdles for broader adoption. Pilot projects in Honduras, Ghana and Rwanda have had limited success so far. While some initiatives are driven by the private sector without legal recognition and state-backing, others are struggling with existing reasons why land registration rates remain low such as improperly registered land titles and lack of digitalized workflows in land registries.



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