Blockchain as a tool to facilitate property rights protection in the Global South: lessons from India's Andhra Pradesh state

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Abstract:

The lack of a comprehensive property rights system is an issue of pressing concern in most economies in the Global South. Property rights-related issues have important social, economic and environmental consequences. This paper argues that one of the most impactful uses of blockchain in the Global South could be in the creation, implementation and enforcement of property rights. The article provides an in-depth analysis of a blockchain-based land registry project in the Andhra Pradesh state of India. It also delves into facilitators for and barriers to a large-scale adoption and deployment of blockchain for this purpose. The paper shows that with blockchain, the benefits of digitisation of land records can be amplified and some of the major drawbacks of digitisation can be avoided.

Keywords: Andhra Pradesh | blockchain | Global South | land-titling reform projects | poverty | property rights protection

Article:

Introduction

The lack of land ownership among the rural poor and highly defective land records are among the greatest socio-economic problems facing India.[1] Over 20 million rural families in India do not own land and millions more lack legal ownership of their lands and houses.[2] Landlessness arguably is a more powerful predictor of poverty in the country than are hierarchical social and economic arrangements such as the caste system, or illiteracy.[3] Bureaucratic red tape and corruption are widespread in property-related transactions.[4] Bribery in land administration is

[1] Bandyopadhyay, "Land System in India."
[2] Hanstad, "Case for Land Reform in India."
[3] Ibid.
[4] Appu, *Land Reforms in India.*

rampant in the country.[5] A 2005 survey found that 79% of those interacting with the Land Administration Department in India paid bribes. More than 36% had paid bribes to department officials and 33% to intermediaries.[6]

A number of studies conducted in India and other Global South (GS) economies have demonstrated that the digitisation of land records might address some of the above challenges.[7] For instance, by digitising land records, ambiguity can be reduced, leaving less room for corruption.[8] Likewise, digitisation facilitates search and retrieval of documents, which can improve administrative efficiency, reducing red tape and waiting time in land-related transactions.[9]

In some GS economies that have digitised land records, however, many of the expected benefits of digitisation have not materialised. For instance, the Bhoomi programme in India's Karnataka state[10] was reported to have increased corruption and bribes as well as the time taken for land transactions.[11] The digitisation was carried out by the centralisation of land records and thus management moved away from villages to district-level taluk offices. Whereas well-connected urban economic agents and large- and middle-level farmers exploited the centralisation and computerisation of land records to their benefit, the systems led to further marginalisation of unconnected poor farmers.[12] Likewise, the Electronic Document Management System (EDMS) implemented in Lagos, Nigeria, did not lead to an increase in the number of applications processed.[13] Finally, land records stored in a centralised database system are susceptible to hacking. To take an example, as of 2018, the Bhoomi system has experienced three cybersecurity breaches in which nefarious actors have manipulated records.[14]

Recent research has suggested that by storing land records in blockchain, some of the major limitations discussed above can be overcome.[15] More broadly, blockchain is viewed as a force that is likely to break the poverty chain in the GS.[16] Blockchain makes it possible to create a tamper-proof digital ledger of transactions and share it among relevant participants. Cryptography allows the participants to add data to the ledger securely. It is impossible, or at least extremely difficult, to change or remove a block of data recorded on the ledger. Blockchain transactions are conducted by the concerned parties themselves without a third party or a central body. Due to these features, researchers have argued that blockchain can play a major role in addressing various challenges facing the humanitarian and development sectors in the GS.

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[5] Heston and Kumar, "Institutional Flaws and Corruption Incentives in India"; Islam and Lee, "Bureaucratic Corruption and Income."
[6] Transparency International, *India Corruption Study 2005*.
[7] Benjamin and Raman, "Illegible Claims"; Thontteh and Omirin, "Land Registration within the Framework"; Moreri, Fairbairn, and James, "Volunteered Geographic Information Quality Assessment."
[8] Benjamin and Raman, "Illegible Claims."
[9] Thontteh and Omirin, "Land Registration within the Framework."
[10] Benjamin, Bhuvaneswari, and Rajan, "Bhoomi: 'E–Governance.'"
[11] Ibid.
[12] Ibid.
[13] Ibid.
[14] Akshatha, "Karnataka's Famed Land Record Database."
[15] Thakur et al., "Land Records on Blockchain."
[16] Kshetri, "Will Blockchain Emerge as a Tool."

Notable uses of this technology include fighting corruption[17] and creating secure digital identities.[18] Improving property registry[19] and securely managing land records and land tenure[20] have been viewed as potentially high-impact uses of blockchain. As a related point, a blockchain-based property registry system can reduce title frauds and guarantee the protection of property titles.[21]

Blockchain can thus help achieve many benefits that are not possible with digitisation alone. Blockchain's decentralisation feature ensures that land-related records are stored in multiple computer systems (called 'nodes'). If new transaction data are added, the blockchain will be updated in all the connected nodes in real time. This means that corrupt officials cannot change land records without being noticed by others. Blockchain-led transparency and accountability can also improve efficiency in land transactions. These features of blockchain can also provide a level playing field for and improve the welfare of the poor. Blockchain is also touted as a technology that is more secure than most other systems. Unsurprisingly, then, many GS economies are currently in various phases of implementing blockchain-based land record systems.

This article provides an in-depth analysis of a blockchain-based land registry project in the Andhra Pradesh (AP) state of India, which has one of the most advanced applications of blockchain for this purpose. It examines benefits and limitations of blockchain-based land registry systems as well as facilitators for and barriers to implementing such systems.

This topic is important because observations from some African economies have revealed that blockchain-based efficient verification of property records and transactions can increase access to credit for individuals and small enterprises from formal sources, which otherwise operate in an informal way.[22] Lessons learned from AP can be helpful for other GS economies in designing and implementing strategies to utilise blockchain in land registry. This study underscores the need for high national priority, rules and regulatory agencies governing land management and local technological capabilities to develop blockchain projects in land registry. It also identifies some potential barriers that may impede GS economies' attempt to develop blockchain-based land registry system.

Before proceeding, some clarifying definitions are offered. Blockchain is a decentralised ledger that maintains records of a transaction simultaneously on multiple computers. After a block of records is entered into the ledger, the information in the block is mathematically connected to other blocks. In this way, a chain of records is formed. Due to this mathematical relationship, the information in one block cannot be changed without changing all blocks in the chain. Any alteration of information in a block would create a discrepancy that is likely to be noticed immediately by others in the network. Blockchain-based ledgers thus do not require record-

[17] Kenny, "How Much Aid Is Really Lost."
[18] Kshetri, "Blockchain-Based Financial Technologies."
[19] Kshetri, *Global Entrepreneurship*; Swan, *Blockchain: Blueprint for a New Economy*.
[20] Zwitter and Boisse-Despiaux, "Blockchain for Humanitarian Action and Development Aid."
[21] Themistocleous, "Blockchain Technology and Land Registry."
[22] Gebre, "Blockchain Opens Up."

keepers to trust each other. In this way, the dangers associated with data being stored in a central location by a single owner do not apply to blockchain.[23]

The article is organised as follows. We first provide a literature review. Next, we examine blockchain-based land registry projects in India's AP state. This is followed by a discussion and implications. In the final section we offer conclusions.

Literature review

In this section, we focus on two key points. First, we review the literature on digitisation of land records in GS economies to understand the limitations of such systems, which can be potentially addressed with blockchain. Second, we look at studies that examine blockchain deployment in the land registry to understand the benefits and limitations of such systems as well as facilitators of and barriers to their implementation. Taking these prior understandings into consideration will help interrogate these understandings using perspectives from AP, one of the most advanced deployments of blockchain in land record systems.

Digitisation of land records in the GS

Social, economic and political factors affect whether and the extent to which the benefits of the digitisation of land records can be realised.[24] The full benefits associated with the digitisation of land records cannot be realised in the absence of a supporting environment. Mixed results have thus been obtained in studies assessing the impact of digitisation of land records in the GS. For instance, various benefits of the EDMS implemented in Lagos, Nigeria, were identified. Land-related files were stored centrally, which facilitated search and retrieval of documents. The waiting time to obtain land-related information decreased and administrative efficiency improved. Overall, it led to an increase in public confidence.[25]

As another example, one can look at the Bhoomi programme in India's Karnataka state.[26] A computerised database was generated comprising 20 million records of land belonging to 6.7 million farmers. In the pre-Bhoomi era, there were many different land ownership forms due to various socio-legal processes that underpinned land claims. Bhoomi unified these heterogeneous land tenure forms.[27] In the pre-Bhoomi system, land-related corruption was related to ambiguity in land records, in which the process was mostly controlled by local-level 'street bureaucrats'.[28] To some extent, digitisation helped overcome such problems.

However, several limitations and drawbacks of digitisation initiatives such as Bhoomi and the EDMS have been noted. For instance, the EDMS showed no improvement in resolving boundary disputes. Moreover, the EDMS system did not lead to an increase in the number of applications processed or the generation of additional revenue.[29]

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[23] Yaga, Mell, and Scarfone, "Blockchain Technology Overview."
[24] Moreri, Fairbairn, and James, "Volunteered Geographic Information Quality Assessment."
[25] Thontteh and Omirin, "Land Registration within the Framework."
[26] Benjamin, Bhuvaneswari, and Rajan, "Bhoomi: 'E–Governance.'"
[27] Benjamin and Raman, "Illegible Claims."
[28] Ibid.
[29] Ibid.

An analysis of the Bhoomi system indicated that that digitisation of land records does not necessarily improve farmers' welfare. The record also included a cropping pattern history of the previous 12 seasons. This was arguably the largest scale digitisation of land cadastrals carried out to date in a developing country. The Bhoomi system increased corruption and bribes as well as time taken for land transactions.[30] The digitisation was carried out by the centralisation of land records and thus the management moved away from villages to taluk offices at the district level.

Before Bhoomi, obtaining a copy of a Record of Rights, Tenancy and Crop Information (RTC), or mutation – the transfer of rights from one owner to another – normally took two to three days. The village accountants (VAs) made such documents available efficiently. After Bhoomi's implementation, a mutation took as long as four months, and farmers needed to depend on agents to get their work done. In many cases, when farmers visited the taluk office, for which they needed to miss several days of their agricultural work, they found that computers were down or there was no electricity.

Large- and middle-level farmers exploited the centralisation and computerisation of land records to their benefit. These groups allegedly used smaller farmers' survey numbers to access government schemes and benefits such as subsidies provided to small farmers to buy seeds, fertilisers and pesticides. Bhoomi also helped powerful economic groups to acquire land in prime locations at a low cost from small farmers, who had used such lands for cultivation. In some cases, the farmers had received such lands under various so-called 'inam' schemes, which restricted them from selling. Economically and politically connected real estate agents contacted several small land holders in an area, negotiated with them and converted the land to commercial use. To do so, the urban economic agents obtained a No Objection Certificate (NOC) from the village panchayat and used the Bhoomi system to issue title for their clients. Large land developers had connections with politicians and senior administrators. In such cases, due to the involvement of powerful and influential interests, the local institutions such as the VA office or the Bhoomi kiosk had no power to influence the process or make a decision.

Bhoomi shows that the process of digitisation and related digital access to land title may shift power and wealth to those with the financial resources and skills to take advantage of it. These groups are in a position to use this information to promote their self-interest and harm the interests of disadvantaged groups such as small farmers.[31]

Blockchain in property registration

Land registry is becoming a popular blockchain application.[32] Some have suggested that land titling could be blockchain's 'low hanging fruit',[33] which can be carried out in an inexpensive way.[34] Various benefits have been suggested for the use of blockchain in developing a national

[30] Benjamin, Bhuvaneswari, and Rajan, "Bhoomi: 'E–Governance.'"
[31] Ibid.
[32] Manski, "Building the Blockchain World."
[33] Swan, "Anticipating the Economic Benefits of Blockchain."
[34] Dwyer, "Blockchain: A Primer."

system for property management.[35] These include elimination of paperwork, reduction of fraud, and increasing the speed with which transactions can be conducted.[36] Both proposed and actual implementations in Honduras,[37] Ghana,[38] Georgia, India and other countries[39] have been given as examples to illustrate such benefits. With a blockchain-based land titling project, the government of the Republic of Georgia aims to enable landowners to borrow against their lands and engage in entrepreneurial activities.[40]

Prior researchers have also documented various barriers to the implementation of blockchain-based land titling projects. A rich blockchain ecosystem in which to apply this technology for land governance has not been developed. Concerns have been expressed about issues such as poor Internet connectivity, and underdeveloped privacy and security practices.[41] Other key barriers include the lack of interoperability and laws to recognise digital signatures.[42]

In most developing countries, value, ownership and other details of lands are in paper-based cadastres, which are mostly incomplete. These pose significant challenges in digitising and updating land records to accurately reflect ownership of property.[43] It is important to tackle the widespread land governance challenges to increase the scalability of blockchain projects. A major challenge is to convert analogue land registers and analogue cadastres to digital land databases. Buenos Aires cleaned up its analogue system and digitised the registry. In cases such as Buenos Aires, where the analogue system was cleaned up and digitised, blockchain can provide major advantages by ensuring immutability. Researchers have also noted the importance of institutional changes and transformations in order to apply blockchain for asset registry.[44] This is because blockchain is a 'social technology' designed to govern people's behaviours.[45]

Blockchain-based land registry in India's Andhra Pradesh state

In 2017, the Telugu Desam Party (TDP) government headed by Chief Minister (CM) Chandrababu Naidu in the AP state, which split from Telangana under India's Andhra Pradesh Reorganization Act, 2014, announced plans to use blockchain for land registry. It was the first Indian state to do so.

After the split, the old state capital Hyderabad became Telangana's capital. AP planned to build a new capital city from scratch in Amaravati. In October 2017, the AP government collaborated with the Swedish start-up ChromaWay to implement blockchain-based land recording project in Amaravati. Regarding the involvement of ChromaWay, it is worth noting that a complaint has been raised against the company that it has merely proven the concept of blockchain-based land

[35] Lemieux, "Evaluating the Use of Blockchain."
[36] Lantmateriet, "Land Registry in the Blockchain."
[37] Lemieux, "Trusting Records."
[38] Kshetri, "Will Blockchain Emerge as a Tool."
[39] Kshetri and Voas,"Blockchain in Developing Countries."
[40] Manski, "Building the Blockchain World."
[41] Thakur et al., "Land Records on Blockchain."
[42] Graglia and Mellon, "Blockchain and Property in 2018."
[43] Kriticos, "Keeping It Clean."
[44] Ølnes, Ubacht, and Janssen, "Blockchain in Government."
[45] Graglia and Mellon, "Blockchain and Property in 2018."

records again and again, while failing to show traction and scalability.[46] In this regard, the AP project has attained some degree of scalability that was missing previously.

Private blockchain used

Before expanding on the case of AP, we first explain the differences between types of blockchains. Blockchains can be permissioned (eg Ripple) or permissionless (eg bitcoin). In a permissioned blockchain, nodes or users are not publicly discoverable. The permission to create smart contracts may also be restricted to approved actors. In a way, permissionless blockchains are like a shared database. Everyone can read everything; however, a user cannot control who can write.

Bitcoin is 'write-uncontrolled, read-uncontrolled',[47] which means anyone can write a new block or read a block. Permissioned blockchains, in contrast, can be designed to be write-controlled and read-controlled. In such blockchains, protocols can be set up in such a way that only permissioned participants can write into or read the database. Ripple, for instance, runs a permissioned blockchain. It determines the nodes that may act as transaction validators. In permissionless blockchains, anyone can join the network and participate in block verification to create consensus and smart contracts.

A key advantage of private or permissioned blockchains is higher speed to process transactions compared to permissionless blockchains. An example of permissioned blockchain used in humanitarian projects is the World Food Programme (WFP)'s 'Building Blocks' pilot launched in 2017 to help refugees. In the first stage, Building Blocks distributed food and cash assistance to needy families in Pakistan's Sindh province. In May 2017, the WFP started distributing food vouchers in Jordan's refugee camps by delivering cryptographically unique coupons to participating supermarkets. Supermarket cashiers were equipped with iris scanners to identify the beneficiaries and settle payments. United Nations databases verify the biometric data of the refugees. Building Blocks' ledger records the transactions on a private version of the Ethereum blockchain: the Parity Ethereum. No banks are involved and beneficiaries thus receive goods directly from the merchants. The Parity Ethereum used in the system employs four nodes to validate transactions.[48] This means that transactions cannot be seen by actors who are not a part of the authorised peer nodes. An additional benefit is that Ethereum miners are not needed to validate the transactions. This feature removes a key bottleneck to the processing speed and transaction capacity.[49] The system is thus designed to scale.

Just like the Swedish system, the AP project uses permissioned blockchains. In the Swedish system, relevant data, such as the authenticity of land transaction-related processes, signatures, files confirming ownership and mortgage deeds, are secured in the blockchain of the Swedish land authority, Lantmäteriet. The copies of the records are also stored and validated by other participants (eg banks). Authorised third parties can verify information. These third parties are

[46] Fintech, "Using Blockchain for Commercial Real Estate."
[47] Bauerle, "What Is."
[48] Stanley, "UN."
[49] Wong, "UN Is Using Ethereum's Technology."

part of the process such as banks, buyers, sellers and real estate agents.[50] When a land title changes hands, each step of the process is verified and recorded. While this system provides a highly secure and transparent verification and storage service for property transactions, it does not function as a full-blown cryptocurrency in which land can be bought and sold in the same manner as a bitcoin transaction.[51] The nodes in AP's land records include the Revenue Department, the Chief Commissioner of Land Administration and other officials.

Implementing blockchain in AP

The director of land laws and policy of the advocacy group Landesa noted that community involvement would be important to verify ownership, resolve disputes and obtain 'clean' land records, especially in rural areas.[52] Some landowners expressed suspicion and distrust towards the blockchain-based system. In particular, the stages before the land records are moved to blockchain are prone to fraud.[53] The Capital Region Development Authority (CRDA) officials visited villages to address these concerns, educate landowners and explain the benefits of using blockchain in land registry before starting the project.[54]

A typical land record in blockchain comprises 58 attributes.[55] These include static attributes that describe the property, such as a unique ID, plot code, geo-coordinates (latitude and longitude), survey number, boundary information (eg information about neighbouring plots, location in relations to roads or other landmarks) and classification of land, as well as dynamic attributes that are subject to change, such as owner (eg Aadhaar number) and mortgage information, right of first refusal (ROFR) and litigation status. Events such as mutation, court case filing, stay issued by the court, sale, approval of buildings, conversion of lands (eg from agricultural to commercial), mortgage, and the owner's death are also recorded. The system also provides flexibility to add new attributes if such needs arise in the future.[56]

Benefits and limitations of blockchain-based land registry systems

Benefits

The case of AP sheds light on various potential benefits of blockchain-based land registry systems, as analysed in this section.

Reduction in administrative and bureaucratic inefficiency and corruption

Bureaucratic inefficiency and corruption in India and other GS economies have been well documented. A study by the civil society organisation Daksh indicated that property-related disputes in India account for 66% of all civil cases and cost the country 0.5% of the gross

[50] chromaway.com, "Land Registry in the Blockchain – Testbed."
[51] Wong, "Sweden's Blockchain-Powered Land Registry."
[52] Chandran, "Indian States Look to Digitize."
[53] Bhattacharya, "Blockchain Is Helping Build."
[54] Ibid.
[55] Ibid.
[56] Sai Baba, "Securing Land Records through Blockchain."

domestic product annually. About US$700 million in bribes related to land transactions is paid every year.[57]

The digitisation of land records does not necessarily address these problems. In the absence of appropriate measures, digitisation of land records may lead to manipulation of the land market process by powerful actors.[58] For instance, errors such as wrongly spelled names, or incorrect entries of survey numbers or measurements, were frequent complaints raised against the Bhoomi system. Rectification of such errors involved multiple visits to the taluk and paying bribes.[59] In this way, the Bhoomi system opened new avenues for inefficiency and corruption.

Regarding the corruption of the centralised system, the then AP Deputy CM Bose put the issue this way: 'The system itself (poor maintenance of records) is the root cause of corruption. Once we purify the records and make them tamper-proof, corruption will be eradicated'.[60]

A blockchain-based system in which many agencies act as nodes or validators of transactions allows these agencies to serve as checks and balances for one another, to assure that no agency can manipulate the system without being noticed by others. Blockchain-based land record systems may use various types of consensus algorithms such as proof of work and proof of stake, in which all or some nodes verify transactions such as a change in the landowner's name for a plot.[61] Following this, a new block of data involving land transactions is added to the ledger.

As noted above, the AP's system, just like the WFP's 'Building Blocks', relies on a small number of nodes to validate land-related transactions. In general, blockchains with a small number of data validators are less trustworthy compared to those with a large number of validators. Despite this, while bribes are not impossible, such activities face considerable challenges in blockchain-based records. In the centralised model, powerful and influential actors can pressure the individuals managing centralised databases (such as the Bhoomi system) to change records. In a blockchain-based system, records cannot be tampered with without being noticed by other nodes. Moreover, in the AP system, if any node tries to change the record, the landowner will receive a text message.[62]

Blockchain-based systems can enhance administrative and bureaucratic efficiency. Currently, after a land transaction is finalised, the officer in charge of the collection of land revenues (tehsildar) needs to submit a land demarcation to register the deed. The process takes one to three months.[63] With blockchain, properties can be transferred in a day without paying bribes. The system would also be integrated with the property tax system,[64] which can lead to further efficiency improvements.

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[57] Bhattacharya, "Blockchain Is Helping Build."
[58] Benjamin, Bhuvaneswari, and Rajan, "Bhoomi: 'E–Governance.'"
[59] Ramnani, "Transfer of Property Title Likely."
[60] ENS, "Andhra Government to Adopt Blockchain Tech."
[61] Vos, Lemmen, and Beentjes, "Blockchain-Based Land Administration."
[62] ENS, "Andhra Government to Adopt Blockchain Tech."
[63] Ramnani, "Transfer of Property Title Likely."
[64] Saibaba, "Securing Amaravati Smart City."

Blockchain can also lead to important cost-saving opportunities. Before the implementation of blockchain, farmers needed to pay at least US$68 to prepare registration papers in the AP state. They can obtain system-generated digital documents for free in the blockchain system. A digital document with a quick response (QR) code can be sent directly to the land registrar for transactions.[65]

Comparatively more beneficial for poorer populations than simple digitisation

In the Bhoomi system, large and middle-level farmers and other powerful economic groups took advantage of the centralised systems of land records to benefit themselves at the expense of small farmers. Blockchain-based systems are designed to prevent corrupt behaviours, in which well-connected and powerful actors benefit in an unfair and illegal way. Blockchain-based land registry systems are more beneficial for poorer populations, and contribute more significantly to poverty reduction, compared to digitisation alone.

Stimulation of entrepreneurial activities and productivity

The lack of land ownership, and the lack of documents to prove land ownership, remain among the most important barriers to entrepreneurship and economic development in India.[66] The AP state hoped that a blockchain-based land registry system would allow people to collateralise property, receive loans from financial institutions, and make investments using that asset.[67] Detailed (with dozens of static, dynamic and event-related attributes) and verifiable information on land transactions would increase landowners' access to financial information.

Furthermore, the integration of the blockchain system with data related to soil and climatic conditions, availability of water, and other environmental conditions would benefit land owners. Such information would help them take actions to increase productivity.

Higher level of cybersecurity

Centralised databases are also susceptible to hacking. In 2018, the Bhoomi system experienced a security breach in which nefarious actors transferred 19 acres of government wasteland in Devanahalli taluk to a private individual. Some of the largest owners of land, known as land sharks, were suspected to have manipulated the records. The Bhoomi software had been breached twice before, in which hackers made attempts to transfer government properties to private persons.[68] While nefarious actors can also exploit loopholes in blockchain systems,[69] such systems are still more secure than centralised systems.[70] For instance, even if a hacker penetrates a blockchain network and changes records, multiple redundant and identical copies of the same records are stored in multiple computers, which serve as backups.[71]

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[65] Bhattacharya, "Blockchain Is Helping Build."
[66] Kshetri, "Fostering Startup Ecosystems in India."
[67] Battacharya, "India's Government Wants to Kill Bitcoin."
[68] Akshatha, "Karnataka's Famed Land Record Database."
[69] Lemieux, "Evaluating the Use of Blockchain."
[70] Kshetri, "Blockchain's Roles in Strengthening Cybersecurity."
[71] Ibid.

Limitations

The discussion above revealed some limitations preventing GS economies' realisation of the full benefits of blockchain-based land registry systems. In private blockchains such as the one used in AP, individual landowners would not be able to access their records.[72] While QR code-based property ownership certificates containing details about all transactions are issued, the owners would lack complete control over their data.[73]

Second, while blockchain systems are secure and trustworthy, their data – like that of other databases – are only as accurate as what is entered. In AP's case, some of the land records are reported to be of poor quality.[74] Without clean records, blockchain's potential as a trust machine cannot be realised.

Third, despite improving literacy rates in the state, a large proportion of the population lacks the literacy and digital skills required to benefit from the blockchain system. For instance, in 2020, AP's adult literacy rates were 80% for males and 69% for females.[75] Fourth, a large proportion of the state's population lacks Internet access. As of January 2021, AP's Internet penetration was 31%, which was below the national average of 36%.[76]

Facilitators for and barriers to implementing blockchain-based land registry

Having discussed the comparative benefits of a blockchain-based land registry system, this section examines how the AP case revealed several facilitators to the development of a blockchain-based land registry system. First, AP's performance in digitisation has been improving. According to the CRDA, in Amaravati, at least one family member on average has a cellphone with Internet access.[77] AP's land records were already digitised, and thus could be more easily moved to blockchain.[78] After completing the survey of the state's land using advanced technologies such as drones, aerial photography, mobile work stations, continuously operating reference station (CORS) networks and rovers, the AP revenue department is planning to assign a unique identification number to every land parcel.[79] At the national level, the government agency Unique Identification Authority of India (UIDAI) was established in 2009 to provide a 12-digit unique identity number to each of India's residents or passport holders. The number, known as Aadhaar, is based on biometric and demographic data. As noted above, the Aadhaar number is one of the attributes a blockchain-based land record. Thus, AP already had most of the foundational elements needed for a blockchain-based land registry system and did not have to start the project from scratch.

Second, foreign and local blockchain companies have played different but complementary roles. Established foreign blockchain firms are likely to offer more sophisticated applications and

[72] Ledger Insights, "Indian State."
[73] Sai Baba, "Securing Land Records through Blockchain."
[74] Panchapagesan, "Can Blockchain Solve Land Record Problems?"
[75] U. Rao, "Andhra Pradesh's Literacy Rate."
[76] V. K. Rao, "AP Internet Penetration."
[77] Bhattacharya, "Blockchain Is Helping Build."
[78] Ibid.
[79] ETGovernment, "Andhra Pradesh Govt to Digitize."

services compared to local companies. For instance, ChromaWay had gained significant experience working with Sweden's land registry authority, Lantmäteriet.[80] Local blockchain companies, on the other hand, are more effective at providing low-cost solutions suitable for local needs. The involvement of local start-up Zebi Data, for example, reduced implementation costs (Table 1). It took just a few weeks and cost about US$0.07/record to move the first 83,000 electronic records to blockchain.[81] It has been argued that the operations of developed world-based technology companies competing for economic advantage in cyberspace are akin to the way the European colonial powers competed to claim allegiance and resources from the colonies.[82] The emergence of local firms such as Zebi Data can help mitigate such concerns. Also, in January 2021, the Indian government published a National Strategy on Blockchain, which is likely to facilitate the creation of more local start-ups and the manpower needed to develop and implement blockchain-based land registry projects.[83]

Third, the uptake and use of new technologies hinge critically on intention, desire and commitment on the part of a government to carry through significant political reforms as well as the agreement of and support from state officials and other key actors.[84] AP's blockchain project has been driven by strong political will from the highest level. There has been continued support to the project even after the TDP was defeated in the 2019 election and the opposition party took control of the state. In December 2019, the then Deputy CM Pilli Subash Chandra Bose emphasised the importance of blockchain for a 'perfect' and 'tamper-free' maintenance of land and planned a satellite survey of the state's 33 million acres of land, at a cost of US$266 million.[85] Without continuous political support, high-profile technology projects would not succeed.

Finally, the adoption of blockchain to manage land records requires institutional and legal arrangements.[86] Rules and regulatory agencies governing land management facilitated the implementation of blockchain in AP. In 2012, the AP government established the AP Land Management Authority (APLMA) as a single-window facility for allotment of lands for various purposes. The APLMA is also charged with monitoring the utilisation of land for the intended purpose and imposing penalties against violators.[87] Amaravati was developed as a Greenfield Smart City. The institutional policy frameworks follow guidelines that emphasise data governance, which is required for the smooth functioning of a smart city.[88]

The Andhra Pradesh Capital Region Development Authority (APCRDA) Act was passed in 2014. The APCRDA's authority included planning, development, regulation and promotion of environmentally friendly investments.[89] Most of the land plots were not acquired but 'pooled' under the APCRDA Act. Under the Land Pooling Scheme (LPS), landowners in the capital

[80] Asia Insights, "This Indian City Is Embracing."
[81] Ibid.
[82] McClure, "Wild, Wild Web."
[83] Meit, "National Strategy on Blockchain."
[84] Daniel and Speranza, "Role of Blockchain in Documenting."
[85] Ibid.
[86] Ibid.
[87] Express News Service, "AP Land Management Authority Constituted."
[88] Saibaba, "Securing Amaravati Smart City."
[89] APCRDA, "Amaravati Sustainable Capital City."

region could volunteer to transfer their plots to the state government. A portion of the land would be returned to the owner as a developed plot.[90] Between June 2014 and February 2015, over 13,000 hectares of agricultural land from over 25,000 landholders in 28 villages were pooled.[91] The pooling feature increased the ease of implementation of the blockchain project, since problems such as boundary disputes did not arise.

Table 1. Blockchain-based land registry projects in AP: A timeline of key events.

Time	Activity	Remarks
June 2014	The LPS started.	Pooled under the APCRDA Act.
February 2015	AP pooled over 13,000 hectares of agricultural land.	Over 25,000 landholders in 28 villages participated.
2017	AP government announced plans to use blockchain for land registry.	Collaborated with ChromaWay.
December 2017	CRDA started entering land registration data in blockchain.	CRDA officials visited villages to educate landowners and explain the benefits of the project before starting.
January 2018	About 100,000 land records were put in blockchain.[92]	The solutions were developed by Zebi Data, which did the data entry for the project.
March 2018	The government of AP signed a memorandum of understanding (MoU) with blockchain company ConsenSys.	ConsenSys agreed to provide strategic technical advisory services to develop blockchain use-cases.[93]
Apr 2018	RBI-regulated bodies were prohibited to have relations with entities dealing with cryptocurrencies.	It negatively affected blockchain ecosystem.
Jul 2018	40,000 plots were allocated.[94]	Over 24,000 farmers received land plots.
May 2019	TDP chief Naidu was defeated in the state election.	YSR Congress Party's Reddy became new CM.
Dec 2019	The AP government announced a plan to conduct a satellite survey of the state's land.	Estimated to cost US$266 million.
Dec. 2020	The AP government announced that the planned satellite survey would start in 2021, and it is expected to be completed by August 2023.	Modern technologies such as drones, aerial photography, mobile work stations, CORS networks and rovers will be used to accurately determine land parcel map boundaries.[95]

AP = Andhra Pradesh; APCRDA = Andhra Pradesh Capital Region Development Authority; CRDA = Capital Region Development Authority; RBI = Reserve Bank of India; YSR = Yuvajana Shramika Rythu; TDP = Telugu Desam Party; CM = Chief Minister; CORS = continuously operating reference station.

Nonetheless, several barriers have limited the implementation of blockchain-based land registry systems in the AP state. One of the largest obstacles to implementing blockchain-based land titling was political rivalry. In 2014, Naidu suggested that the Amaravati project could be completed in five years at a cost of US$15 billion.[96] As of late 2019, the city had not shown

[90] Bhaskaran, "What Happens to Amaravati?"
[91] Jitendra, "Andhra Pradesh Farmers."
[92] Kurmanath, "In AP Capital, Blockchain Technology."
[93] Khatri, "Andhra Pradesh Govt. Signs MoU."
[94] Bhattacharya, "Blockchain Is Helping Build."
[95] ETGovernment, "Andhra Pradesh Govt to Digitize."
[96] Ibid.

much evidence of progress. A major newspaper noted that Amaravati remained 'little more than dust and farms'.[97]

Some interpreted it as Naidu's 'pet project' undertaken mainly to benefit his caste, the Kammas.[98] Others accused Naidu of pursuing the extravagant project for his personal gain and prestige.[99] The opposition leader in the AP Assembly claimed that land plots were arbitrarily allotted to the TDP leaders and bureaucrats.[100] The new CM also argued that the LPS was a land scam and accused Naidu of engaging in 'insider trading'.[101] Naidu, on the other hand, claimed that the national government had not fulfilled its promises regarding financial aid and incentives that it made during its split from Telangana.[102] The country's finance minister, however, argued that the central government had given AP what it had promised.[103] It was reported that, three years after the lands were acquired, the contributing farmers had no land and no jobs. At the same time, their living costs rose, which reduced the real value of the compensation.[104]

In land record projects such as the Bhoomi system,[105] some landowners lost their property rights. Fears that this will occur have also been noted in AP's blockchain project. There were rumours that farmers would be forced to give their lands to the government without compensation if they refused to participate in the LPS. These hidden economic and non-economic costs, which have not been properly measured, underestimate the burden imposed on farmers. Other costs, such as those associated with acquiring the lands and digitising the records, also have not been accounted for. Thus, the costs of about US$0.07 per record of moving onto the blockchain system reported by the AP state are only the 'tip of the iceberg, and this means that blockchain's value proposition based on the low costs reported by prior studies[106] may not always be applicable.

In May 2019, Yuvajana Shramika Rythu (YSR) Congress Party President Jagan Mohan Reddy was elected as the state's new CM, defeating Naidu.[107] Despite its support for blockchain-based land registry, the YSR Congress Party is against the TDP's and Naidu's policies in general. It was reported that a consortium of Singapore companies that had partnered with the AP government exited the Amaravati project in 2019 due to the political change.[108]

Real estate developers, people from neighbouring cities of Hyderabad and Vijayawada as well as non-resident Indians settled in the West were also reported to have purchased lands in Amaravati.[109] Political rivals could paint blockchain-based land titling projects in a negative light. For instance, Reddy claimed that the lands of Naidu and people close to him were exempted from the LPS while the lands of farmers and others were acquired. He went on to say:

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[97] scmp.com, "Amaravati: The New Indian City."
[98] Bhaskaran, "What Happens to Amaravati?"
[99] scmp.com, "Amaravati: The New Indian City."
[100] Jitendra, "Andhra Pradesh Farmers."
[101] Bhaskaran, "What Happens to Amaravati?"
[102] Ibid.
[103] Ibid.
[104] Jitendra, "Andhra Pradesh Farmers."
[105] Benjamin and Raman, "Illegible Claims."
[106] Dwyer, "Blockchain: A Primer."
[107] Bhaskaran, "What Happens to Amaravati?"
[108] PTI, "Singapore Consortium 'Exits' Amaravati."
[109] Bhaskaran, "What Happens to Amaravati?"

'Even under the land pooling, he [Naidu] paid compensation to whoever he wanted and at whatever rate he wanted'.[110] These issues presented a legitimacy challenge to the projects initiated by Naidu.

Second, despite the above-mentioned progress on the regulatory front in AP, some national-level regulations have posed a challenge. In 2018, India's central bank, the Reserve Bank of India (RBI), initiated a crackdown on cryptocurrencies. All RBI-regulated bodies were prohibited from having business relationships with entities dealing with cryptocurrencies, which negatively affected the blockchain ecosystem.[111]

The lack of blockchain standards and legal and regulatory frameworks for smart contracts has also been of concern.[112] In smart contracts, computerised protocols and user interfaces are used to execute a contract's terms and to 'formalize and secure relationships over public networks'.[113] AP's blockchain system uses smart contracts to allow instant data exchange with banks and financial institutions. This feature makes it possible for landowners to access loan and financial services efficiently.[114] However, there are no clear regulations regarding smart contracts in India.[115] Regulatory and enforcement issues related to public key infrastructure (PKI) and underdeveloped privacy and security practices[116] are not well developed. For instance, while India's Information Technology Act 2000 provides the legal basis for e-signatures, there is a low level of understanding of digital signature laws.[117] Some may thus be concerned about the legal aspects of blockchain-based land records.

Third, large-scale adoption and deployment of blockchain requires local technological capability. A challenge faced by Nigeria's Lagos land title registration project was the lack of skilled personnel to meet various Information Technology (IT) needs.[118] Some concerns have been raised regarding a lack of deep expertise on blockchain-related applications. The head of ConsenSys Ventures noted that blockchain knowledge in India 'was at a very shallow level'.[119] In 2018, out of the country's two million software developers, only 5000 were estimated to have blockchain skills.[120] Following the RBI's crackdown on cryptocurrencies, some established blockchain companies left the country, which adversely affected the blockchain ecosystem. For instance, Zebpay, one of the country's largest virtual cryptocurrency exchanges, closed Indian operations in September 2018 and opened new offices in Malta and Singapore.

Fourth, an inefficient bureaucracy has hampered the development and implementation of blockchain systems. As of August 2018, most blockchain projects in the AP had just completed the proof-of-concept (PoC) phase or were developing PoCs. Some government departments were

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[110] Ibid.
[111] Kshetri, "Indian Blockchain Landscape."
[112] Daniel and Speranza, "Role of Blockchain in Documenting."
[113] Szabo, "Formalizing and Securing Relationships."
[114] Sai Baba, "Securing Land Records through Blockchain."
[115] stalawfirm.com, "Overview: The Enforceability of Smart Contracts."
[116] Thakur et al., "Land Records on Blockchain."
[117] Girish, "Everything You Need to Know."
[118] Thontteh and Omirin, "Land Registration within the Framework."
[119] Kaushik, "Need to Build a Big Ecosystem."
[120] Agarwal, "Blockchain: India Likely to See."

not motivated to move beyond the PoC stage.[121] There are also potential issues related to conflict and power relationships. In India, there has also been confusion regarding the central authority to handle blockchain systems.[122]

Finally, the experiences of government blockchain projects in AP and other Indian states have shown that the migration and integration of legacy IT and database management systems into a blockchain-based system would be a difficult task.[123] A major barrier is that different systems from which data need to be transferred to the blockchain system use different data formats and models.[124] The integration of diverse data and systems into blockchain platforms could be costly and time consuming.

Discussion and implications

Blockchain-based land records can provide many benefits for GS economies. Tamper-proof property titles in a digital form provide many benefits. Thanks to a 'super audit trail' and powerful checks and balances, blockchain-based land registries reduce predatory risks from government officials and other actors and streamline the process of buying and selling lands. A typical property sale involves many stakeholders such as a land registry, a buyer, a seller, lawyers, mortgage providers, mortgage surveyors and estate agents. Blockchain can make the entire process more transparent and cut bureaucratic red tape, thus reducing the time and costs of property-related transactions.

As noted above, the EDMS showed no improvement in resolving boundary disputes.[125] In the AP, thanks to the LPS, each plot has newly defined boundaries. Satellite imageries and geofencing will provide detailed information about the precise boundaries. The private corporate sector could take advantage of the Bhoomi system's centralised control of information in which a small group of technologists and senior bureaucrats had the power to influence decisions.[126] In AP's blockchain-based land recording systems different independent government agencies act as nodes, which means that one agency cannot change the record without being noticed by others.

The availability of unambiguous and immutable property titles also releases significant amounts of capital into the economic ecosystem. The title holders can use their property as a collateral to obtain loans from financial institutions. Blockchain can thus unlock economic development in markets characterised by the lack of trust in governing bodies.[127]

The discussion above suggests that blockchain has amplified benefits beyond its direct effects if it is combined with technologies such as satellite imagery. For instance, measurement errors can be reduced significantly by utilising geofencing. The systems generate a unique ID for each

[121] Murali, "Most Government Blockchain Projects."
[122] Poojay, "State Governments Embrace Blockchain."
[123] Ibid.
[124] Kumar, "Blockchain: What Are the Implementation Challenges?"
[125] Ibid.
[126] Benjamin and Raman, "Illegible Claims."
[127] Malinger, "Blockchain Could Change Everything."

property based on geofencing, which involves forming virtual perimeters for a real-world geographic area.[128]

In the absence of efforts to create a level playing field, newly available data resulting from initiatives such as the computerisation of land records may further increase social divides, leaving the poor further marginalised.[129] As noted above, the Bhoomi programme significantly weakened the power and influence of local institutions.[130] For small farmers, dealing with land-related issues in the Bhoomi system became more time-consuming and costly than in the pre-Bhoomi system. In systems such as Bhoomi, the digital divide thus puts the poor at a disadvantage. AP's plan is to handle land records at the village level,[131] which can overcome the problems associated with a centralised database. Blockchain systems put small farmers in a better position than centralised databases, as landowners can obtain system-generated digital documents with a QR code at no cost.

The concept of technological determinism provides a valuable framework to understand how technologies are linked with human and social activities.[132] One version of the theory views the society as 'an inevitable or autonomous technological order based on certain laws'.[133] Other versions claim that technologies play a dominant role in social changes but the cultural meaning given to the technology by people is important. Putting things in context, poor people and elites differ in their interpretations, judgements and responses to high-technology projects. Moreover, different technological systems are interpreted differently by different groups. Whereas corporate private sector and economic elites such as land sharks benefit disproportionately from centralised databases, blockchain-based land registries are likely to shift the benefits towards small farmers.

While other researchers have noted the importance of institutional changes and transformations in order to apply blockchain for asset registry, the nature of the required changes is not well understood.[134] In this regard, our analysis extended the prior work by providing some descriptions of required institutional changes. For instance, AP's LPS under the APCRDA provided institutional readiness to implement a blockchain-based land registry. The AP experience also underscores the importance of broad political support. Due to political rivalry, the project failed to gain wide support. Significant changes thus cannot be brought by technology disruptors alone. Regulatory frameworks need to be revised to new models of property ownership. A proper collaboration among participants such as blockchain innovators and industry incumbents is also necessary to maximise the benefits.[135]

The benefits of blockchain in land administration have not been fully achieved due to the technology's immaturity and the underdeveloped standardisation of real estate transaction processes.[136] Regarding the argument that land titling systems could be blockchain's 'low-

[128] Sai Baba, "Securing Land Records through Blockchain."
[129] Gurstein, "Open Data: Empowering the Empowered."
[130] Benjamin and Raman, "Illegible Claims."
[131] ENS, "Andhra Government to Adopt Blockchain Tech."
[132] Bimber, "Karl Marx and the Three Faces."
[133] Ibid.
[134] Ølnes, Ubacht, and Janssen, "Blockchain in Government."
[135] Malinger, "Blockchain Could Change Everything."
[136] Vos, Lemmen, and Beentjes, "Blockchain-Based Land Administration."

hanging fruit',[137] the above discussion illustrates that implementing such systems is far from easy. However, when the technology matures, and institutions become more favourable, blockchain's potential could be more fully realised. For instance, the WFP expects that refugees may be able to access their funds by controlling their own cryptographic keys. This would also allow them to incorporate personal data from diverse sources such as medical records, academic credentials and nutritional data.[138] Currently in the AP project, citizens engaged in buying and selling property do not need to have blockchain accounts or wallets. They interact with the land registry system in the same manner as they did before. In the future, landowners may access their records in blockchain to engage in transactions.

AP made rapid progress in the early stages of blockchain deployment. The population in Amaravati was predominantly from the same caste community as Naidu, who initiated the project. Due to this homogeneous population, developing preconditions required for the project was relatively easy and practical. The case of Amaravati is far from representative of other villages and cities. GS countries with heterogeneous ethnic and cultural backgrounds may show a higher degree of resistance to such projects.

The issues of cost and access are important. Blockchain projects can be designed and implemented at reasonably low costs if local firms can provide the solutions. Regarding implementation costs and absorptive capacity, the lack of blockchain manpower is a major roadblock that will prevent GS economies from taking advantage of this technology.

Concluding remarks

Blockchain-based systems provide easy, trustworthy and tamper-proof mechanisms to create, implement and enforce property rights. Such systems can reduce friction and corrupt practices and costs of property registration. Thus, blockchain-based land registry projects can bring significant social and economic benefits to communities.

With blockchain, the benefits of digitisation of land records can be amplified and major limitations of such records can be overcome. Digitisation of land records has some benefits but also some downsides. Blockchain-based property registration systems can counter the negative aspects of digitisation, such as those observed in the Bhoomi system, and help realise the intended benefits. Current centralised systems are susceptible to manipulation, and the information is likely to be put to inappropriate uses. Blockchain's decentralised access and immutability mean that malicious actions can be detected and prevented. At the same time, blockchain's immutability is only useful if measures are taken to ensure that land-related data entered into the ledger are accurate.

Many important prerequisites have to be fulfilled for the successful implementation of a blockchain-based land registry system. For instance, AP's land records were already digitised, which made it easy to enter them into the blockchain system. The planned survey of the state's land using advanced technologies is likely to further increase the accuracy of the land data. A high level of smartphone access and technology literacy are also important. Commitment on the

[137] Swan, "Anticipating the Economic Benefits of Blockchain."
[138] Wong, "UN Is Using Ethereum's Technology."

part of the government, political consensus to promote the technology and broad public support are some of the key factors that lead to large-scale adoption of blockchain in property rights enforcement. The blockchain-based land registration system has received high political priority in AP. GS economies that lack these factors may not be able to benefit from blockchain-based land registry.

Digitisation by itself thus does not necessarily lead to poverty reduction or better property management. By putting digitised land data in blockchain, however, a number of goals such as poverty reduction, efficiency in land transaction and cybersecurity of land records can be achieved.

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Bibliography

Agarwal, M. "Blockchain: India Likely to See Brain Drain as 80% Developers May Move Abroad." 2018. https://inc42.com/buzz/blockchain-india-likely-to-suffer-brain-drain-as-80-developers-prepare-to-move-abroad/

Akshatha, M. "Karnataka's Famed Land Record Database Bhoomi Faces Another Security Breach." September 10, 2018. https://tech.economictimes.indiatimes.com/news/corporate/karnatakas-famed-land-record-database-bhoomi-faces-another-security-breach/65748534

APCRDA. "Amaravati Sustainable Capital City Development Project (ASCCDP)." Andhra Pradesh Capital Region Development Authority, Government of Andhra Pradesh, Amaravati.

August, 2017. https://documents1.worldbank.org/curated/pt/650051486971245674/pdf/Environmental-and-Social-Manageent-Framework.pdf

Appu, P. S. *Land Reforms in India: A Survey of Policy, Legislation and Implementation*. New Delhi: Vikas Publishing House, 1997.

Asia Insights. "This Indian City Is Embracing BlockChain Technology – Here's Why." 2018. https://www.forbes.com/sites/outofasia/2018/03/05/this-indian-city-is-embracing-blockchain-technology-heres-why/#617e45b48f56

Bandyopadhyay, R. "Land System in India: A Historical Review." *Economic and Political Weekly* 28, no. 52 (1993): A149–A155.

Battacharya, A. "India's Government Wants to Kill Bitcoin, But It Loves Blockchain." 2018. https://qz.com/1148361/budget-2018-indias-government-wants-to-kill-bitcoin-but-it-loves-blockchain/

Bauerle, N. "What is the Difference Between Public and Permissioned Blockchains." Coindesk, 2019. https://www.coindesk.com/information/what-is-the-difference-between-open-andpermissioned-blockchains

Benjamin, S., R. Bhuvaneswari, and P. Rajan. "Bhoomi: 'E–Governance', or, an Anti-Politics Machine Necessary to Globalize Bangalore?" *CASUM–m Working Paper*, 2007. https://www.semanticscholar.org/paper/Bhoomi-%3A-%E2%80%98-E-Governance-%E2%80%99-%2C-Or-%2C-An-Anti-Politics-Benjamin-Bhuvaneswari/f07edf3436b77a7888558ba95e37d3951875703e

Benjamin, S., and B. Raman. "Illegible Claims, Legal Titles, and the Worlding of Bangalore." *Dans Revue Tiers Monde* 2, no. 206 (2011): 37–54.

Bhaskaran, N. "What Happens to Amaravati? On the Ground, Ambiguity Remains." *The News Minute*, 2019. https://www.thenewsminute.com/article/what-happens-amaravati-ground-ambiguity-remains-105609

Bhattacharya, A. "Blockchain Is Helping Build a New Indian City, But It's No Cure for Corruption." July 17, 2018. https://qz.com/india/1325423/indias-andhra-state-is-using-blockchain-to-build-capital-amaravati/

Bimber, B. "Karl Marx and the Three Faces of Technological Determinism." *Social Studies of Science* 20, no. 2 (1990): 333–351. https://doi.org/10.1177/030631290020002006.

Chandran, R. "Indian States Look to Digitize Land Deals with Blockchain." 2017. https://www.reuters.com/article/us-india-landrights-tech/indian-states-look-to-digitize-land-deals-with-blockchain-idUSKBN1AQ1T3

chromaway.com. "The Land Registry in the Blockchain – Testbed." 2017. https://chromaway.com/papers/Blockchain_Landregistry_Report_2017.pdf

Daniel, D., and C. I. Speranza. "The Role of Blockchain in Documenting Land Users' Rights: The Canonical Case of Farmers in the Vernacular Land Market." *Frontiers in Blockchain* 3 (2020): 19. doi:https://doi.org/10.3389/fbloc.2020.00019.

Dwyer, G. "Blockchain: A Primer." MPRA Paper 76562, University Library of Munich, Germany, 2016.

ENS. "Andhra Government to Adopt Blockchain Tech to End Land Record Tampering." *The New Indian Express*, 2019. https://www.newindianexpress.com/states/andhra-pradesh/2019/dec/15/andhra-government-to-adopt-blockchain-tech-to-end-land-record-tampering-2076359.html

ETGovernment. "Andhra Pradesh Govt to Digitize Land Records Through State-Wide Resurvey Using Hybrid Technology." December 2, 2020. https://government.economictimes.indiatimes.com/news/digital-india/andhra-pradesh-govt-to-digitize-land-records-through-state-wide-resurvey-using-hybrid-technology/79530468

Express News Service. "AP Land Management Authority Constituted." October 12, 2012. https://www.newindianexpress.com/states/andhra-pradesh/2012/oct/12/ap-land-management-authority-constituted-414517.html

Fintech. "Using Blockchain for Commercial Real Estate." Nanalyze, 2020. https://www.nanalyze.com/2020/01/blockchain-commercial-real-estate/

Gebre, S. "Blockchain Opens Up Kenya's $20 Billion Informal Economy." *Bloomberg*, June 13, 2018. https://www.bloomberg.com/news/articles/2018-06-14/blockchain-is-opening-up-kenya-s-20-billion-informal-economy

Girish, D. "Everything You Need to Know about E-Signature Laws in India." *Sign Easy*. https://signeasy.com/blog/electronic-signature-law/esign-law-india/

Graglia, J. M., and C. Mellon. "Blockchain and Property in 2018: At the End of the Beginning." *Innovations: Technology, Governance, Globalization* 12, no. 1–2 (2018): 90–116. doi:https://doi.org/10.1162/inov_a_00270.

Gurstein, M. "Open Data: Empowering the Empowered or Effective Data Use for Everyone?" *First Monday* 16, no. 2 (2011). https://firstmonday.org/ojs/index.php/fm/article/view/3316/2764 doi:https://doi.org/10.5210/fm.v16i2.3316.

Hanstad, T. "The Case for Land Reform in India." 2013. https://www.foreignaffairs.com/articles/india/2013-02-19/untitled?cid=soc-twitter-in-snapshots-untitled-022013

Heston, A., and V. Kumar. "Institutional Flaws and Corruption Incentives in India." *The Journal of Development Studies* 44, no. 9 (2008): 1243–1261. doi:https://doi.org/10.1080/00220380802264960.

Islam, A., and W. Lee. "Bureaucratic Corruption and Income: Evidence from the Land Sector in Bangladesh." *The Journal of Development Studies* 52, no. 10 (2016): 1499–1516. doi:https://doi.org/10.1080/00220388.2016.1146702.

Jitendra. "Andhra Pradesh Farmers Get a Raw Deal in Exchange of Land." *DownToEarth*, 2017. https://www.downtoearth.org.in/news/governance/capital-loss-58663

Kaushik, M. “Need to Build a Big Ecosystem for Blockchain in India: Kavita Gupta of ConsenSys Ventures.” 2018. https://www.businesstoday.in/opinion/interviews/need-to-build-a-big-ecosystem-for-blockchain-in-india-kavita-gupta-of-consensys-ventures/story/278701.html

Kenny, C. “How Much Aid Is Really Lost to Corruption?” Center for Global Development, 2017. https://www.cgdev.org/blog/how-much-aid-really-lost-corruption

Khatri, B. “Andhra Pradesh Govt. Signs MoU with ConsenSys for Blockchain Innovation in the State.” March 6, 2018. https://inc42.com/buzz/andhra-pradesh-govt-mou-consensys-blockchain/

Kriticos, S. “Keeping It Clean: Can Blockchain Change the Nature of Land Registry in Developing Countries?” *World Bank Blogs*, 2019. https://blogs.worldbank.org/developmenttalk/keeping-it-clean-can-blockchain-change-nature-land-registry-developing-countries

Kshetri, N. “Blockchain-Based Financial Technologies and Cryptocurrencies for Low- Income People: Technical Potential Versus Practical Reality.” *Computer Magazine* 53, no. 1 (2020): 18–29. doi:https://doi.org/10.1109/MC.2019.2951977.

Kshetri, N. “Blockchain’s Roles in Strengthening Cybersecurity and Protecting Privacy.” *Telecommunications Policy* 41, no. 10 (2017): 1027–1038. doi:https://doi.org/10.1016/j.telpol.2017.09.003.

Kshetri, N. “Fostering Startup Ecosystems in India.” *Asian Research Policy* 7, no. 1 (2016): 94–103.

Kshetri, N. *Global Entrepreneurship: Environment and Strategy*. 2nd ed. New York: Routledge, 2019.

Kshetri, N. “The Indian Blockchain Landscape: Regulations and Policy Measures.” *Asian Research Policy* 9, no. 2 (2018): 56–71.

Kshetri, N. “Will Blockchain Emerge as a Tool to Break the Poverty Chain in the Global South?” *Third World Quarterly* 38, no. 8 (2017): 1710–1732. doi:https://doi.org/10.1080/01436597.2017.1298438.

Kshetri, N., and J. Voas. “Blockchain in Developing Countries.” *IT Professional* 20, no. 2 (2018): 11–14. doi:https://doi.org/10.1109/MITP.2018.021921645.

Kumar, P. “Blockchain: What Are the Implementation Challenges?” 2018. https://www.idgconnect.com/blog-abstract/29865/blockchain-what-implementation-challenges

Kurmanath, K. V. “In AP Capital, Blockchain Technology Secures Land.” January 8, 2018. https://www.thehindubusinessline.com/info-tech/in-ap-capital-blockchain-technology-secures-land-records/article10020465.ece#

Lantmateriet. “The Land Registry in the Blockchain.” Blockchain Landregistry Report, 2016. http://ica-it.org/pdf/Blockchain_Landregistry_Report.pdf

Ledger, Insights. “Indian state to adopt blockchain in governance.” August 19, 2019. https://www.ledgerinsights.com/indian-state-maharashtra-blockchain-in-government/

Lemieux, V. “Evaluating the Use of Blockchain in Land Transactions: An Archival Science Perspective.” *European Property Law Journal* 6 (2017): 392–440. https://www.degruyter.com/view/j/eplj.2017.6.issue-3/eplj-2017-0019/eplj-2017-0019.xml

Lemieux, V. “Trusting Records: Is Blockchain Technology the Answer?” *Records Management Journal* 26, no. 2 (2016): 110–139. doi:https://doi.org/10.1108/RMJ-12-2015-0042.

Malinger, E. “Blockchain Could Change Everything for Real Estate.” 2017. https://venturebeat.com/2017/11/18/blockchain-could-change-everything-for-real-estate/

Manski, S. “Building the Blockchain World: Technological Commonwealth or Just More of the Same?” *Strategic Change* 26, no. 5 (2017): 511–522. doi:https://doi.org/10.1002/jsc.2151.

Mbogo, A. “Ghana Partners with IBM to Create a Blockchain-Based Land Administration System.” *Bitcoin Africa*, 2018. https://bitcoinafrica.io/2018/07/19/ghana-partners-with-ibm-blockchain-based-land-administration/

Meit, Y. “National Strategy on Blockchain, Government of India Ministry of Electronics and Information Technology.” January, 2021. https://negd.gov.in/sites/default/files/NationalStrategyBCT_%20Jan2021_final_0.pdf

Moreri, K. K., D. Fairbairn, and P. James. “Volunteered Geographic Information Quality Assessment Using Trust and Reputation Modelling in Land Administration Systems in Developing Countries.” *International Journal of Geographical Information Science* 32, no. 5 (2018): 931–929. doi:https://doi.org/10.1080/13658816.2017.1409353.

Murali, A. “Most Government Blockchain Projects in India Are Stuck at the Starting Blocks.” 2018. https://factordaily.com/india-government-blockchain-projects/

Ølnes, S., J. Ubacht, and M. Janssen. “Blockchain in Government: Benefits and Implications of Distributed Ledger Technology for Information Sharing.” *Government Information Quarterly* 34, no. 3 (2017): 355–364. https://doi.org/10.1016/j.giq.2017.09.007.

Panchapagesan, V. “Can Blockchain Solve Land Record Problems?” 2018. https://www.livemint.com/Opinion/t60KeJCjKuEkzU9hEC01GI/Can-blockchain-solve-land-record-problems.html

Poojay, T. “State Governments Embrace Blockchain to Improve Citizen Services, Start with Reform of Land Records.” *Yourstory*, 2018. https://yourstory.com/2018/11/state-governments-embrace-blockchain-improve-citizen-services-start-reform-land-records

PTI. “Singapore Consortium ‘Exits’ Amaravati Start-Up Area Project.” *IndianWeb2*, 2019. https://www.indianweb2.com/2019/09/04/singapore-consortium-exits-amaravati-start-area-project/

Ramnani, V. “Transfer of Property Title Likely on Same Day Through Blockchain.” 2018. https://www.moneycontrol.com/news/business/real-estate/transfer-of-property-title-likely-on-same-day-through-blockchain-2449981.html

Rao, U. “Andhra Pradesh’s Literacy Rate Goes Up but Gender Divide a Concern.” December 19, 2020, The Times of India. https://timesofindia.indiatimes.com/city/visakhapatnam/states-literacy-rate-goes-up-but-gender-divide-a-concern/articleshow/79802446.cms

Rao, V. K. “AP Internet Penetration Lower than National Average.” January 12, 2021, The Times of India. https://timesofindia.indiatimes.com/city/visakhapatnam/ap-internet-penetration-lower-than-natl-average/articleshow/80219473.cms

Sai Baba, N. S. S. “Securing Land Records through Blockchain.” Andhra Pradesh Human Resource Development Institute, February 2, 2020. http://www.aphrdi.ap.gov.in/documents/Trainings@APHRDI/2020/feb_2/Citizen%20Centric%20Services/Block%20Chain%20Technology.pdf

Saibaba, S. “Securing Amaravati Smart City Land Registry with Blockchain Technology.” *Community.Data.gov*, 2019. https://community.data.gov.in/securing-amaravati-smart-city-land-registry-with-blockchain-technology/

scmp.com. “Amaravati: The New Indian City Modelled on Singapore, but Far from It.” *South China Morning Post*, 2018. https://www.scmp.com/news/asia/south-asia/article/2148448/amaravati-new-indian-city-modelled-singapore-far-it

stalawfirm.com. “Overview: The Enforceability of Smart Contracts in India.” December 12, 2019. https://www.stalawfirm.com/en/blogs/view/enforceability-of-smart-contracts-in-india.html

Stanley, A. “U.N. Official Defends Refugee Voucher Program, Even Though It Doesn’t Require Blockchain, Forbes, 9 June, 2018. https://www.forbes.com/sites/astanley/2018/06/09/u-n-official-defends-refugee-voucher-program-even-though-it-doesnt-require-blockchain/?sh=713be1501f66

Swan, M. “Anticipating the Economic Benefits of Blockchain.” *Technology Innovation Management Review* 7, no. 10 (2017): 6–13. https://doi.org/10.22215/timreview/1109.

Swan, M. *Blockchain: Blueprint for a New Economy*. Sebastopol, CA: O’Reilly Media, 2015.

Szabo, N. “Formalizing and Securing Relationships on Public Networks.” *First Monday* 2, no. 9 (1997). doi:https://doi.org/10.5210/fm.v2i9.548.

Thakur, V., M. N. Dorja, Y. Dwivedi, T. Ahmad, and G. Khadange. “Land Records on Blockchain for Implementation of Land Titling in India.” *International Journal of Information Management* (2019). 52, June 2020, 101940. https://www.sciencedirect.com/science/article/pii/S0268401219303329#!

Themistocleous, M. “Blockchain Technology and Land Registry.” *Cyprus Review* 30, no. 2 (2018): 195–202. http://cyprusreview.org/index.php/cr/article/view/579

Thontteh, E. O., and M. M. Omirin. "Land Registration within the Framework of Land Administration Reform in Lagos State." *Pacific Rim Property Research Journal* 21, no. 2 (2015): 161–177. doi:https://doi.org/10.1080/14445921.2015.1058033.

Transparency International. *India Corruption Study 2005*. New Delhi: Transparency International India, 2005.

Vos, J., C. Lemmen, and B. Beentjes. "Blockchain-Based Land Administration: Feasible, Illusory or Panacae?" Paper Prepared for Presentation at the Annual World Bank Conference on Land and Poverty, March 20–24, 2017, Washington, DC.

Wong, J. "Sweden's Blockchain-Powered Land Registry Is Inching towards Reality." 2017. https://qz.com/947064/sweden-is-turning-a-blockchain-powered-land-registry-into-a-reality/

Wong, J. "The UN Is Using Ethereum's Technology to Fund Food for Thousands of Refugees." *Quartz*, November 3, 2017. https://qz.com/1118743/world-food-programmes-ethereum-based-blockchain-for-syrian-refugees-in-jordan/

Yaga, D., N. R. P. Mell, and K. Scarfone. "Blockchain Technology Overview." National Institute of Standards and Technology Internal Report (NISTIR) 8202, Gaithersburg, MD, USA. 2018.

Zwitter, A., and M. Boisse-Despiaux. "Blockchain for Humanitarian Action and Development Aid." *Journal of International Humanitarian Action* 3, no. 1 (2018): 16. doi:https://doi.org/10.1186/s41018-018-0044-5.