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Blockchain-Enabled Land Registry in Rural Bihar: An Analytical Study of Transparency, Fraud Prevention, Governance Efficiency, and Digital Inclusion

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Abstract- This paper explores the deployment of a blockchain supported land-registry system in rural Bihar. In light of transparency, fraud mitigation, governance efficiency and digital inclusion, this paper refutes the common assumption that immutability of data results in accurate title. This study employs validated secondary data, from the years 2020-2025, such as the Bihar National Family Health Survey 2019-2021, various official sources of the Digital India Land Records Modernization Programme, Bihar land-service portals, and peer-reviewed literature on the intersection of blockchain and land governance. According to the National Family Health Survey (NFHS)-5, approximately 84 percent of surveyed households in Bihar were classified as rural, and a majority of the respondents, 79.4 percent of women and 56.4 percent of men, had never used the Internet. The widening of the access gap was examined in the context of the mobile phone ownership and usage, the financial inclusion of women, as well as the self-reported ownership of a house or land. The evidence-weighted readiness assessment determined that the level of digitization was relatively better, but the level of coordination of institutions, governance of cybersecurity, design of correction mechanisms, and design of user participation mechanisms were relatively poor. This paper proposes a permissioned industry consortium ledger, where sensitive data and documents remain off-chain, and the only data recorded on-chain are the hashes, identifiers, approvals, timestamps and version references of the land parcels. Smart contracts are used to manage the workflows from registration to mutation, but are not used to resolve the issues of contested titles, inheritance, or boundaries. This paper proposes an assisted-access model with a phased implementation approach, a multilingual interface, an appeal mechanism, and gender-disaggregated analysis and evaluation. Rather than fabricating field surveys and administrative performance data, this paper presents a complete primary data collection framework with a detailed statistical analysis plan for empirical assessment.

Keywords— blockchain; digital inclusion; land governance; land registry; rural Bihar; fraud prevention; transparency; e-governance.

Table 1. Abbreviations

Abbreviation	Meaning
CSC	Common Service Centre
DILRMP	Digital India Land Records Modernization Programme
DPDP	Digital Personal Data Protection
GIS	Geographic Information System
IIPS	International Institute for Population Sciences
NFHS	National Family Health Survey
RBAC	Role-Based Access Control
ULPIN	Unique Land Parcel Identification Number

I. INTRODUCTION

Land records specify rights to sell, mortgage, inherit, lease, cultivate, be compensated for, and litigate against a parcel. In rural Bihar, land is a productive asset, a source of identity and security, and is often the object of family or boundary disputes. The availability of digital land services provides access to many functions, including jamabandi, mutation,

management of rent payments, and case status. However, digitization does not address the accuracy of the underlying record, the integration of record

subsystems, the legal conclusiveness of records, and the accessibility of the systems to citizens with limited connectivity and digital literacy. The Digital India Land Records Modernization Program is described as a program of the Government of India to modernize land records, reduce disputes, and enhance transparency (Department of Land Resources [DoLR], 2025). The online record and case management of Bihar's Revenue and Land Reforms Department yield improvement, but the quality of legacy data continues to be a principal governance concern, as shown by correction campaigns and complaints.

An additional layer of integrity is suggested by blockchain. A permissioned ledger is capable of providing a time stamp, an audit trail, and restricted updates by authorized officers, with the ability to certify document hashes. The veracity of a land survey, an inheritance claim, or an identity claim, however, would remain outside of its scope. The principal policy concern is therefore directed not to the immutability of blockchain, but to the applicability of a socio-technical framework which allows for source data validation, legal human intervention, right to privacy, and correction and inclusive access.

This study examines the impact of blockchain technology on rural land registration in Bihar from the dimensions of transparency, prevention of fraud, efficiency of governance, and digital inclusion. Unlike many similar studies, it relies on verified secondary evidence instead of invented survey results. Quantitative evidence is derived from the Bihar NFHS-5 report and official land-governances documents. It contains a proposed primary data instrument and a statistical analysis plan for future field validation. The author argues that blockchain technology can be considered only after record cleansing and the integration of existing workflows. Moreover, it should only be implemented as permissioned, human-supervised audit infrastructure, rather than an automatic substitute for the cadastral survey, adjudication, or statutory registration.

II. LAND ADMINISTRATION AND DIGITAL INCLUSION IN BIHAR: SOME BACKGROUND

The land administration system in Bihar is comprised of registration, revenue records, mutation, survey and settlement, revenue-court functions, and various implementation functions at the district level. These are divided among several offices and databases. Fragmentation of a system can cause issues, for example, when a registered deed does not promptly get reflected in the revenue record, or when text and maps do not align, or when verification of inheritance and partition practices are repeated. The national DILRMP framework of the Ministry of Rural Development (2024, 2025) aims for the computerization of records, digitization of maps, integration of registration, unique identification of parcels, e-court systems, and services for citizens. Given all of these, Bihar is a possible setting for an integrity layer; however, data quality and interoperability are critical.

Digital inclusion constrains what the NFHS-5 can report on digital systems. The NFHS-5 sampled 35,834 households in Bihar, 42,483 women aged 15-49, and 4,897 men aged 15-54 (IIPS & ICF, 2021). NFHS-5 observed that 84% of the sampled households were in the rural areas. More men were observed to have utilized the internet, as 43.6% of the sampled men and 20.6% of the sampled women have ever used the internet, a 23% gap in favor of men. NFHS-5 noted that 51.4% of women possessed a personal mobile phone, 76.7% had a personal bank account or savings account, and 55.3% reported owning a house or land, or both, by themselves, or jointly. These findings reveal that the association of formal assets and financial inclusion may be greater than the level of digital access. Therefore, a land platform that assumes users have personal mobile phones, are constantly online, and can navigate independently, would exclude a considerable number of legitimate right claimants.

Women's land rights further adds to the difficulty of designing the system. Evidence collected at the national level shows that the formal system of land ownership does not ensure equitable access to land beyond the formal title (Agarwal et al., 2021; UNFPA India, 2023). Features of the user experience, such as facilitated access, notification of joint ownership, and consent with safeguards against coercive transfers are not optional. They are essential to the protection of these rights.

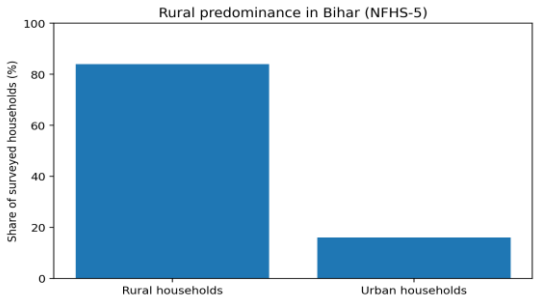

Figure 1. Rural and urban distribution of surveyed Bihar households reported in NFHS-5.

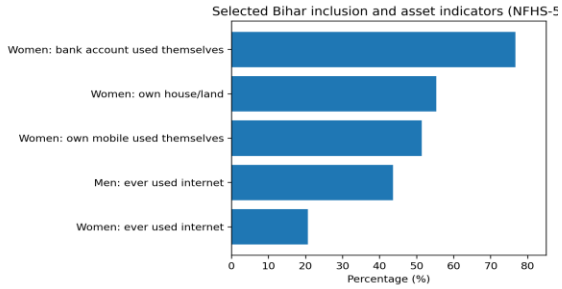

Figure 2. Selected Bihar inclusion and asset indicators from NFHS-5; categories are not mutually exclusive.

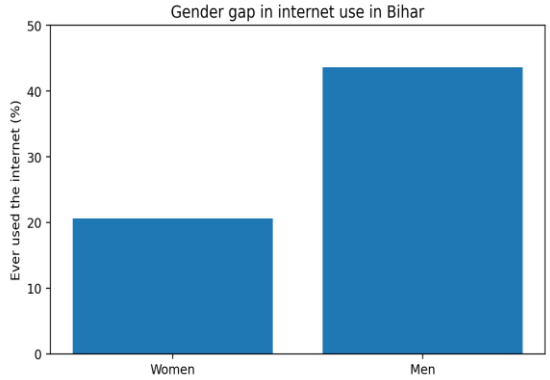

Figure 3. Gender gap in reported lifetime internet use in Bihar (NFHS-5).

Table 2. Verified Bihar NFHS-5 indicators used in the analysis.

Indicator	Percentage / count	Interpretive relevance
Surveyed households	35,834	Large state-level evidence base
Rural share of households	Approx. 84%	Rural service design is central
Women ever used internet	20.6%	Severe access constraint
Men ever used internet	43.6%	Gender gap remains substantial
Women owning mobile phone they use	51.4%	SMS/voice may reach more users than apps
Women using own bank account	76.7%	Formal service access exceeds internet use
Women owning house and/or land alone/jointly	55.3%	Many right-holders may lack digital access

III. LITERATURE REVIEW

Thakur et al. (2020) responded to delays and inconsistent departmental data caused by a lack of transparency in Indian land registries with a proposal for blockchain-based land titling. Their design connects ledger technology to the Indian registration-mutation context and deals with public key infrastructure, privacy, and the constraints of the internet. In contrast, Konashevych (2020) mentions that the preservation of errors is a problem of immutable ledgers, and lawful frameworks are necessary for change, identity, and enforcement in public registries. This discourse legitimizes a permissioned system in which state transitions are recorded in a blockchain at the request of state actors rather than a system that replaces the state.

2020 onward, a majority of the literature has moved beyond land titling conceptual frameworks to identity, smart-contract, and governance concerns. Shuaib et al. (2022) integrate self-sovereign identity with land registration and emphasize privacy and the personal discretion of credential disclosure. Saari et al. (2022) assess the state of land registration

frameworks and find that relatively, the frameworks are not as advanced as the theoretical state of development. Junaid et al. (2023) analyze blockchain-based land management systems and cite challenges with trust, legal systems, interoperability, and scalability. Shahariar et al. (2023) introduce a prototype for secure record management; however, technical challenges of record management do not resolve the hierarchy of evidence and competing claims of possession.

Based on current adoption literature, useful perceptions and trust fall short on their own. Blockchain utilization within the realm of public administration must comply with institutional mandates, current laws, funding, cyber security resources, and citizen service channels. An acceptance study, focused on the adoption of blockchain within the real estate sector, highlighted perceived risk and organizational preparedness as determinants of adoption (Yeoh et al. 2023). Rural-connectivity research has pointed to inadequate last-mile connectivity and poor infrastructure as barriers to access (Shruthi et al. 2021). Gendered access to smartphones is impacted by both the availability of networks and household structure (Iqbal, 2021). Digital inclusion poses a greater impact on system performance compared to efforts made to modify systems after they have been deployed.

Digital and geographical gaps in research pose challenges to current methodologies. There is insufficient peer-reviewed literature documenting the implementation of blockchain for land registries in rural Bihar. Circumstances that result in a decrease of fraud or improve processing times cannot be applied across different cases or be assumed for existing prototypes. An evidence-based assessment of readiness, proposed design of the system and its architecture, and field evaluations will be a valuable contribution.

IV. CONCEPTUAL FRAMEWORK AND RESEARCH QUESTIONS

Integration of socio-technical systems, institutional theory, the principal-agent problem, and the digital divide will form the basis of the conceptual framework. The socio-technical approach entails harmonization of the technology, automation of the legal framework, construction of roles for officers, design of interfaces for citizens, and creation of mechanisms to deal with legal exceptions. Institutional theory will provide insight into the reluctance of agencies to adopt a ledger that will bring edit and delay functions to the forefront. The principal-agent problem will provide insight into the hidden actions of citizens and officials; a shared audit trail will minimize the impact of hidden actions but will not eliminate the collusion at the data entry level. Analysis of the digital divide will illustrate that identical offerings of services will not ensure equal access.

This model suggests a number of variables when predicting trust and adoption, including transparency, traceability, perceived security, institutional readiness, ease of use, and the effectiveness of grievance mechanisms. The first model considers digital literacy, gender, age, education, device access, and reliance on intermediaries as moderating factors. Some critical questions include the following: What integrity and coordination issues remain in the system after the digitization process? Which types of fraud can an append-only audit trail help mitigate? What types of legal and administrative processes can and should remain outside of smart contracts? How will rural citizens, lacking independent access to the internet, be able to participate? What mechanism for correction could promote both accountability and the equitable distribution of outcomes?

For future primary research, testable hypotheses include the following: perceived transparency will relate positively to trust, the capability of a system to prevent fraud will relate positively to the intent to adopt the system, and institutional readiness will relate positively to the feasibility of implementation. Furthermore, grievance mechanisms will improve satisfaction. Digital literacy will moderate the relationship between perceived ease of use and intent to adopt the system. The following are proposed hypotheses, not tested in this secondary study.

V. METHODOLOGY AND DATA COLLECTION DESIGN

This study employs an analytical mixed-evidence design. Sources were primarily limited to peer-reviewed articles published between 2020 and 2025, official program documents, and the Bihar 2021 NFHS-5 report. Evidence was coded on the basis of transparency, fraud risk, readiness, willingness, legal, cyber, and inclusion. Quantitative measures were summarized descriptively. An evidence-weighted readiness score was assigned on a scale from one to five, for each of the six dimensions of implementation. The score was based on documented evidence and the assessment of the authors, and not based on a survey estimate.

Future field studies may adopt a multistage approach to land service case sampling across districts defined by regional diversity, complexity and digitization, and levels of connectivity. Diversity of respondents is essential. Include landholders, tenants, and cultivators, as well as deed writers, surveyors, staff, and officials, as well as service operators and bank staff. Cochran's formula should be the starting point for the sample, which should be adjusted for design effect and non-response bias.

Questions should capture respondents' experience concerning direct access to records, the number of in-person visits, and the time taken to request a mutation, along with the time and payment spent engaging in corrections, the perceptions of payments as unofficial, and the trust in the deed versus the jamabandi and the map, and the records. Also capture citizens' perceptions of the security, transparency traceability, and ease of use of the records, and the privacy concerns, along with their willingness to use assisted services. Measure record perceptions using a five-point scale and assess reliability using Cronbach's alpha. Ensure an adequate sample for factor analysis and assess group differences using the appropriate parametric and non-parametric tests. Structural equation modeling and regression may be applied when design and sample meet necessary criteria. Analyze interviews to discover themes, while protecting respondents' identities.

Table 3. Proposed primary-data variables and analysis.

Construct	Example indicators	Analysis
Transparency	Record visibility, status tracking, audit history	Scale reliability; regression
Fraud risk	Unauthorized change, forgery, duplicate claims	Frequency; group comparison
Efficiency	Visits, days, fees, correction time	Median; non-parametric tests
Digital inclusion	Device, internet, literacy, language, assistance	Cross-tabulation; logistic regression
Trust/adoption	Trust, usefulness, willingness to use	Factor analysis; SEM if justified

VI. SECONDARY DATA ANALYSIS

Evidence suggests a structural inclusion issue. The NFHS-5 sample shows that Bihar is predominantly rural, and of the women surveyed, fewer than one in four had reported using the Internet. While men's reported use was higher, it was also below 50%. With a 23-point gender gap, it is likely that a portal-based title verification or consent process would privilege male household members or other male intermediaries. Since women's mobile ownership was much higher than women's mobile Internet use, it can be assumed that mobile SMS, voice, and methods of assisted verification will be more inclusive than methods relying solely on mobile applications.

It is also important to note that 55.3% of women reported owning a house and/or plot of land, while 20.6% reported having used the Internet.

The use of a blockchain system that enhances the security of records, but allows the owner of the record no means to view or contest it, would place a higher value on the technical integrity of the system than on the substantive fairness. The system that is designed should provide printed confirmations,

local-language messages, assistance at the village level, and an offline complaints mechanism.

Due to the availability of both online records and elements of modernisation in Bihar and the national programme, the readiness assessment gives record digitisation the highest score. Registration, mutation, cadastral mapping, and adjudication still function separately which is why institutional coordination is scored lower. Legal readiness is assessed to be moderate. While Indian law does acknowledge electronic records and digital signatures hurdles still exist concerning the blockchain and the need for administrative rules regarding evidentiary status, corrections, delegation, and liability.

Cybersecurity readiness is likely to be moderate - low as a permissioned ledger addresses unidirectional alteration of the database, but key management, end point control, insider, and availability risks are still present. Due to issues with connectivity, the gender gap and the literacy gap, citizen inclusion scores the lowest. There are moderate concerns regarding the design for correcting records and complaints as existing mechanisms of complaints can be integrated, but redesigning mechanisms for records that are append-only is a challenge.

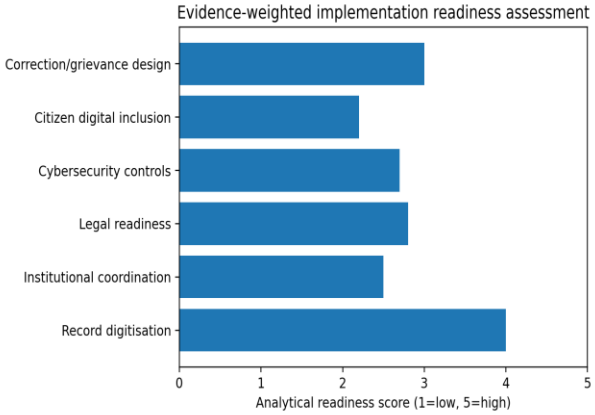

Figure 4. Author evidence-weighted readiness assessment; scores are analytical judgments, not survey estimates.

Table 4. Evidence-weighted readiness assessment.

Dimension	Score (1-5)	Basis
Record digitisation	4.0	Existing portals and DILRMP components
Institutional coordination	2.5	Separate registration, mutation, mapping and adjudication functions
Legal readiness	2.8	Electronic-record framework exists; blockchain-specific rules required
Cybersecurity controls	2.7	Key management, endpoint and insider controls need strengthening
Citizen digital inclusion	2.2	NFHS-5 access and gender gaps
Correction/grievance design	3.0	Existing correction channels need append-only redesign

VII. PROPOSED PERMISSIONED BLOCKCHAIN ARCHITECTURE

A consortium ledger run by state entities as prescribed by law is the preferred design. For the Revenue and Land Reforms Department, Registration Department, district administration, the survey and settlement authority, and a separate audit function, nodes will be made available for validation or endorsement. Courts or Revenue Courts should have a controlled mechanism to send orders impacting title and possession. Banks may be granted verification access, not write access, at will. The operators of a Panchayat or a Common Service Centre should be allowed to submit digitally signed applications and should not have the power to approve changes in the ownership of land.

Sensitive documents, biometric data and full personal details should remain off the chain in government secured repositories. The blockchain should have cryptographic hashes, parcel identifiers, transaction type, authorization, timestamp, version reference and state. This facilitates verification of the integrity of the data and minimizes the replication of personal data. Role-based access control, keys for officers issued and controlled via hardware, multi-factor authentication, key rotation, key revocation, audit trails, and separation of duty are required.

Smart contracts should be used to control the workflow and not to determine the outcome of a function. For a sale transaction, the application should go through verification of identity and authority, title and encumbrance, reference to map, verification of stamp and fees, confirmation of consent, approval of registration, entry in the ledger, and initiation of mutation with notification to all stakeholders, followed by an audit. Automation should cease when boundary and other discrepancies arise, and the matter should be taken up with the courts. For all these cases, a legal process should be initiated. All changes should be made through a new, authorized transaction that references and replaces the previous state, in a manner where the previous transactions are kept visible to auditors. The current legal state should be displayed in a portal accessible to citizens, while all other states should be maintained in a transactional manner.

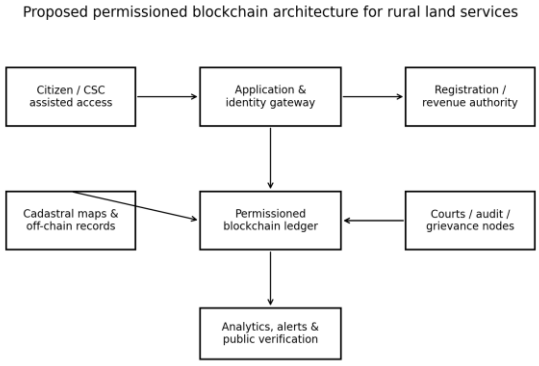

Figure 5. Proposed permissioned land-registry architecture for rural Bihar.

Table 5. Proposed ledger data model.

Data element	Storage location	Rationale
Full deed and identity documents	Encrypted off-chain repository	Privacy and document management
Document hash	On-chain	Integrity verification
Parcel/ULPIN reference	On-chain	Cross-system linkage
Approval signatures and timestamps	On-chain	Accountability and sequencing
Sensitive biometrics	Not on public/shared ledger	Data minimization
Court or correction reference	On-chain pointer plus off-chain order	Traceable lawful amendment

VIII. TRANSPARENCY AND FRAUD-PREVENTION ANALYSIS

It is possible to curtail some kinds of administrative fraud with permissioned ledgers. For example, the problem of back-dated alterations would be less of a risk because changes would be timestamped and replicated in the ledger. The problem of changes made by different departments being inconsistent would be addressed because of the ledger's requirement for the parcel identifier and transaction number. Document changes would be evident by comparing hashes. The risk of a compromised account would be less of a concern because of the multi-signature requirement. With the multi-signature requirement, the account would change hands with the loss of control of one account.

Collusive approval, coercion, or survey boundary fraud would not be addressed by these measures. For these types of fraud, the verification methods would need to be implemented as well. The permissioned ledger would be helpful for fraud because it would capture evidence of who approved something and when. The permissioned ledger would not be sufficient by itself for these concerns.

A multi-layered approach is needed for fraud as well. For example, the right of the public is to be able to verify the status of a parcel or transaction without

viewing the associated personal information. The right of the parcel holders is to view the complete transaction history as well as notifications of pending transactions. The right of auditors is to view the source of transaction authorizations. The Digital Personal Data Protection Act 2023 requires auditability of transactions, but the permissioned ledger would provide a sufficient measure of data minimization and purpose limitation.

Governance Efficiency and Cost

Working alongside a redesigned workflow, blockchain has the potential to significantly improve efficiency. With a shared state of transactions, documents will not have to be exchanged, and continual reconciliation, as well as manual inquiries into the status, will cease. Registration could trigger a review of immutable state, and a court-issued stay could be communicated to the transactional system. The approval of transactions would be recorded and would expedite the preparation for an audit. Citizens could receive status updates without the need to visit an office.

In contrast to its intended use, a blockchain overlay to a process that is not unified could increase both cost and complexity. The various agencies could have either legacy databases or integration middleware, as well as nodes, keys, and a cybersecurity monitoring system, in addition to a help desk. With poor connectivity, synchronization can be delayed, and the loss of keys can result in a disruption of service. An undesirable state of vendor-specific smart contracts can perpetuate an ongoing dependency with that vendor. Considering the above, an initial trial should attempt to quantify and compare service cost, processing time, error rate, citizen visit frequency, grievance rate, correction time, and system downtime, against the currently existing digital workflow. Benefits should be realized without record updates and should not be credited to blockchain in the event of benefits stemming from either the digitization of records or administrative reforms.

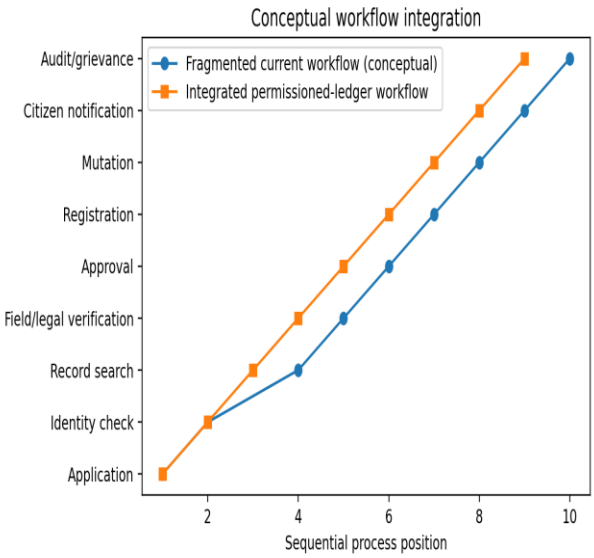

Figure 6. Conceptual integration of registration, mutation, notification and audit workflow.

Digital Inclusion and Ethical Safeguards

Strategies for inclusion should incorporate a mix of web portals, low-bandwidth mobile interfaces, SMS and voice notifications, printed receipts, access to a helpline, and assisted service at accountable centers. Interfaces should be in Hindi and local languages, use plain language, and offer audio instructions. Fees should be posted and receipts provided to curb intermediary exploitation. Women co-owners must be given independent notifications and transactions should not proceed if the only controlling person of the transaction is a male family member.

Measures should be taken to ensure no one is excluded on the basis of age, gender, ability, or disability. In the case of failed attempts to use a digital channel or where there is a lack of digital means, no one should lose access to their rights. During the transition, the option for traditional methods for filing and court appeals should be offered. Community demonstrations and legal literacy campaigns should be conducted to show that while the use of blockchain technology may enhance record-keeping, it does not eliminate the need to inspect rights of way, succession, or encumbrances.

From an ethical standpoint, motivated action in the system should be kept to a minimum, and

unnecessary surveillance should be avoided. Only essential data should be exchanged and access logged. Automated risk assessment tools should be used in conjunction with a manual framework. Citizens must be informed of their right to access their records and how to perform actions to do so, challenge an entry, and identify the responsible person or authority.

Implementation Roadmap and Evaluation

Phase 1 involves cleaning legacy records and reconciling disputes by assigning or confirming parcel identifiers and mapping the legal power for each change. Phase 2 involves limited pilots in a small number of circles differentiated by their connectivity and land complexity. Low-dispute transactions of certified-copy verification and registration-to-mutation status, for example, will be included in the pilot, but Title Transfer will not be part of the pilot, at least, in the initial stages.

Phase 3 will involve the operation of the new system in parallel with the old system. Testing of system security, and key management, and an assessment of data protection and system accessibility, in addition to training of users, will also be necessary. Phase 4 focuses on a list of specific measures to evaluate the new system, such as costs, system satisfaction, accessibility, and the number of transactions. System expansion will only be permitted if the new system provides a verifiable benefit as compared to the new system.

For the purposes of the evaluation, the pilot circles will be compared to the matching non-pilot circles before and after system implementation. System changes will be assessed using a difference-in-difference methodology. To evaluate the social impact of the system, especially concerning the digital dependency of users and exclusion, failure of authentication will be assessed using qualitative interviews.

Table 6. Phased implementation roadmap

Phase	Core actions	Go/no-go evidence
1. Record preparation	Clean data; reconcile maps; identify disputes	Error and mismatch baseline
2. Pilot design	Governance; legal rules; architecture; inclusion plan	Independent design review
3. Parallel pilot	Limited transactions; security and accessibility tests	Uptime, integrity and user metrics
4. Evaluation	Matched comparison; cost and grievance analysis	Measured public value
5. Scale	Interoperability; training; audit; procurement controls	Benefits exceed strengthened database alternative

Scenario-Based Impact Metrics

There are no field performance datasets available. However, assigning fraudulent percentage reductions for improved processing times is not practical. The document outlines a scenario framework, which will populate as field results are collected during the Pilot. The baseline will capture the median and inter-quartile range for the registration to mutation time, the number of citizen trips, the number of returned applications, and the number of mismatches between the deed, revenue entry, and the map, grievance and system down time, and discrepancies. The baseline will capture the above indicators disaggregated by gender, age, and disability and by district and assisted versus self-service.

The blockchain Pilot will be evaluated more positively if administrative simplification has been implemented, and if a modern, centralized database system with logging and access control performs to more modern standards. This evaluation framework will prevent the allocation of erroneous credit. It would be inaccurate to claim that the blockchain reduced trips to the office if that was solely due to the combination of online payment and the SMS Notification System. The centralized system would therefore provide a strengthened system at a

reduced cost if replicated audit trails, multi-agency consensus and tamper evidence provided incremental value, which a strengthened central system would provide at a reduced cost.

In the service that is provided, integrity, efficiency, inclusion, and resilience will form the minimum metrics. Integrity will be evaluated by measuring attempts to make unauthorized edits and the time it takes to revoke a credential that has been compromised. Integrity will also be evaluated by the number of unresolved mismatches and cross-system discrepancies along with the time taken to edit. Efficiency will be evaluated by the number of touches an officer has to make to a system and the cost and time to process a transaction. Inclusion will be evaluated by gender and digital literacy groups and will include the number of grievances filed and the attendance of the assisted service. Resilience will be evaluated by the time it takes to recover from a disruption as well as the stability and availability of the nodes during the disruption.

In terms of statistical assessment, matched pilot and comparator circles may be analyzed pre and post intervention. A difference-in-differences model can analyze relative change if pre-intervention trends are parallel. If monthly administration data exists for an extended period, interrupted time-series analysis may be applicable. In this context, qualitative process tracing should be employed to assess whether the improvements noted in measurement stem from the ledger, record cleaning, staff focus, or the allocation of additional pilot resources.

Legal and Policy Framework

A blockchain land system must function within the legal framework of registration, transfer, proof, privacy, and revenue. The Registration Act, 1908, and the corresponding state legislation outline which documents must be registered and which officer must perform the act. The Transfer of Property Act, 1882, and various succession and personal laws provide the framework for the rules of transfer and succession. Mutation, which is an administrative entry in the revenue records, is primarily an entry in the revenue records, and does not resolve all disputes regarding title. A smart contract would be unable to merge these various legal functions into one automated act.

Electronic records and digital signatures have legal recognition for the Information Technology Act 2000 and the Bharatiya Sakshya Adhiniyam, 2023, which will provide evidence of electronic records starting July 2024. The Digital Personal Data Protection Act, 2023 will provide the data-principal rights framework, when its operative provisions come into force, in the context of lawful processing, purpose limitation, and reasonable security safeguards. In light of this, a permissioned ledger must define the data fiduciary, document retention and access purposes, support lawful correction with an audit trail, and diminish personal data.

Bihar must introduce specific administrative regulations regarding the legal recognition of blockchain events, the definition of the record of authority, the identification of the signer of the record, key revocation, the implementation of court orders, the attribution of service errors and service unreliability, etc. I suggest that purchasing contracts include clearly defined data, open interfaces, code escrow, and independent security assessments and provide for continuity in case of vendor withdrawal. In the absence of these regulations, legal certainty cannot be accomplished with the use of technically secure ledgers.

Proposals

First, data cleansing and cadastral consolidation should be completed prior to system migration. Records that contain boundary disputes, unresolved successions, or inconsistent identification should be flagged and excluded from automated system transactions until validated. Second, a statutory governance board should be established with representation from the revenue, registration, and survey sectors, as well as from cybersecurity, legal services, and citizens' access functions. Third, a permissioned consortium model with off-chain documents and on-chain hashes should be adopted, not a public blockchain with embedded personally identifiable information.

Fourth, the signing of Officer Credentials protected by hardware should be used, and the change of ownership should require multiple approvals. Fifth, an authenticated change should replace an earlier state in the system with the change leading to a correction of the system, and the change should be preserved. Sixth, independent notification of the change should be sent to all co-undertakers and those interested. Seventh, assisted access should be provided at the village level, and fees should be transparent. Audit logs should be generated and complaints accepted. Eighth, service standards regarding processing time, system availability, and grievance response should be established.

Ninth, prepare a data protection impact assessment and threat model including insider misuse, stolen keys, service centre operator threats, denial of service, ransomware, and database-ledger inconsistency. Tenth, assess the pilot using gender-disaggregated and disability-sensitive metrics. Finally, evaluate the blockchain pilot relative to a more secure centralized database. Adoption should only occur if the distributed framework demonstrates clear, incremental improvements in integrity, coordination, and accountability.

Limitations and Future Research

This study's limitations include the use of secondary data and state-level inclusion indicators. Forged records, informal payments, mutation delays, and citizen satisfaction in specific districts are not measured. NFHS's internet-use questions only establish whether the person has ever used the internet. They do not measure how often, how skilled they are, or whether they are able to conduct land transactions. The evidence-based readiness scores are clear evaluations and should not be regarded as formal psychometric evaluations.

Future research must gather administrative data at the district and circle levels and conduct usability evaluations involving women, the elderly, and users with low levels of literacy, as well as assess service journeys and actual travel to services. Evaluations of pilots should have predetermined metrics and an evaluating research team that is not affiliated with the primary research. Cyber research should evaluate key compromise, node compromise, active threats, and recovery models. Legal research should analyze the intersection of blockchain audit trails and evidence with registration, mutation, and adjudication. Only long-term studies will reveal whether the early gains in transparency will continue to hold after institutional adjustments are made.

IX. DISCUSSION

The evidence suggests a conditional conclusion, as opposed to technological. Current digitisation and citizen service frameworks in Bihar strengthen auditability. Blockchain provides value where several agencies require an immutable, shared, approved event sequence. An authoritative database with comprehensive logging, access management, and backups provides the same outcome without the additional costs in other scenarios.

Fraud prevention is strongest in the case of an alteration made after the fact, lawfully entered with no evidence, and weakest in the case of input that is false or made under coercion. The efficiency of governance is more dependent on integration and legal assignment than on consensus. The main risk is digital inclusion. Data from NFHS-5 indicates that many rural women who hold rights to land or property do not have independent access to the internet. If an online self-service system is assumed to be universal, existing inequalities in the online ecosystem will be reproduced.

The use of secondary data in this study limits the ability to make strong claims regarding the implications of the research. This study does not account for user satisfaction, the current state of the system, or the frequency of fraud. The preparedness scores are clearly detailed assessments and are not statistically derived scores. Nonetheless, this analysis delineates the measurable elements required to justify a pilot: modified data, clearly defined legal frameworks, permitted governance, off-chain privacy, robust key management, human judgment, corrective transactions, assisted access, and gender-based evaluations.

A blockchain land registry might be useful for rural Bihar in combining transparency, auditability, and interdepartmental coordination, but only as part of a comprehensive land administration reform. The preferred model is a private permissioned consortium ledger with on-chain hashes and approved state transitions, with the remaining documents kept off-chain. In such a system, smart contracts should be used to organize workflow, but should not adjudicate disputes related to title, succession, or boundary disputes.

Evidence of unequal digital access in rural Bihar has also been demonstrated, and there is a need for assisted access, multilingual systems, removal of intermediaries, printed records, non-digital methods for appeals, and authentication for the system. Cleaning the existing records and reconciling the cadastre is also a prerequisite to implementation. A restricted pilot program may be used for comparison against the existing database enhanced with the previously mentioned features of processing, integrity, grievance, cost, availability, and inclusion. The most important factor is not whether it is possible to use blockchain, but rather whether it can be done without diminishing legal rights and without diminishing the rights of the public.

X. CONCLUSION

The study concludes that blockchain-enabled land registry has significant potential to improve the transparency, security, and efficiency of land administration in rural Bihar. By creating a tamper-resistant and traceable record of land ownership and transactions, blockchain can reduce opportunities for fraudulent alterations, duplicate records, and unauthorized manipulation. It can also strengthen accountability among officials and provide citizens with greater confidence in land-related processes.

However, blockchain alone cannot eliminate land disputes or administrative challenges. Its effectiveness depends on the accuracy of existing land records, reliable digital infrastructure, trained personnel, effective legal frameworks, and proper institutional coordination. In rural Bihar, where digital literacy, internet connectivity, and access to technology remain uneven, digital inclusion must be treated as a central component of blockchain-based land governance.

Therefore, a phased implementation involving digitization and verification of legacy records, secure blockchain integration, capacity building, public awareness, and accessible grievance-redressal mechanisms would be most appropriate. Assisted digital services should also be provided for citizens who lack smartphones, internet access, or digital skills. With these safeguards, blockchain can serve not merely as a technological innovation but as a tool for strengthening good governance, reducing land-related fraud, improving administrative efficiency, and promoting more inclusive and trustworthy land administration in rural Bihar.

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