Journal of International Research & Multidisciplinary Innovation

Feasibility of Blockchain Technology in the Indian Electoral Processes: A Comprehensive Review

Tagged Discipline(s): Engineering and Technology, Humanities, Political Science

Author: Adv. Avanishkumar J. Yadav

Affiliation: Maharashtra National Law University, Mumbai

Email: avanish@lynxlegal.in

Submitted to: Journal of International Research & Multidisciplinary Innovation (JIRMI)

Date: 12 January 2026

Abstract

This paper aims to analyze the possibility of incorporating blockchain technology in the Indian electoral process, which is the biggest democratic exercise in the world. Given the fact that due to domestic migration, voter disenfranchisement is becoming a problem for the Election Commission of India, the voting system is being explored for remote voting technologies. At the same time, there is long-standing public doubt about the transparency of the current Electronic Voting Machines (EVMs), requiring a shift to Electronic Voting Machines that are End-toEnd Verifiable (E2E-V). The methodology used in this research is multi-dimensional, combining literature review on cryptographic aspects, data analysis from the pilot e-voting studies conducted in the region, and comprehensive legal analysis of the Indian constitution and related legislation, such as the Representation of the People Act, 1951, and the Digital Personal Data Protection (DPDP) Act, 2023. The main results suggest that pure Internet based public blockchains are highly dangerous from a national level cyber security perspective, deepen the digital divide, and a convergence of the two architectures is

very viable. The combination of consortium blockchains with secure, local EVM hardware and the use of sophisticated cryptographic protocols such as the Minimal Anti-Collusion Infrastructure (MACI) and Chameleon Hashing makes it possible to achieve a balance between absolute cryptographic immutability, coercion resistance, and statutory privacy requirements. The paper concludes that this hybrid paradigm provides a pragmatic, safe and legally viable pathway forward for Indian elections.

Keywords: Blockchain voting, Electronic Voting Machines, DPDP Act 2023, End-to-End Verifiability, Minimal Anti-Collusion Infrastructure, Chameleon Hashing.

Introduction

The democratic structure of the Indian Republic is the largest and most complicated electoral process in the history of mankind with a growing electorate of more than 900 million registered voters today. Such a democratic exercise requires an electoral infrastructure that is both absolutely secure and highly scalable, with unsurpassed accessibility. In-depth demographic analysis of the General Elections of 2019 shows that a substantial share of this disenfranchisement is because of domestic migration. The ECI's latest prototype of a Multi-Constituency Remote Electronic Voting Machine (RVM) that can support voting from up to 72 constituencies from a single polling booth, underscores the need for a paradigm shift.1 At the same time, there is another issue in the electoral system and that is the crisis of public trust on the transparency of the voting system. The blockchain, a decentralised, unalterable and transparent distributed ledger system originally designed for cryptocurrency trading, has become a much-discussed theoretical solution to the vulnerabilities and inflexibility of both traditional paper ballot and conventional electronic voting systems in recent years. The advent of decentralised voting to a distributed ledger technology (DLT) framework, such as blockchain, from India's battle-tested electronic voting machines (EVMs), which have a built-in hardware isolation system and feature Voter Verifiable Paper Audit Trails (VVPATs), presents significant structural, constitutional and cryptographic challenges. The paper is a comprehensive research on blockchain technology and its potential for every stage of the electoral process in India, and is written at an expert level. It examines theoretical cryptographic architectures, empirical evidence from regional pilot studies, emerging hybrid

blockchain-hardware, inflexible constitutional and legal structures, socio-economic obstacles, and the innovations being designed to reconcile the inviolability of blockchain with the principles of sovereignty and democracy.

The Demographic Crisis of Electoral Participation and the Migrant Imperative

Before delving into the rapidly evolving landscape of electoral innovations and technologies, it is essential to look into the situation of apathy among the Indian populace. The basic principle of a representative democracy is universal adult suffrage, but the geographical limitations of the existing electoral system in practice is an implicit disadvantage for the mobile citizen.

As set out above, in the 2019 General Elections only 300,000,000 out of more than 400,000,000 eligible citizens participated in the elections, resulting in a 67.4% turnout. Internal migration within India shows that around 85% of the migration takes place within the states, mainly from rural areas to urban areas for economic necessities, education and marriage. This internal migration is the chief cause of voter disenfranchisement.

On taking office, Chief Election Commissioner Rajiv Kumar pointed to this crisis after having personally visited and first-hand assessed the problem of domestic migration in the Dumak village of Chamoli district.1 This was a local observation reflecting a systemic failing on a macro level: voters are routinely denied their franchise because it is impossible to logistically travel back to their home constituencies on polling day, and too expensive.

The study also gauged trust in proposed remote voting solutions among the people who are expected to use them, with 53% registering as voter in the slum area of Delhi while a substantial 27% were registered in their home states, effectively de-politicising their registration. A baseline level of trust in the idea of a remote voting system was found among 47% of respondents, while 31% of respondents explicitly expressed mistrust, with the overall level of trust being highly stratified by gender and level of education, with higher education corresponding closely with higher overall trust.

Public Distrust, the Supreme Court, and the EVM Infrastructure

It is crucial to understand the skepticism of the public regarding the existing EVM-VVPATs, to the extent that it lies at its core, and to appreciate the strict judicial supervision of technological developments in order to accurately measure the feasibility of introducing blockchain voting. The Indian legal system does not allow for the use of new electoral technologies without statutory definition and the legal mandate. The shift from paper ballots to new and sophisticated digital systems is highly interwoven with legislation, statutory definitions and law.

The Genesis and Legal Battles of the EVM Infrastructure

This was the conceptualization of Electronic Voting Machines in India, first presented in 1977, followed by the development of the first hardware prototypes by the Electronics Corporation of India Limited (ECIL) and later, the first working machines were demonstrated in 1979, and a trial with EVMs was conducted in May 1982 in Parur Assembly Constituency, Kerala, with the ECI sanctioning this through its plenary powers as provided by Article 324 of the Indian Constitution.

But the technological modernization was brought to a standstill as soon as it faced legal challenges in the form of A.C. Jose v. Sivan Pillai (1984), where the Supreme Court pointed out that the Indian Parliament was not an "absolute despot" in the field of elections; it was clear that manual ballot papers must be followed. This meant that the process of modernization could not continue till the Indian Parliament amended the RPA in 1988 and introduced Section 61A, authorizing the use of "voting machines.

Addressing Modern Mistrust: The 2024 Supreme Court Ruling

Even though the EVMs are completely hardware isolated (no external signal can be received, and they have software programmed on One Time Programmable (OTP) masked chips), they are still under extensive public scrutiny.

This deep skepticism towards elections led to Supreme Court proceedings in April-May 2024 in Association for Democratic Reforms v. Election Commission of India, before the General

Elections. Ahead of the elections, petitioners had asked for 100% verification of VVPAT slips or a return to paper ballot papers, arguing that the right to vote is a fundamental right of the voters and ensures that they have an opportunity to see the ballot paper they cast marked correctly. The Division Bench had finally rejected the cries of the petitioners by stating that it was a fact that going back to paper ballots would set aside the important electoral reforms and that EVMs do not allow human tampering, but in so doing, the court also had made a clear recognition of the need to strengthen the confidence of the people in the electoral process.

The Court also directed for fresh technical audits, sealing of symbol loading units for the next 45 days after the elections and giving candidates the right to request post-poll verification of the microcontroller memory. This ongoing court and public battle communicates a critical truth; future electoral technologies, such as blockchain, must go beyond procedural security and deliver absolute, mathematical, E2E-V to meet a growing electorate who are skeptical.

Theoretical Foundations of Blockchain in Electoral Systems

The architecture of Blockchain technology has several core pillars that aim to address problems with voter manipulation, lack of transparency and trust in the past.15 These pillars include:

Decentralization and Cryptographic Immutability

In contrast to centralized databases, a blockchain distributes voting records over a number of geographically dispersed nodes, making there a virtual absence of single points of failure. Each block is secured cryptographically to the previous one by a complex hash function. That is, any attempt at changing a recorded vote will change its hash value and thus invalidate the following blocks, thus ensuring that a recorded vote cannot be unalterably changed or withdrawn.

Advanced Encryption and Coercion Resistance Innovations

The blockchain voting system is a new way to democracy by issuing secure digital tokens. The literature emphasizes Zero-Knowledge Proofs (ZKPs) and Fully Homomorphic Encryption (FHE) to preserve voter anonymity and transparency as computational vote tallying on ciphertexts will be possible without revealing the individual ballots.

In addition, to address the pressing problem of voter intimidation in less accessible areas, there are proposals that aim to create a minimal anti-collusion infrastructure (MACI). On-chain voting project MACI is open-source and offers a way to vote without collusion and bribery. With the combination of Ethereum smart contracts and zk-SNARKs, MACI conceals votes and reveals a correct, tamper-proof final tally, publicly. This cryptographic hiding guarantees receipt-freeness, meaning that it is not possible for the voter to reliably prove to the briber or coercer that he or she voted for a specific candidate.

Architectural Blueprints and Academic Innovations

Indian tech institutes are converting blockchain's theoretical mechanics into hugely complex software architectures.

The BEVM Model and Plenome Technologies

Academically, the proposed BEVM architecture has proven to be very stable, with the Admin Module responsible for configuring elections and the User Module for secure casting through digital wallets, such as MetaMask, and through Smart Contracts.17 The "BlockVote" software, developed by the deep-tech start-up Plenome Technologies, an IIT Madras spin-off by Prof. Prabhu Rajagopal with Vijayaraja Rathinasamy and Anirudh Varna, is based on a pay-per-use remote election model. Plenome successfully raised Rs. and achieved the scalable deployment of blockchain solutions within sensitive public systems, thereby validating the use of blockchain solutions. The company raised $6.5 Crore in seed funding to scale their interoperable, blockchain secured data architectures on e-governance and healthcare platforms.

Empirical Evidence: The Telangana Smartphone EVoting Dry Run

Academic deployment is proof of viability, whereas sovereign deployment needs empirical testing. In October 2021, Telangana State Election Commission (TSEC) in partnership with CDAC, held a dry-run of a smartphone based e-voting solution in Khammam.20 The application involved Artificial Intelligence (AI) driven facial recognition and the use of a Distributed Ledger Technology (DLT) database.

But empirical findings showed high level of deficiencies in infrastructure. A system that excludes a large majority of citizens who are eager to register because the back end verification process is hampered by technical problems is not ready to accommodate 900 million voters.

The Cybersecurity Critique vs. The Convergence of Hardware and Consortium Blockchains

This is nothing new for the global cybersecurity community, who have made some of the most fierce criticisms of internetbased blockchain voting ever. Internet voting's weaknesses have been demonstrated in practice around the world, and in Estonia—in which the Internet in fact constitutes up to 25% of legally-binding national elections—several independent security audits conducted by international experts have documented significant structural weaknesses. However, the research that was seminal at MIT also puts forth another argument that using blockchain for political voting is fundamentally based on a misunderstanding of security guarantees. Their thesis ("Going from bad to worse") emphasizes that the security of the ledger is very good, but consumer endpoint devices (smartphones/PCs) are extremely susceptible to malware, Zero-Day exploits and DDoS attacks.

The Shift to Consortium Blockchains and Embedded Hardware Integration

Recent studies conducted from 2024 to 2026, however, show that the technological paradigm is changing fast in response to the very same criticisms. Vulnerable, fully public, Internet-connected blockchains are slowly being replaced by Hybrid and Consortium Blockchains that can be connected directly to physical hardware.

1. **Consortium Blockchains:** These are chains based on a consortium model, such as the proposed HAC-Bchain (Hierarchical Authoritative Consensus), which are operated by trusted, verified nodes. That means it is highly resistant to external 51% attacks, and has the capacity to deliver the transaction throughput requirements needed for an nationwide election.

2. **Hardware-Blockchain Convergence (Embedded Architecture):** Recent studies (IEEE 2025/2026) have introduced an innovative embedded system architecture designed to secure EVMs on the blockchain to address the endpoint vulnerability. Voters do not vote on their smartphone, but on a specially designed physical EVM setup in a supervised polling booth. It's an embedded lightweight high-performance machine with a cryptographic coprocessor for tamper suppression at the machine level. Votes are tokenized and processed instantly on a private consortium blockchain, maintaining end-to-end verifiability and alerting to any anomalies like hardware failures and unauthorised attempts.

This hybrid model perfectly addresses the gap: it combines the coercion-resistant, physically secured setting of a traditional polling booth with the mathematics E2E-V, transparency and immutability of the blockchain backend.

Legal and Regulatory Impasses: Reconciling Immutability with the DPDP Act

Despite the adoption of sophisticated hybrid designs, blockchain voting has significant hurdles, including in the form of statutory laws and changing data privacy policies.

There is a fundamental structural conflict between the core feature of blockchain – immutability and the content of India's Digital Personal Data Protection (DPDP) Act, 2023, which more acutely requires parliamentary amendments to legally authorise cryptographic ledgers and digital identity tokens across the country. The DPDP Act provides the "Right to Erasure" (also known as the right to be forgotten) explicitly to the data principals. The system is a permanent violation of the DPDP Act if the demographic data or digital identity tokens are permanently recorded on a state-run election blockchain. This is also an issue with the European Union's GDPR regime, which had a significant influence on the Indian data protection laws.

Innovative Cryptographic Solutions: Chameleon Hashing

The cryptographic community is making strong progress towards the implementation of Chameleon Hash Functions as a way to dynamically resolve this regulatory conflict. To prevent

any change, standard blockchains employ collision-resistant hashes. With a Chameleon Hash, however, there's a very secure mathematical "trapdoor". The DPDP Act requires that a legally authorised erasure request be approved, which can be done by using the trapdoor key to produce a hash collision. This would enable certain personal information to be masked or obscured without affecting the hash value of the block, which would maintain the integrity of the whole of the surrounding ledger cryptography. Although it is challenging to implement securely on a national level, Chameleon Hashing offers a promising and innovative solution that connects the world of blockchain technology with today's privacy rights and regulations.

Conclusion

Blockchain technology is moving from theory to advanced and practical engineering in India's electoral process. Early proposals for all-or-nothing, smartphone-based public blockchain voting were rightly criticized by the international cybersecurity community for massive endpoint vulnerabilities and coercion risks, but to reject the technology is to overlook recent and dynamic, state-of-the-art developments. Given the current general public distrust over the VVPAT-EVM mechanism and the Supreme Court's recent demands to make the system verifiable, the Election Commission needs to move towards a system that provides mathematical End-to-End Verifiability (E2E-V). Pure software solutions are still susceptible, and pure hardware solutions are still enigmatic. The ideal and creative path for the Indian Electoral Process is along both lines: Hybrid Consortium Blockchains and Secure, Physical Embedded Hardware. The ECI can, by using the EVM hardware in booths that are supervised, and by communicating directly with a private, extremely scalable consortium ledger, achieve the best of both worlds: the coercion resistance and physical security of the voting booths, and the absolute transparency, immutability, and auditability of the blockchain. Moreover, the rapid advancement of cryptographic innovations, such as MACI and Chameleon Hashing, offers a promising trajectory for ensuring adherence to DPDP Act's anti-collusion provisions and privacy obligations. Although there are still major legislative changes to be made and extensive infrastructural digital divides to be addressed, the various technological configurations highlighted here make a scientifically possible reality for India's future democratic processes.

Bibliography

1. ECI ready to pilot remote voting for domestic migrants - PIB, accessed on May 27, 2026, https://www.pib.gov.in/PressReleasePage.aspx?PRID=1887248
2. Remote Voting for Migrants - Drishti IAS, accessed on May 27,2026,https://www.drishtiias.com/daily-updates/daily-news-analysis/remote-voting-formigrants-2
3. Remote EVM ready to help migrants vote outside States: ECI - GS SCORE, accessed on May 27, 2026, https://iasscore.in/current-affairs/remote-evm-ready-to-helpmigrants-vote-outside-states-eci
4. Webinar Organised On Technology Aspects of Remote Voting - PIB, accessed on May 27, 2026, https://www.pib.gov.in/PressReleasePage.aspx?PRID=1645063
5. Election Commission of India working with IIT Madras and CDAC for a more efficient voting system - Principal Scientific Adviser, accessed on May 27, 2026, https://psa.gov.in/CMS/web/sites/default/files/psa_custom_files/Election%20Commission%20of%20India-IIT%20Madras.pdf
6. Supreme Court's Stand on EVMs and VVPATs - B&B Associates LLP, accessed on May 27, 2026, https://bnblegal.com/article/supreme-courts-stand-on-evms-andvvpats/
7. LEGAL HISTORY OF EVMs AND VVPATs - Election Commission of India, accessed on May 27, 2026, https://www.eci.gov.in/eci-backend/public/uploads/monthly_2022_11/10386732_LegalHistoryofEVMsandVV PATs_pdf.a942a6ed2e36892f92adecb5e88f6d3d
8. Sivan Pillai vs B.C. Jose on 17 December, 1984 - Indian Kanoon, accessed on May 27, 2026, https://indiankanoon.org/doc/1229406/
9. Article 324: Superintendence, direction and control of elections to be vested in an Election Commission - Constitution of India, accessed on May 27, 2026, https://www.constitutionofindia.net/articles/article-324-superintendence-directionand-control-of-elections-to-be-vested-in-an-election-commission/
10. ,https://indiankanoon.org/docfragment/390634/?formInput=324&ref=static.internetf reedom.in

11. Electronic Voting Machine – INTERNATIONAL JOURNAL OFLAW MANAGEMENT & HUMANITIES, accessed on May 27, 2026, https://ijlmh.com/wp-content/uploads/Electronic-Voting-Machine-ConstitutionalExamination.pdf
12. AC Jose vs Sivan Pillai & Ors on 5 March, 1984 - State Election Commission, Maharashtra, accessed on May27,2026, https://mahasec.maharashtra.gov.in/Upload/PDF/3%20A%20C%20Jose.pdf
13. Section 61A in The Representation of the People Act, 1951 - Indian Kanoon, accessed on May 27, 2026, https://indiankanoon.org/doc/7557203/
14. Credibility of Electronic Voting Machines- regarding. - PIB, accessed on May 27, 2026, https://www.pib.gov.in/newsite/printrelease.aspx?relid=159351
15. Democratic Innovation: Systematic Evaluation of Blockchain-Based Electronic Voting (2022–2025) - MDPI, accessed on May 27, 2026, https://www.mdpi.com/2227-7080/14/2/95
16. Blockchain Voting in the Indian Context: Potentials ... - TIJER, accessed on May 27, 2026, https://tijer.org/tijer/papers/TIJER2509087.pdf
17. (PDF) Blockchain based Electronic Voting System for Secure and Transparent Elections in India - ResearchGate, accessed on May 27, 2026, https://www.researchgate.net/publication/397806677_Blockchain_based_Electronic_Voting_System_for_Secure_and_Transparent_Elections_in_India
18. IIT Madras-incubated Start-up Plenome raises Rs. 6.5 Crore in Seed Funding, targets Global Expansion - PIB, accessed on May 27, 2026, https://www.pib.gov.in/PressReleasePage.aspx?PRID=2146469
19. SGE 2024 Election Report.pdf - IIT Madras, accessed on May 27, 2026, https://web.iitm.ac.in/secc/assets/pdf/SGE%202024%20Election%20Report.pdf
20. TS develops smartphone based e-voting solution - The Hindu, accessed on May 27, 2026, https://www.thehindu.com/news/national/telangana/ts-develops-smartphonebased-e-voting-solution/article36865780.ece
21. Mock e-voting conducted - The Hindu, accessed on May 27, 2026, https://www.thehindu.com/news/national/telangana/mock-e-votingconducted/article37096968.ece

22. Emerging Technologies – Invest Telangana, accessed on May 27, 2026, https://invest.telangana.gov.in/emerging-technologies/
23. Going from bad to worse: from Internet voting to blockchain voting, accessed on May 27, 2026, https://www.dci.mit.edu/projects/going-from-bad-to-worse-frominternet-voting-to-blockchain-voting
24. Going from Bad to Worse: From Internet Voting to Blockchain Voting - Semantic Scholar, accessed on May 27, 2026, https://pdfs.semanticscholar.org/d60e/045731228b1118918cbd8cc41f2e19ac143f.p df
25. Going from bad to worse: from Internet voting to blockchain voting | Journal of Cybersecurity, accessed on May 27, 2026, https://academic.oup.com/cybersecurity/article/7/1/tyaa025/6137886
26. Election Commission working with IIT-Madras on e-voting - The Hindu, accessed on May 27, 2026, https://www.thehindu.com/news/national/election-commissionworking-with-iit-madras-on-e-voting/article34170161.ece
27. Election Commission of India working on remote voting system - The Hindu, accessed on May 27, 2026, https://www.thehindu.com/news/national/system-toenable-electors-to-cast-votes-from-anywhere-in-the-works/article30836003.ece
28. Independent Report on E-voting in Estonia | A security analysis of Estonia's Internet voting system by international e-voting experts., accessed on May 27, 2026, https://estoniaevoting.org/
29. Security Analysis of the Estonian Internet Voting System - J. Alex Halderman, accessed on May 27, 2026, https://jhalderm.com/pub/papers/ivoting-ccs14.pdf