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Harnessing Blockchain Technology for Transparent and Efficient Government Schemes

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Abstract:

Government welfare schemes are vital for over 140 million people in India, providing essential aid like food subsidies, healthcare, and financial support to those in greatest need. However, these programs often face challenges: corruption diverts funds, inefficiencies cause delays, and misallocation prevents help from reaching the right people. Blockchain technology offers a modern solution—a transparent, tamper-proof ledger that can enhance these schemes. This paper examines how blockchain can improve government programs by making them more transparent, accountable, and efficient. We review case studies such as India's land record pilots and Estonia's successful e-governance initiatives, alongside technical features like smart contracts and decentralized records. Our aim is to show how this technology can reduce fraud, speed up processes, and rebuild public trust. Key findings reveal blockchain's potential to streamline fund distribution, reduce middlemen, and ensure every dollar is traceable—though hurdles like scalability and privacy must be carefully addressed. Ultimately, blockchain isn't just a trending topic; it's a practical tool to improve how government schemes serve everyone.

Keywords **— Blockchain, Smartcontract, governance, decentralized, privacy, schemes, scalability.**

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I. INTRODUCTION

Imagine a world where every rupee of public funds can be tracked, every beneficiary is verified, and government schemes run smoothly and efficiently. In countries like India, government initiatives are the backbone of socio-economic development, lifting millions out of poverty and fostering inclusive growth. Programs like PM-KISAN, which deliver direct income support to farmers, Ayushman Bharat, providing health insurance to the underprivileged, and the Public Distribution System (PDS) for ration distribution are more than just policies—they're lifelines. These schemes address critical needs like food security, healthcare access, and financial stability, contributing to broader economic progress and social equity. Under schemes like PM-KISAN, farmers have been empowered by receiving funds directly into their accounts, while Ayushman Bharat has brought healthcare within reach for over 500 million people. The PDS, a cornerstone of food security, ensures subsidized grains reach millions of households. Together, these initiatives are pivotal in building a more equitable society, reducing disparities, and driving sustainable development.

Yet, despite their promise, these schemes often falter due to systemic issues and challenges. Corruption remains a persistent foe, with data manipulation—where records are altered for personal gain—undermining fairness. Ghost beneficiaries, fictitious individuals who siphon off benefits meant for the needy, further drain resources. Fund leakages, where money is diverted before reaching its intended recipients, are another hurdle, with studies estimating significant losses in welfare budgets due to such mismanagement. These issues not only waste public resources but also

erode trust in government systems, leaving citizens frustrated, disillusioned, and underserved. The inefficiency and lack of transparency in these processes often mean that aid is delayed or misallocated, hindering the very goals these schemes set out to achieve.

Enter blockchain technology, a revolutionary tool that could change how government programs operate. At its heart, blockchain is a decentralized, immutable ledger that records transactions across a network of computers. Once data is entered, it's locked in—immutable, time-stamped, and visible to authorized users. This ensures transparency and integrity, making it nearly impossible to tamper with records. Best known for powering cryptocurrencies like Bitcoin, Blockbuster Chain's applications extend far beyond finance. Its ability to create secure, traceable records makes it a perfect fit for government schemes, where trust and accountability are paramount. Blockchain can be used to ensure that every transaction in a welfare program is verifiable, from fund allocation to delivery, reducing opportunities for fraud and delays.

This paper sets out to explore blockchain's potential to reshape public welfare systems by addressing two critical research questions:

- Can blockchain technology effectively eliminate or reduce instances of data manipulation, ghost beneficiaries, and fund leakages in government schemes?
- What can be challenges in implementing blockchain solutions in the context of government operations?

We propose that blockchain has the potential to revolutionize government schemes by providing a transparent, traceable, and corruption-resistant framework. By using its immutable nature, blockchain can guarantee that every transaction and beneficiary is verified, enhancing accountability and building public trust. However, implementing blockchain is not without challenges. Issues like scalability, infrastructure costs, and balancing transparency with privacy must be carefully navigated. Drawing on case studies, such as India's blockchain-based land record pilots and Estonia's e-governance successes, this paper will evaluate how blockchain can address current shortcomings and pave the way for more efficient, trustworthy governance. While the road ahead is complex, the promise of blockchain to transform public welfare systems is undeniable, offering a path toward a future where government schemes deliver on their full potential.

II. LITERATURE REVIEW:

Blockchain technology, known for its decentralized, immutable, and transparent ledger, has become a promising tool for improving governance, especially in government programs aimed at socio-economic development. This review combines existing research on blockchain's uses in governance, highlighting case studies from Estonia, the UAE, and India, as well as its applications in healthcare, supply chain management, and financial aid distribution. It also points out gaps in the research, particularly the lack of large-scale implementation studies in India and its integration with digital identity systems like Aadhaar.

(A) Blockchain in Governance: Global and Regional Perspectives

The global adoption of blockchain in governance is gaining traction, with over 100 government-led projects trialed across more than 40 countries by 2018, encompassing areas such as electronic voting, land registries, and digital identities (Jun 2018). Estonia stands out as a leader, integrating blockchain into its E-Estonia initiative. The KSI Blockchain secures registries for healthcare, property, business, and judicial systems, using timestamping to ensure data integrity [11]. However, research notes that Estonia's implementation prioritizes administrative control over public transparency, raising questions about whether it fully leverages blockchain's potential for citizen trust [11]. In the UAE, blockchain is explored for digital identity and supply chain management, emphasizing transparency and security (World Economic Forum, 2020).

In India, the government has initiated several blockchain pilots, as outlined in Niti Aayog's Blockchain: The India Strategy (2020). Notable examples include a fertilizer subsidy pilot that reduced claim processing times from 3-4 months to

near real-time, demonstrating significant efficiency gains. Other pilots involve land records and pharmaceutical supply chains, where blockchain ensures transparency through real-time auditing and immutable records. Despite these advancements, challenges such as data quality, regulatory hurdles, and integration with legacy systems persist [4].

Blockchain's application in healthcare focuses on securing electronic health records (EHRs) and optimizing supply chains. In Estonia, blockchain safeguards patient health records, enhancing data integrity and privacy [5]. In India, blockchain is proposed for the electronic Vaccine Intelligence Network (eVIN), unifying immunization data and enabling real-time visibility, which could support innovations like smartcontracts for rewarding health workers [4]. These applications highlight blockchain's potential to reduce fraud and improve efficiency in healthcare-related government schemes.

III. METHODOLOGY

Blockchain can bring transparency, accountability, and efficiency to government schemes. By analysing real-world applications in Indian and international contexts, analysing public documents and policy papers, and evaluating technical architectures using specialized tools

(A) International Case Studies:

In India, drawing from Niti *Aayog's Blockchain: The India Strategy Part 1* (2020) and other sources,

***Fertilizer Subsidy Supply Chain*:** In Gujarat, Narmada Valley Fertilisers & Chemicals (GNFC) reduced subsidy claim processing from 3-4 months to real-time, integrating blockchain with Aadhar-enabled PoS machines.

Immunization Supply Chain: Enhanced the Universal Immunization Program by improving data visibility and automating transfer of benefits, addressing issues like incomplete data (only 18% of children receive the full DPT course)

Land records: Pilots in Chandigarh and West Bengal (e.g., New Town Kolkata's NFT-based land mutation covering 27,000 acres, 50,000 NFTs for 1 million property records) for tamper-proof registries.

Educational Certificates (SuperCert): Implemented blockchain for secure, verifiable academic credentials, reducing fraud from over 7500 organizations issuing fake certificates.

(B) International Case Studies:

Estonia: Blockchain secures digital identity and health records for 1.3 million citizens, digitizing 99% of government services post-2007 cyber-attack [11]

Georgia: The world's first blockchain-based land registry (2016), speeding up registration and ensuring transparent ownership [10]

Australia: Blockchain for supply chain tracking in fruit and vegetable exports, enhancing transparency [10]

Sweden: Exploration of Blockchain for land-title recordation and transfer to streamline processes [10]

USA (Department of Homeland Security): Blockchain exploration for digital entitlement attestations and counter-fraud technologies via the Silicon Valley Innovation program [10]

(B) The data collection

Public Documents and policy papers: These include:

Niti Ayog's Blockchain: The India Strategy-Part 1(2020), outlining India's blockchain roadmap

- Government of India's National Strategy on Blockchain (2021), detailing plans for a "Made in India" blockchain ecosystem by 2027 (ORF Online, 2023).
- International reports, such as the World Economic Forum's Inclusive Deployment of Blockchain for Supply Chains (2020) and academic papers like [11].
- Technical Reports and Case Study Analyses: Sources like [10] and ORF Online (2023) provide detailed insights into blockchain implementations, supplemented by academic studies [3].

(C) Analysis of Technical Architecture

The technical architecture of blockchain solutions is analyzed to understand their design and functionality:

Blockchain Types: Most case studies use permissioned blockchains for controlled access, unlike public blockchains like Bitcoin. For example, India's fertilizer subsidy pilot uses a permissioned

blockchain integrated with Aadhaar and ERP systems.

Integration with Existing Systems: The study examines how blockchain interfaces with digital infrastructure, such as Aadhaar (1.2 billion identities, 25 million daily authentications) and UPI (1.3 billion transactions in December 2019).

Smart Contracts: Analysis of smart contract logic, such as automated B1 certification in fertilizer subsidies or audit processes in land records, to assess automation and security.

Data Privacy and Security: Evaluation of measures like identity encryption (e.g., SuperCert) and adjustable read/write access (e.g., land records) to balance transparency and privacy.

IV CHALLENGES AND LIMITATIONS OF IMPLEMENTING BLOCKCHAIN IN GOVERNMENT SCHEMES

Blockchain technology offers a transformative potential for the implementation of government schemes by enhancing transparency, reducing corruption, and improving efficiency. However, its Blockchain in public welfare programs, such as India's PM-KISAN, Ayushman Bharat, or Public Distribution System (PDS), faces significant challenges across technical, economic, legal and regulatory, and social dimensions. Addressing these hurdles is critical to realizing blockchain's benefits in governance. Below, we detail these challenges, drawing on insights from India's blockchain pilots and global experiences.

(A) Technical Challenges

Blockchain's technical limitations pose substantial barriers to its adoption in government schemes, particularly when scaling to meet the demands of large populations.

- ***Scalability and Transaction Volume*:** Current blockchain networks struggle with high transaction volumes required for government operations. For example, Ethereum processes only a few hundred transactions per second, compared to Visa's 50,000 transactions per second [4]. This limitation could hinder schemes like PDS, which serves millions daily. Solutions like sharding or Layer 2 protocols are still experimental and add complexity.
- ***Interoperability with Legacy Systems*:** Governments rely on legacy systems like Enterprise Resource Planning (ERP) and Supply Chain Management (SCM). Integrating blockchain with these systems is resource-intensive, requiring custom adapters or middleware. India's pharmaceutical supply chain pilot, for instance, used enterprise application adapters to ingest IoT data, highlighting integration challenges [4].
- ***Data Privacy and Security*:** Blockchain's transparency and immutability, while beneficial for accountability, raise privacy concerns. Public blockchains expose data to all participants, conflicting with data protection laws like India's proposed Personal Data Protection Bill, which mandates the right to deletion (Brookings, 2025). Permissioned blockchains with controlled access can mitigate this, but they increase setup complexity.
- ***Suitability for Transaction Types*:** Blockchain is more effective for atomic transactions (e.g., supply chain tracking) than non-atomic ones (e.g., land records), which require dispute-free data. Land record pilots in Chandigarh faced challenges due to unclear titles, underscoring the need for clean antecedents [4].

(B) Economic Challenges

The financial burden of blockchain adoption can strain government budgets, particularly in developing nations like India.

- ***Initial Investment and Maintenance Costs*:** Permissioned blockchains, common in government schemes, require significant upfront investment in infrastructure, unlike public blockchains, where costs are crowdsourced. Ongoing maintenance, including hardware and software updates, adds to the expense. India's fertilizer subsidy pilot required businesses to bear computing and development costs [4].

- ***Human Resource Constraints*:** A global shortage of blockchain experts—approximately 10,000 qualified developers compared to over 10 million Java developers—limits implementation capacity. Governments must invest in upskilling, which is costly and time-consuming. Regulatory uncertainties further deter private sector talent from engaging in public projects [4].

(C) Legal and Regulatory Challenges

Blockchain's decentralized nature often conflicts with existing legal frameworks, necessitating significant reforms.

- ***Lack of Blockchain-Specific Laws*:** India's legal system requires updates to support blockchain. For example, the Registration Act, 1908, mandates physical presence for land transactions, and the Indian Stamp Act, 1889, requires physical stamp paper. These laws must be amended to recognize digital records and smart contracts, which also face issues of legal enforceability and liability [4].
- ***Regulatory Clarity*:** Public blockchains with token economies need clear regulations to enable their use in government schemes. Without standardized frameworks, legal ambiguities hinder scalability across jurisdictions [4].
- ***Data Protection Compliance*:** Blockchain's immutability can conflict with data protection laws requiring data deletion rights. Balancing transparency with privacy requires innovative solutions, such as permissioned blockchains or encrypted data storage, which add complexity.

(D) Social Challenges

Societal readiness and acceptance are critical for blockchain's success in government schemes, particularly in diverse contexts like India.

- ***Digital Illiteracy*:** Many beneficiaries, especially in rural areas, lack the digital literacy needed to engage with blockchain-based systems. Schemes like PM-KISAN or PDS rely on digital platforms, but widespread adoption requires extensive education programs to teach beneficiaries how to use these systems effectively.
- ***Resistance to Change*:** Government officials and citizens may resist blockchain due to familiarity with traditional processes. For example, India's insurance sector faced stakeholder resistance due to fears of unequal benefits [4]. Similarly, government workers accustomed to manual systems may oppose digitization efforts.
- ***Process Changes and Stakeholder Reluctance*:** Blockchain implementation often requires significant workflow changes. India's pharmaceutical supply chain pilot, for instance, mandated QR/barcode stickers and scanning at each stage, which stakeholders found disruptive. Such changes can lead to reluctance, slowing adoption [4].

V. ARCHITECTURE OVERVIEW

The proposed framework utilizes a permissioned blockchain network to enhance transparency, accountability, and efficiency in government schemes, such as India's PM-KISAN, Ayushman Bharat, and the Public Distribution System (PDS). By integrating blockchain with decentralized storage (IPFS) and existing e-Governance systems like Aadhaar and Digilocker, the system ensures secure, traceable, and automated processes. The architecture is designed to address challenges like data manipulation, ghost beneficiaries, and fund leakages, while incorporating role-based access control to balance transparency with privacy.

(A) Participants

The system involves four key stakeholders, each with defined roles:

- ***Government Authority***: Oversees the scheme, approves applications, and authorizes fund disbursements.
- ***Beneficiary***: Applies for benefits, provides identity and documentation, and receives funds.
- ***Verifying Agency***: Validates beneficiary eligibility and documents, ensuring compliance with scheme criteria.

- ***Auditor***: Monitors transactions and processes to ensure integrity and compliance, with read-only access to the blockchain ledger.

(B) Components

The architecture comprises the following components:

- ***Permissioned Blockchain Network***: A controlled blockchain (e.g., Hyperledger Fabric or Ethereum Enterprise) restricts participation to authorized entities, ensuring security and scalability for government use. It hosts smart contracts and maintains an immutable ledger of transactions.
- ***Smart Contracts***: Self-executing contracts automate key processes, including registration, verification, approval, and fund release, reducing manual intervention and errors.
- ***IPFS (InterPlanetary File System)***: A decentralized storage system for large files, such as beneficiary documents or utilization proofs. IPFS stores data off-chain, with cryptographic hashes recorded on the blockchain to ensure integrity and reduce blockchain bloat.
- ***Digital Wallets***: Manage identities and facilitate secure transactions. Beneficiaries and agencies use wallets linked to Aadhaar for authentication and fund management.
- ***External Systems***: Integration with Aadhaar for biometric authentication, Digilocker for document retrieval, and banking systems for direct benefit transfers (DBT).

(C) Smart Contract Workflow

The workflow is automated through smart contracts, ensuring a transparent and efficient process:

1. ***Beneficiary Registration:***
    - Beneficiaries authenticate using Aadhaar's biometric verification via the Aadhaar API.
    - A smart contract records its details (e.g., name, Aadhaar number, scheme-specific data) on the blockchain.
    - Required documents (e.g., income certificates, land records) are fetched from Digilocker or uploaded to IPFS, with their hashes stored on the blockchain for immutability.
2. ***Verification:***
    - The verifying agency accesses beneficiary details and document hashes from the blockchain.
    - Documents are retrieved from IPFS or Digilocker for verification.
    - The agency records the verification outcome (approved/rejected) on the blockchain via a smart contract.
3. ***Approval:***
    - The government authority reviews the verification results on the blockchain.
    - A smart contract records the approval or rejection decision, ensuring traceability.
4. ***Fund Release:***
    - Upon approval, a smart contract triggers a fund transfer to the beneficiary's Aadhaar-linked bank account through a banking API.
    - The transaction details are recorded on the blockchain for auditability.
5. ***Utilization Tracking***:
    - Beneficiaries submit proofs of fund utilization (e.g., receipts, expenditure reports) to IPFS.
    - Hashes of these proofs are stored on the blockchain, enabling auditors to verify compliance.

(D) Diagram of the Proposed Blockchain-Based Model

The architecture can be visualized as a flowchart. Figure 1 shows the flow chart:

- **Beneficiary Interface**: A user-friendly portal where beneficiaries authenticate via Aadhaar and submit applications.
- **Aadhaar API**: Verifies identity through biometric authentication, feeding results to the blockchain.

- **Blockchain Network**: Hosts smart contracts that manage registration, verification, approval, and fund release. Stores transaction data and IPFS hashes.
- **IPFS**: Stores documents and utilization proofs, with hashes linked to the blockchain for integrity.
- ***Digilocker***: Provides verified documents, reducing redundant uploads.
- ***Verifying Agency***: Accesses blockchain and IPFS to verify eligibility, updating the blockchain with results.
- ***Government Authority***: Approves applications via smart contracts, triggering fund transfers.
- ***Banking System***: Executes fund transfers, with details recorded on the blockchain.
- ***Auditor***: Accesses the blockchain for real-time auditing of all transactions.

(E) Integration with Existing e-Governance Systems

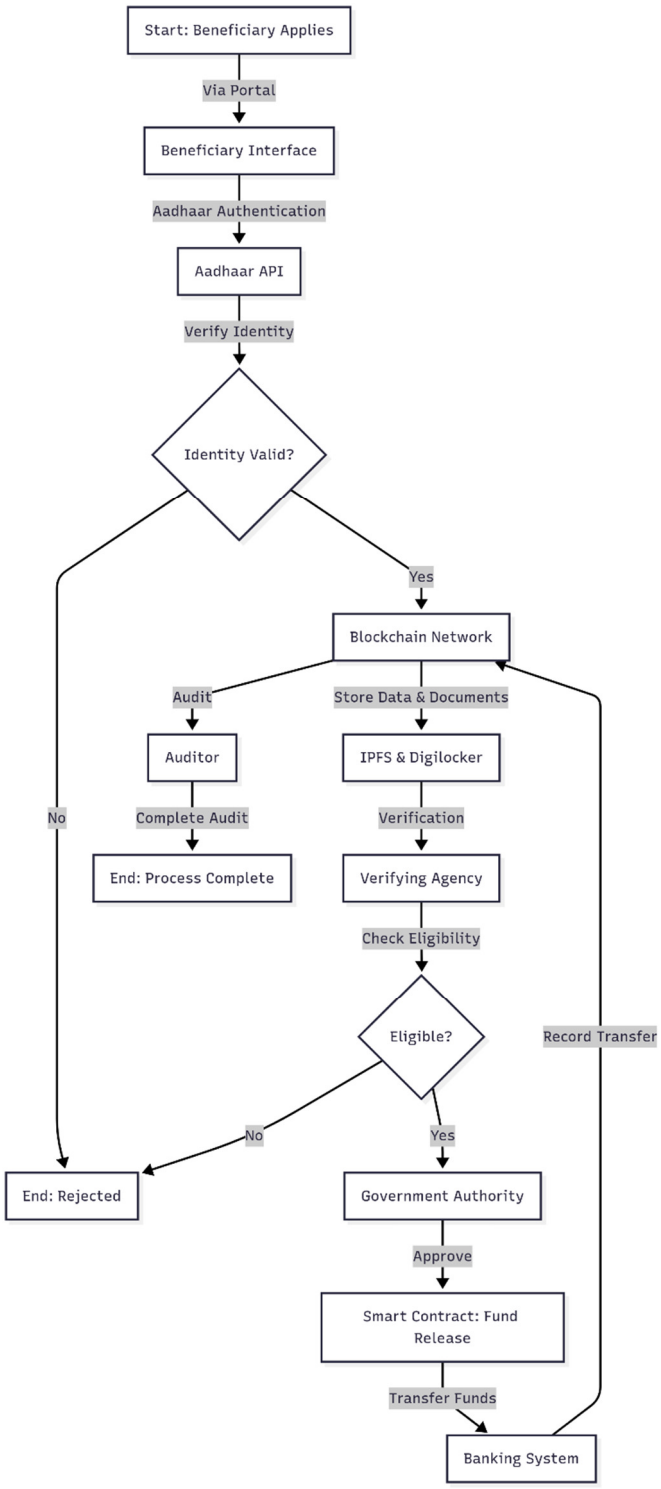

Fig 1: Flow Chart of the Blockchain-based Model

The framework integrates seamlessly with India's e-Governance infrastructure:

- **Aadhaar**: Used for biometric authentication during registration and fund transfers. The Aadhaar API ensures secure identity

verification, reducing the risk of ghost beneficiaries. For example, in the fertilizer subsidy pilot, Aadhaar-enabled PoS machines verified farmer identities [4]

- **Digilocker**: Facilitates document retrieval, allowing beneficiaries to share verified documents (e.g., income certificates) without physical submission. Document hashes can be stored on the blockchain for additional security.
- **Banking Systems**: Integrated with Unified Payments Interface (UPI) or other banking APIs to enable direct benefit transfers, as seen in schemes like PM-KISAN, where funds are transferred to Aadhaar-linked accounts.

(F) Benefits of the Framework

- ***Transparency***: All transactions are recorded on an immutable blockchain, accessible to auditors and authorized stakeholders.
- ***Efficiency***: Smart contracts automate processes, reducing delays and manual errors, as demonstrated in India's fertilizer subsidy pilot, which cut claim processing from months to near real-time [4].
- ***Security***: IPFS and blockchain ensure data integrity, while Aadhaar integration prevents fraud.
- ***Auditability***: Auditors can track every step from registration to fund utilization, ensuring accountability.

(G) Challenges and Considerations

- ***Scalability***: Blockchain networks may struggle with high transaction volumes, requiring solutions like sharding or Layer 2 protocols.
- ***Privacy***: Sensitive data must be encrypted or stored off-chain (e.g., on IPFS) to comply with data protection laws like India's proposed Personal Data Protection Bill.
- ***Integration Complexity***: Linking with legacy systems like ERP or SCM requires custom adapters, as seen in India's pharmaceutical pilot [4].
- ***Cost***: High initial setup and maintenance costs, along with a shortage of blockchain developers, pose economic challenges.

VI. CONCLUSIONS

Blockchain's potential to revolutionize government schemes is undeniable, but its implementation faces multifaceted challenges. Technical limitations like scalability and interoperability, economic barriers such as high costs and skill shortages, legal and regulatory gaps, and social hurdles like digital illiteracy and resistance to change must be addressed. A phased approach, starting with pilot projects and supported by public-private collaboration, can help overcome these obstacles. By investing in infrastructure, legal reforms, and public education, governments can harness blockchain to deliver transparent and efficient welfare programs.

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