The Promise of Block Chain: Revolutionizing Indian Elections

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Abstract

This abstract delves into the potential of blockchain technology for revolutionizing the voting system in India. As the world's largest democracy, India faces challenges such as voter fraud and logistical difficulties. By leveraging blockchain's transparency, security, and efficiency, these challenges can be effectively addressed. Blockchain provides a decentralized and immutable ledger, ensuring transparency and preventing tampering with voting data. The use of cryptographic techniques enhances security, reducing the risk of identity theft and unauthorized voting. Additionally, blockchain-based voting systems can streamline the electoral process by eliminating physical ballot papers and manual vote counting, reducing costs, time, and human errors. Real-time vote counting and result verification can provide instant and accurate election outcomes. However, implementing blockchain-based voting requires addressing issues such as technological infrastructure, accessibility, and digital literacy. Legal and regulatory frameworks must also be established to govern the use of blockchain in elections and protect voter privacy. With careful planning, collaboration, and investment, India can establish a more robust and trustworthy voting system through blockchain technology.

Keywords -

Introduction

The act of voting stands as a cornerstone of democratic societies, serving as a mechanism for citizens to express their preferences and collectively determine the direction of their nation. In the context of India, the world's largest democracy [*India holds the distinction of being the world's largest democracy, with more than 900 million eligible voters participating in the 2019 general elections*.], the voting system is not just a procedural formality but an embodiment of the diverse voices and aspirations of over a billion people. India has a rich history of conducting elections, with the first general elections taking place in 1951-1952, making it one of the earliest instances of a large-scale democratic election in the developing world.

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India's way of voting has changed and improved over time to fit the needs of its large and diverse population. It's made to be fair for everyone and make sure that the results truly represent what the people want.

In India, when it's time to vote, people pick their leaders for different levels of government, from local areas to the whole country. But this traditional voting system also has some problems, like ensuring the accuracy of voter rolls, preventing voter fraud, enabling equitable access to voting, and maintaining the transparency and fairness of the electoral process. [India's elections (2019) witnessed a 67% voter turnout].

t is against this backdrop of challenges and the quest for an increasingly robust and secure voting mechanism that emerging technologies are being explored. One such technology is blockchain, which has garnered attention worldwide for its potential to revolutionize traditional systems by offering transparency, security, and tamper resistance.

This research aims to combine India's complex voting system with the new possibilities of blockchain technology. It looks into how blockchain might solve the problems and weaknesses in the current voting setup. The goal is to add to the ongoing conversation about what the future of Indian elections could be like.

By studying the benefits that blockchain offers and thinking about how it could fit with the way India works, this research wants to show how blockchain might help make Indian elections better. This involves understanding what blockchain can offer, how it could affect things, and if it would work well within India's unique situation. Ultimately, this study wants to provide insights into how India can update and strengthen its democratic processes using these modern tools.

Literature Review

Blockchain Voting In India: Illusion Or Reality? By Harsh Kumar,11 December 2022.The recent elections in India have raised concerns about electronic voting machine (EVM) tampering, prompting discussions on enhancing transparency. Blockchain technology is gaining global attention as a solution to ensure transparent elections. Countries like South Korea are pioneering online voting systems based on blockchain, offering secure storage of ballot processes and results safeguarding against forgery and manipulation. As nations explore these innovations, the potential for blockchain to revolutionize election integrity is becoming increasingly evident.

By Harshit Rakheja, 27 March 2021, India Explores Block Chain-Based E-Voting by 2024 General Elections. In order to make the procedure more convenient, Arora claimed that the Election Commission of India is collaborating with IIT-Madras to deploy block chain technology to offer app-based e-voting. In addition to payments and cryptocurrencies, block chain technology has been promoted for keeping data on real assets like land and educational records to prevent fraud. A block chain-based certification verification mechanism was introduced by Start-up India in October of last year, allowing for immediate verification and access to certificates of recognition given by the industry group.

Block chain based Voting: The Future of Elections? By Sam Daley. According to the Council on Foreign Relations, overall turnout in 2020 U.S. national elections lied at 62 percent, falling three percent below the 65 percent average for members of the Organization for Economic Cooperation and Development — meaning that we still have a way to go to improve our voting participation.

How Block chain Technology Can Prevent Voter Fraud by JOE LIEBKIND, 09 December 2020. In its most basic form, blockchain is a digital ledger. The technology draws its power from the peers—or nodes—on

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its network to verify, process, and record all transactions across the system. This ledger is never stored, but rather exists on the "chain" supported by millions of nodes simultaneously. Thanks to encryption and decentralization, blockchain's database of transactions is incorruptible, and each record is easily verifiable. The network cannot be taken down or influenced by a single party because it doesn't exist in one place.

Election tally: Does block chain beat the ballot box? by Andrew Singer, 21 November 2022. Greenland's consideration of blockchain-based online voting highlights blockchain's potential to bolster election transparency. While the idea of blockchain-enabled elections has been discussed for years, practical implementation remains limited. The technology's traceability and decentralized nature could mitigate voting irregularities and enhance voter confidence, which is particularly relevant amid global concerns over election integrity. For remote regions like Greenland, blockchain-based systems offer a promising solution to improve accessibility and trust in the electoral process.

Blockchain To Be Used For Voting In The Coming Days By Team Cryptonomics, Dec 01, 2022. Kåre Kjelstrom, chief technology officer at Concordium, shared his thoughts on the voting basics with Cointelegraph. He said any voting system has the essential requirement of trust, and this trust requires a number of check marks, any one of which can stand as a challenge depending on the circumstances. He went on to comment, "Any digital system that replaces a manual voting system needs to address at least those same issues to ensure trust, and this has proven to be rather tricky to pull off. But blockchain may prove to be part of a solution."

New MIT Paper Roundly Rejects Blockchain Voting as Solution to Election Woes by Benjamin Powers, Sep 14, 2021. A new report from MIT, however, strongly argues against the idea of blockchain-based e-voting, largely on the basis that it will increase cybersecurity vulnerabilities that already exist, it fails meet the unique needs of voting in political elections and it adds more issues than it fixes.

Voting on the blockchain by Neha Narula, Nov 17, 2020. This article critically examines claims that Internet or blockchain-based voting would enhance election security, finding them misleading. The risks of undetectable, large-scale election failures are heightened with such systems. While online voting may seem convenient, studies show inconclusive effects on turnout, and security vulnerabilities persist, including malware and denial-of-service attacks. Blockchain-based systems, while not immune, can introduce additional problems. The article proposes key questions for evaluating the security of new voting system proposals.

Blockchain for Electronic Voting System—Review and Open Research Challenges by Uzma Jafar, 31 August 2021. The rising trend of online voting holds the potential for cost reduction and increased turnout, enabled by accessibility and convenience. Yet, concerns persist due to vulnerabilities that could lead to widespread manipulation. Blockchain technology emerged as a solution, offering decentralized and secure electronic voting. This article explores blockchain-based electronic voting systems, aiming to analyze current research status and anticipate future developments. While blockchain can address election system issues, challenges like privacy and transaction speed remain. To establish a sustainable blockchain-based voting system, security and scalability must be addressed, necessitating improvements to existing frameworks.

Background on blockchain

Blockchain technology traces its origins to the pioneering efforts of cryptographers like David Chaum, who proposed a protocol resembling blockchain in 1982, and Stuart Haber and W. Scott Stornetta, who further developed the concept in 1991. They envisioned secure, tamper-resistant systems where data could be recorded and verified. Over time, blockchain has evolved from its role in Bitcoin's creation to become a decentralized, transparent, and secure digital ledger with applications across industries. Its architecture,

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characterized by decentralized consensus and cryptographic linking of blocks, has inspired innovations in finance, supply chain management, healthcare, and more. This technology's potential to enhance security and transparency makes it pertinent even in domains like voting systems, where its attributes could fortify democratic processes.

Decentralized and Immutable Distributed Ledger

Blockchain is a revolutionary technology that serves as a decentralized and immutable digital ledger, designed to record and verify transactions in a transparent and secure manner. It operates on a distributed network of computers, known as nodes, where each node stores a copy of the entire ledger. Transactions are grouped into blocks, and these blocks are linked together in chronological order to form a chain, hence the name "blockchain."

Key Concepts

Decentralization: Unlike traditional centralized databases, where a single authority maintains control, blockchain operates on a decentralized network of computers (nodes). Each node stores a copy of the entire blockchain, ensuring redundancy and reducing the risk of a single point of failure.

Distributed Ledger: The blockchain ledger is distributed across all nodes in the network. Every participant has access to the same ledger, and any changes must be agreed upon through consensus mechanisms, minimizing disputes and unauthorized alterations.

Immutability: Once data is recorded on the blockchain, it is nearly impossible to alter. Transactions are stored in blocks, and each new block contains a reference to the previous one, creating a chain. This cryptographic linkage ensures the integrity of the data.

Transparency: Transactions on a blockchain are transparent and visible to all participants with access. While the identities of participants are often pseudonymous, the transaction history is open and accessible, enhancing accountability.

Consensus Mechanisms: Blockchain networks employ consensus mechanisms to validate and agree on the state of the ledger. Various algorithms like Proof of Work (PoW) or Proof of Stake (PoS) ensure that a majority of nodes must reach agreement before a transaction is added.

Smart Contracts: Smart contracts are self-executing contracts with the terms of the agreement directly written into code. They automate processes, ensuring that predefined conditions are met before executing actions, reducing the need for intermediaries.

Indian election

Around 912 million people were eligible to vote, and voter turnout was over 67 percent.

Electronic Voting background.

The e-voting system in India, commonly known as Electronic Voting Machines (EVMs), revolutionized the traditional paper-based voting process. EVMs are standalone electronic devices designed to enable voters to cast their votes digitally. Each EVM accommodates multiple candidates, and voters select their preferred candidate by pressing the corresponding button. EVMs offer simplicity, speed, and accuracy, and they eliminate the need for paper ballots, reducing manual errors and enhancing the efficiency of vote counting.

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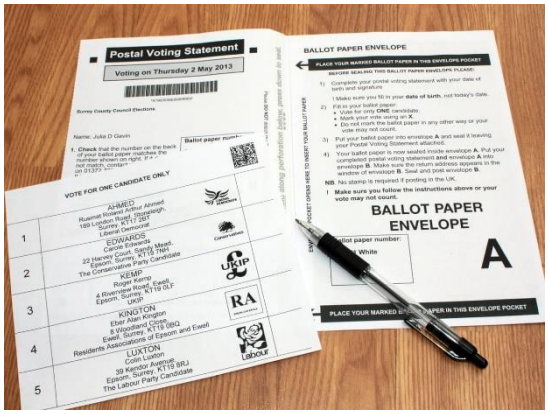
The Indian EVM system involves a two-step process: the voting process and the result tabulation. When a voter presses the button for their chosen candidate, their vote is recorded electronically. This data is stored securely within the EVM. After the voting period concludes, the EVMs are transported to counting centers. During the result tabulation phase, the votes recorded in each EVM are counted, and the final tallies determine the election outcome. EVMs have played a pivotal role in expediting the voting process and minimizing fraudulent practices, contributing to the transparency and integrity of India's democratic elections.

E-voting cost.

EVM is manufactured by The Bharat Electronic Ltd. (BEL). The cost per M3 EVM was Rs.17000.

Postal voting:

Postal voting in India, also known as "absentee voting," has a history that dates back several decades. Postal voting is a method that allows eligible voters to cast their votes in an election without physically visiting a polling station. Instead, they receive their ballot papers through the postal system and send their votes back to be counted.



Limitations

Limited Accessibility: Postal voting might not be feasible for voters in remote areas or regions with poor postal services.

Privacy Concerns: Maintaining the secrecy of the vote can be challenging, as voters might be influenced by others or coerced when marking their ballots at home.

Potential Delays: Delays in postal delivery can lead to votes arriving after the deadline, which may result in the votes not being counted.

Verification Challenges: Ensuring the authenticity of postal votes and preventing fraud can be more difficult compared to in-person voting.

Technological Limitations: In an increasingly digital age, postal voting might not appeal to younger generations who are accustomed to digital solutions.

Process

Application: Eligible voters who cannot physically go to the polling station due to reasons such as being away from their constituency on election day apply for postal voting.

Verification: Authorities verify the applications to ensure they meet the criteria for postal voting.

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Sending Ballot Papers: Approved voters receive their ballot papers through the postal system before the election.

Marking Votes: Voters mark their preferences on the ballot papers in private, just as they would at a polling station.

Sealing and Return: Voters seal their marked ballot papers in an envelope, which is then placed in a larger envelope along with a declaration form.

Sending Back: The voter sends the sealed envelopes back through the postal system to the relevant election authority.

Counting: On election day, the sealed envelopes are opened, and the votes are counted along with those from other methods.

Research Gap

Votes being stolen through hacking of EVMs, public agitation needed against it to save democracy: Digvijaya Singh.*(Digvijaya Singh is an Indian politician and a Member of Parliament in the Rajya Sabha.)*

Around 20,000 fake voters registered in every assembly seat in Mumbai: Sanjay Nirupam*(He is a former member of the Indian Parliament from Indian National Congress party, and former President of the Mumbai Regional Congress Committee).*

Real-time simulation.

Countries That Already Used Blockchain

United state

In recent years, the United States has ventured into utilizing blockchain-based electronic voting systems to modernize the voting process. Notably, the 2018 midterm election in West Virginia and the 2020 Presidential election in Utah County saw the implementation of the Voatz electronic voting application. Voatz's promise of end-to-end encryption and robust security mechanisms allowed remote voting for military personnel stationed abroad through biometric verification. Despite these advancements, concerns have emerged regarding application security, with MIT researchers identifying vulnerabilities that led to calls for caution from the Department of Homeland Security. While Utah County maintains the system due to its popularity, West Virginia temporarily halted its use in response to these security concerns.

Japan

In a pioneering move, Tsukuba City in Japan adopted blockchain-based digital voting, facilitated by local startup LayerX, as part of its smart city initiative. This innovative approach supplements Tsukuba's existing electronic voting system, with LayerX's integration aligning with government-established criteria for electronic voting systems. Although the system has yet to be utilized in official government elections, it has been employed for voting on social development proposals. Operating within Japan's "My Number" system, the blockchain-based process employs decentralized ledger technology, allowing voters to cast their ballots remotely online. While encountering minor challenges such as password retrieval, the rollout achieved overall success, garnering commendation from Mayor Tatsuo for its user-friendly and straightforward voting process.

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Russia

Russia's pursuit of blockchain-based voting systems has witnessed a series of state-funded initiatives, marked by iterations and varying degrees of success. Despite deployments in elections, these systems have faced accusations of mismanagement, data breaches, and manipulation. The summer's constitutional amendment vote allowing Vladimir Putin's prolonged rule introduced remote voting via a Bitfury Exonum-powered platform, designed by Kaspersky Lab. The proof of authority method to confirm voter identity encountered challenges, including a node attack and system crashes. Subsequent September by-elections featured two blockchain pilots. Rostelecom employed a private Waves blockchain variant but faced encryption vulnerabilities, while the Department of Information Technologies revisited the Exonum-based system, grappling with recurring issues.

Countries at a Poc level

South Korea

South Korea explores blockchain adoption for enhanced security, collaborating with IBM's Hyperledger Fabric to develop a blockchain voting pilot. The system aims to verify voters' authenticity and promptly record results. Tested privately by Handysoft Consortium for surveys from Korea's internet and Security Agencies, legislative approval is pending before it can be used in federal elections. Despite its potential, challenges like password issues and skepticism over vote counting surfaced, paralleling experiences in other countries.

Thailand

Thailand's National Electronics and Computer Technology Center has developed a blockchain-based voting system for national, local, and business decisions. Utilizing email voting and facial recognition from devices, the system is poised for small-scale election testing and potential use by expatriates in national elections, as per 2019 updates.

India

In India, the Election Commission partnered with IIT Madras to develop a blockchain-powered voting solution aimed at enabling nationwide remote voting. The system is designed to leverage the Electoral Registration Network, utilizing biometrics and mobile camera authentication to verify identities. As of February 2020, the project was in its developmental phase.

Methodology

Voter Registration: Document Verification and Key Generation

Document Verification by Government and Financial Institutions

The voter registration process begins with government authorities and potentially financial institutions verifying the identity and eligibility of individuals who wish to participate in the voting process.

This verification may involve validating personal information, legal identification, citizenship status, and other relevant details.

Ensuring Legitimate Participants

By conducting thorough document verification, government agencies and financial institutions ensure that only eligible and legitimate individuals are allowed to participate in the voting process. This prevents fraudulent activities and maintains the integrity of the electoral system.

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Key Generation by Government Agency

Generating a Pair of Keys

Once an individual's eligibility is confirmed, a government agency responsible for voter registration generates a pair of cryptographic keys for the voter. This pair consists of a private key and a corresponding public key.

Private Key as a Unique Identifier

The private key is a unique, secret cryptographic code that is associated exclusively with the specific voter. It is generated using advanced cryptographic algorithms and techniques to ensure its randomness and uniqueness.

Public Key as a Transaction Identifier

The public key serves as a transaction identifier on the blockchain. It is derived from the voter's private key using cryptographic processes. The public key acts as a pointer to the voter's record and helps facilitate secure interactions within the blockchain network.

Cryptographic Relationship between Keys

The relationship between the private and public keys is fundamental to the security of the system. While the private key remains confidential and is known only to the voter, the public key is openly shared and visible on the blockchain.

Authentication and Data Integrity

The private key's secrecy and cryptographic properties ensure the authentication of the voter's identity when interacting with the blockchain system. The public key, in combination with cryptographic techniques, ensures the integrity of data and transactions.

Key Delivery: Ensuring Secure Access

Delivery Methods

After the government agency generates a pair of cryptographic keys for each voter, the private key must be securely delivered to the voter. This can be achieved through various secure methods:

Physical Hardware: Distribution of a secure hardware token (e.g., USB drive or smart card) containing the private key.

Secure Email: Sending an encrypted email containing the private key, accessible only by the voter.

Digital File: Providing a digitally signed and encrypted file that holds the private key.

Additional Protection with TOTP:

For extra security, the private key files can be protected by Time-Based One-Time Passwords (TOTP). TOTP is a two-factor authentication method that requires a temporary code generated by an authenticator app within a specific timeframe.

Voting Process: Ensuring Authenticity and Security

Generating Digital Signature:

When it's time to vote, the voter accesses the election portal using their unique private key.

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The voter selects their preferred candidates or choices, and their original vote information is hashed using a cryptographic hash function.

Creating the Digital Signature:
The voter uses their private key to encrypt the hash value, creating a digital signature. This digital signature serves as a cryptographic proof of the voter's identity and their selected choices.

Sending the Vote:
The voter sends the digital signature, along with their public key and photo authentication, to the government agency responsible for vote collection and counting.

The public key acts as the identifier for the voter's identity on the blockchain.

Photo Authentication:
The inclusion of photo authentication adds an extra layer of verification by visually confirming that the person casting the vote matches the individual associated with the public key.

Illustration: Hashing and Encryption for Security
Hashing Original Document:

The voter's original vote information is processed through a cryptographic hash function, resulting in a hash value (digest).

Encryption of Hash Value:
This hash value is encrypted using the voter's private key, creating a digital signature. The encrypted hash value effectively represents the voter's choices and serves as proof of their authentic vote.

Verification Process: Converting Digital Signatures into Votes

Receipt of Documents
The government agency, acting as the receiver, receives three documents from the voter's public key: the encrypted digital signature, the original document (vote), and the voter's photo ID for authentication.

Decrypting the Digital Signature:
The receiver uses the sender's public key to decrypt the encrypted digital signature received from the voter. Decrypting the digital signature reveals the original hash value that was created by the voter using their private key.

Creating New Hash Value:
The receiver calculates a new hash value by processing the original document (vote) through the same cryptographic hash function used by the voter. This new hash value represents the original, unaltered document.

Comparing Hash Values:
The receiver compares the decrypted original hash value (from the digital signature) with the newly calculated hash value (from the original document).

If the two hash values match, it indicates that the document (vote) has not been tampered with since the digital signature was created. This verifies the authenticity and integrity of the vote.

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Scope of Using Blockchain.

Digital Divide and Accessibility

India has a diverse population with varying levels of digital literacy and access to technology. Implementing a blockchain-based voting system could exclude segments of the population that lack access to the necessary technology or are not familiar with digital platforms.

Large-Scale Deployment and Scalability:

Conducting elections in India involves millions of voters across a vast geographic area. Scaling a blockchain network to handle such a large number of transactions in a short time frame could pose significant technical challenges, potentially leading to delays or inefficiencies.

Complex Identity Verification:

Verifying the identity of voters accurately and securely is crucial for maintaining the integrity of the voting process. Integrating blockchain with existing identity verification systems and ensuring foolproof authentication for all voters could be a complex undertaking.

Ensuring Voter Privacy:

While blockchain provides transparency and immutability, preserving the privacy of individual votes is equally important. Designing a system that allows for transparent verification without revealing voters' choices presents a challenge, especially in a culture where vote secrecy is paramount.

Regulatory and Legal Framework:

Adapting existing legal and regulatory frameworks to accommodate blockchain-based voting poses challenges. Establishing guidelines for digital signatures, data protection, dispute resolution, and addressing potential legal challenges that may arise due to the adoption of new technology requires careful consideration.

Analysis & Discussion

1. Voting for Indian Expatriates:

Opportunity: Blockchain technology can enable Indian citizens living abroad to securely and conveniently cast their votes in Indian elections without the need to visit polling stations physically.

Explanation: A blockchain-based voting system could provide a digital platform for expatriates to vote from their current locations. Their votes would be securely encrypted and recorded on the blockchain, ensuring their participation in the democratic process.

Total voters: 1,34,59,195 [NRI].

[https://indiancitizenshiponline.nic.in/Ic_GeneralInstruction.pdf]

2. States with High Literacy Rates:

Opportunity: States with higher literacy rates can leverage blockchain technology to streamline and modernize their voting processes.

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Explanation: States like Kerala, Tamil Nadu, and Karnataka, which have higher literacy rates, could adopt blockchain-based voting systems more effectively due to the population's familiarity with digital technologies. This could lead to increased voter engagement and participation.

Table 1:

State	Literacy Rate	population
Kerala	94.00%	34,698,876
Lakshadweep	91.85%	66,001
Mizoram	91.33%	1,308,967
Goa	88.70%	1,521,992
		TOTAL= 3,75,95,836

state and literacy rate

3. Island States and Remote Locations:

Opportunity: Island states and remote locations face logistical challenges during traditional elections. Blockchain can overcome these challenges by offering a secure and accessible voting method.

Explanation: States such as Andaman and Nicobar Islands, Lakshadweep, and parts of Northeast India often struggle with infrastructure and connectivity issues. Blockchain can allow residents of these areas to vote remotely, improving their access to the electoral process.

Table 2:

State with Population

State Name	Population	Literates	Literacy
Andaman & Nicobar Islands	3,80,581	2,94,281	**86.63%**
Lakshadweep	64,473	52,553	**91.85%**
	4,45,054		

Willingness to Embrace Technology

Opportunity: States with a higher willingness to adopt innovative technologies can lead the way in implementing blockchain-based voting.

Explanation: States with a progressive mindset toward technology adoption, such as Telangana, Maharashtra, or Gujarat, could be early adopters of blockchain voting. Their willingness to explore and embrace new solutions could set a precedent for other states.

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Enhancing Voter Turnout

Opportunity: Blockchain can attract younger and tech-savvy voters, contributing to increased voter turnout, especially among the youth.

Explanation: Younger generations in states like Uttar Pradesh, Rajasthan, or Bihar, where youth constitute a significant demographic, are often more comfortable with technology. A blockchain-based voting system could resonate with them, encouraging higher participation.NOTE:[*The NSO recently released a report based on an all-India survey conducted in 2017-18. The survey shows that only 10.6% of the Indian population aged above 15 years has successfully completed a graduate degree*.]

As of 2022, the Indian population who have a single degree is 16.6%. This means that about 1 in 6 people in India have a bachelor's degree or equivalent.

India population in 2022 is 1,417,173,173(1.42 billion) *16.6% = 235,250,747.

Conclusion:

Reference:

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