

From Cash Transfers to Programmable Money: CBDCs and Public Service Delivery in India

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Abstract

The emergence of Central Bank Digital Currencies (CBDCs) represents a paradigm shift in monetary innovation, with significant implications for financial inclusion and public service delivery in emerging economies. This paper critically examines the feasibility of integrating CBDCs with India’s e-Governance platforms, focusing on their potential to enhance efficiency, reduce leakage, and improve targeting in subsidy disbursements. Using secondary data from the Reserve Bank of India (RBI), Union Budget 2025–26 allocations, and international case studies (China, Nigeria, Bahamas, and Sweden), the study evaluates both the current status and design considerations of CBDCs in India. A conceptual framework is proposed for CBDC–e-Governance interoperability, distinguishing between retail CBDC applications (e.g., PDS, LPG subsidies) and wholesale CBDC applications (e.g., interest subventions, fertiliser subsidies). The findings highlight that while CBDC circulation in India remains negligible (₹1,016 crore retail value vs. ₹36.9 lakh crore notes in circulation as of March 2025), the strategic deployment of programmable CBDCs could generate significant fiscal savings, strengthen accountability, and accelerate digital inclusion. The paper contributes to the literature by linking CBDC design choices to welfare state objectives, identifying institutional and regulatory challenges, and suggesting a phased roadmap for policy implementation.

Keywords: Central Bank Digital Currencies (CBDCs), Digital Currency, E-Governance, Financial Inclusion, Technological Challenges, Regulatory Framework, Public Delivery Services

Introduction

Imagine waking up in a bustling Indian city in the near future. As you step out of your home, you realize that the cash in your wallet has become a relic of the past. The chaiwala on the corner no longer accepts crumpled notes or jingling coins; instead, you pay for your morning chai with a few taps on your smartphone. This isn’t just any digital payment—it’s a direct transfer of digital rupees, the new Central Bank Digital Currency (CBDC) introduced by the Reserve Bank of India.

As you navigate through the day, from buying groceries to paying for an auto-rickshaw ride, you notice that everyone around you is adjusting to this new financial ecosystem. Some are embracing it with ease, while others, particularly the elderly and those less familiar with technology, struggle to adapt. The young shopkeeper down the

road mentions how he misses the simplicity of UPI, and a startup entrepreneur you meet later in the day shares concerns about the limited incentives for innovation in this new system.

Despite the excitement surrounding this digital revolution, there are whispers of unease. People are questioning the security of their digital wallets, the privacy of their transactions, and the potential bypassing of traditional banks. The promises of convenience and transparency are compelling, but they come with a host of challenges that the country must navigate carefully.

This story reflects India’s current journey towards adopting CBDCs, a path paved with both opportunities and obstacles. As the country stands on the cusp of this digital transformation, it faces a complex web of financial and technological challenges that must be addressed to ensure the successful integration of CBDCs into everyday life.

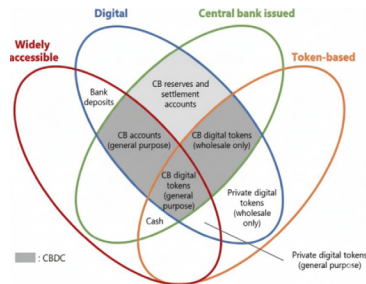


Figure 1: CBDC Vs other form of money supply

In this research, we delve into these challenges, exploring the real-life implications of a digital currency that could reshape the future of money in India.

Literature Review

Central Bank Digital Currencies (CBDCs) have emerged as a pivotal innovation in global payment systems. Early conceptual work by **Mancini-Griffoli et al. (2018)** framed CBDCs as a sovereign liability capable of combining the safety of central-bank money with the efficiency of digital payments, highlighting critical design trade-offs between retail and wholesale models. Building on this foundation, **Auer, Corneli, and Frost (2020)** examined the drivers of CBDC issuance across more than sixty jurisdictions and stressed the importance of digital identity and interoperability for emerging market economies.

Comparative evidence is now available from several live or large-scale pilots. **Eichengreen, Gupta, and Marple (2022)** analysed macro-financial consequences of CBDCs in Asia, noting that programmability and fiscal integration can improve the efficiency of government transfers but require robust governance. The **Bank for International Settlements (2023)** highlighted lessons from multi-CBDC bridge projects and recommended standardised messaging protocols and layered cryptographic safeguards for cross-platform interoperability. Case studies such as the Bahamas’ *Sand Dollar* and China’s *e-CNY* underscore how offline functionality, merchant integration, and privacy-preserving architectures affect adoption and financial stability (BIS, 2023).

Legal scholarship has turned to the private-law dimensions of tokenised money. **Bechara et al. (2025)** emphasise that token-based CBDCs raise questions of property rights, settlement finality, and custody relationships that must be clarified before mass issuance. For India, the **Reserve Bank of India (2021)** laid out a phased CBDC strategy and identified design choices around retail versus wholesale scope, token-versus account-based models, and privacy safeguards.

Despite this growing body of work, **few studies examine the interoperability of CBDCs with national e-Governance platforms for targeted welfare delivery.** Existing analyses of

India's Direct Benefit Transfer and Public Distribution System emphasise leakage and targeting challenges (e.g., Ministry of Finance, 2024), but do not evaluate programmable CBDC integration. This paper addresses that gap by linking global CBDC design lessons to India's digital public infrastructure—Unified Payments Interface (UPI), Aadhaar, and Jan Dhan accounts—while proposing an operational framework for CBDC-enabled, conditional public transfers.

Research Objective

To examine the key **challenges** and operational constraints in the present CBDC framework in India.

To analyse the technical and regulatory **feasibility** of linking CBDC with major **e-Governance and subsidy including interoperability**, digital-identity management, and data-governance requirements.

To develop a **programmable CBDC framework** that enables conditional, auditable public-fund transfers aiming to reduce leakage, improve targeting, and enhance fiscal efficiency.

Research Methodology

This study adopts a mixed-method approach combining secondary data analysis, case study review, and expert insights to evaluate the feasibility of integrating Central Bank Digital Currencies (CBDCs) with e-Governance platforms for public service delivery in India. Secondary data will be drawn from reliable sources such as Reserve Bank of India (RBI) reports on the e-Rupee pilot, National Payments Corporation of India (NPCI) statistics on UPI, UIDAI authentication records, and Direct Benefit Transfer (DBT) scheme data. These datasets will be analyzed to assess digital readiness, transaction scalability, and existing leakages in welfare delivery. Case studies of ongoing CBDC pilots in India and international interoperability projects such as BIS's Project mBridge will be examined to identify best practices and challenges. In addition, qualitative insights will be gathered through a review of policy papers, regulatory frameworks, and academic literature addressing cybersecurity, privacy, and interoperability issues. Together, this methodology provides both quantitative evidence of feasibility and qualitative understanding of governance, technological, and social implications, enabling a comprehensive review of CBDC–e-Governance interoperability in the Indian context.

Analysis

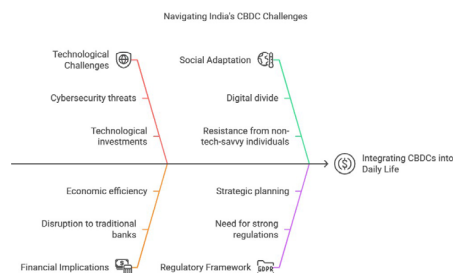


Figure 2: Ishikawa Fishbone diagram of challenges of CBDC integration

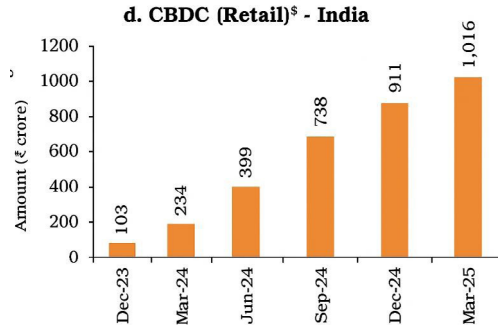


Figure 3: CBDC Circulation in India for the Retail

The Figure 3 illustrates the steady rise in the circulation of India’s retail Central Bank Digital Currency (CBDC) between December 2023 and March 2025. Starting from just **₹103 crore in December 2023**, the outstanding amount expanded more than ninefold to **₹1,016 crore by March 2025**. This consistent growth reflects the gradual scaling of the Reserve Bank of India’s pilot programme, increased participation by banks and payment service providers, and the ongoing push to test CBDC use cases in retail transactions and public delivery systems. The upward trend signals improving acceptance and the early stages of institutional readiness for digital currency in India.

However, despite this growth, the overall volume of CBDC in circulation remains minuscule when compared with traditional currency notes. As of 2024–25, **notes in circulation stood at ₹36.8 lakh crore**, making the CBDC’s share **less than 0.003%** of total currency. This contrast underscores the fact that, while India’s CBDC initiative is progressing steadily, it is still at an experimental stage and far from replacing or even substantially supplementing physical cash in the monetary system.

Table 1: Currency in circulation comparison

(Amount in ₹ crore)

Currency in Circulation	2023-24	2024-25
Notes in circulation	34,77,795.32	36,86,799.39
CBDC-W	0.08	0
CBDC-R	234.04	1,016.46

RBI Currency in Circulation : Notes Vs CBDC

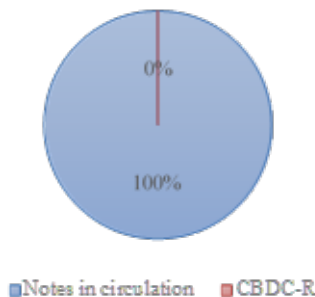


Figure 4: Currency in Circulation (RBI Annual Report 2024-25)

The comparative Figure 4 and Table 1 highlight that the volume of Central Bank Digital Currency (CBDC) in India remains extremely small when measured against the total notes in circulation. In 2024–25, the value of notes in circulation stood at

₹36,86,799.39 crore, whereas the retail CBDC (CBDC-R) accounted for only

₹1,016.46 crore, and wholesale CBDC (CBDC-W) registered no outstanding balance. Even in 2023–24, while notes in circulation were **₹34,77,795.32 crore**, CBDC-R was merely **₹234.04 crore**, with CBDC-W at **₹0.08 crore**. This stark disparity illustrates that despite ongoing pilot programs, CBDCs currently represent only a negligible fraction of India's monetary base. It underscores both the **nascency** of the initiative and the long road ahead before CBDCs can become a meaningful component of the overall currency ecosystem.

Limited Incentives in Non-Remunerated CBDCs

Most of the CBDCs which are proposed or implemented across the globe are non-remunerated CBDC, which **do not offer interest** to their holders. They function similarly to cash, meaning holding the digital currency does not generate any additional financial return. Indian e Rupee also does not pay any interest to the holder of CBDC.

A significant challenge in the adoption of Central Bank Digital Currencies (CBDCs) in India is the potential lack of public interest, as existing digital payment platforms like Google Pay, Paytm, and others already offer highly convenient interfaces along with additional features such as savings accounts, rewards, and cashbacks. These private platforms have become deeply integrated into the daily lives of users, providing seamless and rewarding experiences. Without offering clear, distinct advantages over these well-established options, CBDCs may struggle to attract users who see little reason to switch from platforms that already meet their needs. This preference for private apps over government-backed alternatives is evident in the continued dominance of apps like GPay, despite the availability of government-led payment solutions. (Shobha, 2020)

User Adoption and Behavioral Transition Barriers

The transition to Central Bank Digital Currencies (CBDCs) could pose a significant adaptation challenge, particularly for users who are not tech-savvy. This difficulty mirrors the struggles many faced during the demonetization period in 2016, when a substantial portion of the Indian population, especially in rural areas, found it challenging to quickly shift to digital payments due to limited familiarity with technology. The abrupt move to digital transactions highlighted the digital divide, leaving many people grappling with the new system. Similarly, the introduction of CBDCs could face resistance and difficulties in adoption if adequate support and education are not provided to ease the transition for those less accustomed to technology. (Manocha et al., 2019)

Interface and Accessibility Constraints

The success of Central Bank Digital Currencies (CBDCs) in India will significantly depend on the user interface of the platforms through which they are accessed, such as e-wallets. A user-friendly and intuitive interface is crucial for widespread adoption, as complex or cumbersome systems may deter potential users. This was evident in the success of the Unified Payments Interface (UPI) in India, where seamless integration with e-wallets and mobile banking apps played a key role in making digital payments accessible and easy to use for a broad audience. The simplicity and efficiency of UPI's interface helped drive its rapid adoption, setting a precedent that CBDCs will need to follow to achieve similar success. (Gupta et al., 2020)

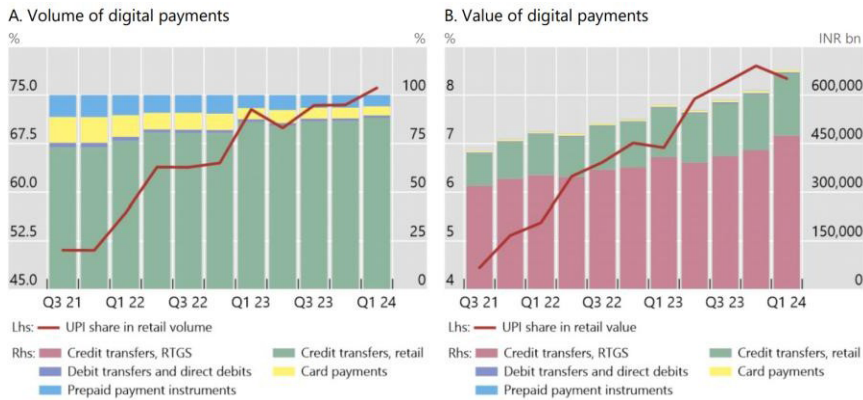


Figure 5: UPI in payment system

As of November 2024, it was processing over 15 billion transactions per month. This demonstrates its widespread adoption for everyday transactions. But despite dominating volumes, UPI transactions contributed only 8.7% by value in March 2024

Limited Innovation Incentives for FinTech Startups

Startups may lack sufficient incentive to develop additional layers or applications for Central Bank Digital Currencies (CBDCs) if the existing digital payment infrastructure, like UPI, already adequately meets consumer needs. The introduction of UPI was enthusiastically embraced by startups because its open API provided ample opportunities for innovation and growth. However, if CBDCs do not offer similar benefits or potential profit margins, startups might be reluctant to engage and innovate in this space, which could limit the development of new applications and features that could drive the adoption and success of CBDCs. Without clear incentives, the startup ecosystem may not invest the necessary resources to explore and expand the potential of CBDCs.

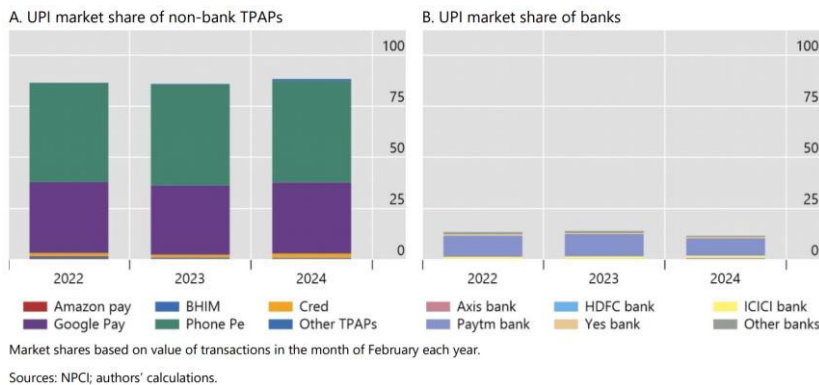


Figure 6: Growth of UPI because of private players

UPI has five key attributes – i) an open architecture infrastructure, ii) multi-party transactability, iii) ease of doing transactions, iv) strict data regulations, and v) a carefully calibrated regulatory environment. An open infrastructure simply means that UPI allows third-party developers to build on top of its open platform and create their own app that can be integrated with UPI. UPI also enables multi-application transactions. This means that users registered on any UPI platform

can make safe and quick transactions to any other account registered with UPI. These could be accounts linked to third-party payment service providers (PSPs) or bank accounts. (Aurazo et al., 2024)

Risks of Banking Sector Disintermediation

One of the foremost challenges in the adoption of Central Bank Digital Currencies (CBDCs) lies in their potential to disrupt the banking and financial system by accelerating both **slow and fast disintermediation**. Evidence from recent BIS research (Bidder, Jackson & Rottner, 2025) demonstrates that households are likely to substitute a portion of their deposits with CBDC under normal conditions, gradually eroding banks' low-cost funding base. This phenomenon of slow disintermediation may elevate banks' funding costs, compress their net interest margins, and constrain credit availability. More critically, during financial stress, CBDC introduces an additional channel for **digital runs**, whereby depositors can instantaneously convert bank deposits into central bank liabilities. Such a mechanism heightens systemic fragility, as the absence of frictions could exacerbate liquidity crises and accelerate contagion. While proposed mitigants such as **holding limits, tiered remuneration, and transaction caps** can dampen these risks, the calibration of such thresholds remains highly context-dependent. For India, where CBDC outstanding retail value stood at merely

₹1,016 crore as of March 2025 compared to ₹36.9 lakh crore in total notes in circulation (RBI, 2025), the current systemic impact is negligible. However, scaling CBDC for welfare transfers or broader retail use without adequate safeguards could destabilize bank intermediation and monetary policy transmission. Thus, designing CBDC with embedded constraints and strong governance mechanisms is essential to balance innovation with financial stability.

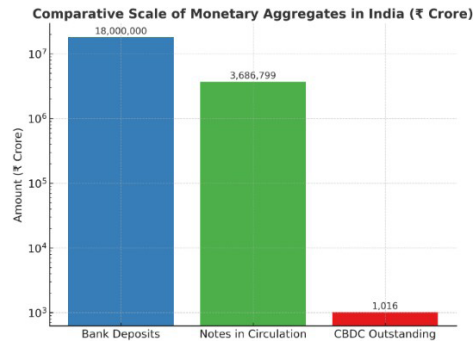


Figure 7: Monetary Aggregates in India

Comparative Benchmarking with global CBDC platforms

The global experimentation with Central Bank Digital Currencies (CBDCs) offers valuable lessons for India as it transitions from pilot-stage initiatives to scalable integration with e-Governance platforms. While India's retail CBDC pilot (₹1,016 crore outstanding as of March 2025) remains at an early adoption stage, benchmarking with international peers provides insights into design choices, adoption patterns, and welfare applications.

China (e-CNY): China's digital yuan represents the most advanced large-scale CBDC pilot, with over 260 million wallets opened and active usage across public transit, e-commerce, and government subsidy payments (PBOC, 2024). Its token-based retail model emphasizes programmability, enabling conditional disbursement of municipal subsidies. India can draw from China's experience in scaling merchant acceptance and embedding CBDC in routine transactions.

Nigeria (eNaira): Nigeria’s eNaira was launched in 2021, primarily for retail payments and welfare transfers. Despite policy efforts, adoption remains limited, with less than 2% of the population actively using it by 2023 (IMF, 2023). Key challenges include low digital literacy, mistrust in government systems, and inadequate incentives for merchants. This case highlights the risks of premature rollout without robust ecosystem readiness—a cautionary note for India.

Bahamas (Sand Dollar): The Bahamas was the first to issue a nationwide retail CBDC (2020), focusing on financial inclusion in geographically dispersed islands. Integration with prepaid cards and offline functionality has been central to its success

(CBOB, 2022). For India, the Sand Dollar demonstrates the importance of offline, low-connectivity features for rural inclusion.

Sweden (e-Krona): Sweden’s e-Krona project responds to declining cash usage, testing account-based models and integration with commercial banks (Riksbank, 2024). Unlike India, where cash remains dominant, Sweden’s case shows how CBDCs may serve as a public guarantee of central bank money in a near-cashless economy. India can extract lessons on regulatory oversight and data privacy frameworks.

Implications for India: Comparative benchmarking reveals that India’s CBDC trajectory must balance scale with trust. China and Sweden highlight scalability and stability, while Nigeria warns against insufficient stakeholder preparation. The Bahamas underscores inclusion through offline functionality—critical in India’s rural hinterlands. India’s advantage lies in its mature digital rails (UPI, Aadhaar, PFMS), but its challenge is to ensure interoperability, programmability for targeted subsidies, and high levels of citizen trust in a government-issued digital currency

Rationale for CBDC for targeted subsidy distribution

Table 2: Global benchmarking of CBDCs

Country	CBDC Type & Scope	Stage of Adoption	Account Onboarded	Key Design Features
China (e-CNY)	Primarily Retail	Large-scale pilot in >26 provinces, millions of users	>180 million	Account-based, controlled anonymity, programmable use-cases, QR-code integration with Alipay/WeChat Pay
Nigeria (eNaira)	Retail	Launched Oct 2021; low adoption (<0.5% of population, IMF 2023)	>850,000	Two-tier model (CBN issues, banks distribute), linked to mobile wallets
Bahamas (Sand Dollar)	Retail	First nationwide CBDC (2020)	>100,000	Wallets tiered by KYC, offline capabilities for islands with weak internet
Sweden (e-Krona)	Retail (exploratory)	Pilot phase (since 2020) with Riksbank tests		DLT-based; tested for wholesale clearing and retail payments; privacy & resilience focus
Jamaica (JAM-Dex)	Retail	National rollout launched 2022 after pilot in 2021; legal tender under the Bank of Jamaica Act (2022 amendment).	>190,000	Two-tier distribution

Table 3: Subsidy outlay for the fiscal year 2025-26

Subsidy Scheme Particulars	Budget Estimates 2025-26	
	Subsidy in Crores	
Food Subsidy	₹	2,03,420
Urea Subsidy	₹	1,18,900
Nutrient Based Subsidy	₹	49,000
LPG Subsidy	₹	12,100
Interest Subsidies	₹	27,840
Pradhan Mantri Annadata Aay Sanrakshan Yojna	₹	6,941
Prime Minister Employment Generation Programme (PMEGP)	₹	2,954
Assistance to Ship building, Research and Development	₹	365
Price Stabilisation Fund	₹	4,020
Total Subsidy Outlay	₹	4,26,216

The Table 3 from the Union Budget 2025–26 signifies that a substantial ₹4,26,216 crore towards subsidies, with food subsidy (₹2,03,420 crore), fertilizer support including urea (₹1,18,900 crore) and nutrient-based subsidy (₹49,000 crore), and LPG subsidy (₹12,100 crore) accounting for the bulk of the expenditure. Together, these categories reflect the government's continuing emphasis on social welfare and price stabilization for essential goods. However, the magnitude of these allocations—over 8% of the total budgetary expenditure (Figure 8) raises persistent concerns regarding fiscal efficiency, leakage, and improper targeting. Numerous studies and reports have documented how subsidy distribution through conventional channels is prone to challenges such as ghost beneficiaries, diversion of resources, and administrative inefficiencies, undermining the intended welfare impact.

**Figure 8: Total Budget Expenditure of 2025-26 Vs Total Subsidy Outlay**

In this context, the adoption of a Central Bank Digital Currency (CBDC) offers a transformative pathway to improve subsidy delivery. A CBDC-enabled framework could enable direct, programmable transfers to beneficiary wallets, with usage restricted to approved merchants or categories through mechanisms such as merchant category codes (MCCs), smart contracts, and Aadhaar-linked digital identity verification. Such design would not

only prevent leakages by eliminating intermediaries and fraudulent claims but also improve targeting by ensuring that funds are used strictly for the intended purposes—such as ration shops for food subsidies or fertilizer outlets for agricultural inputs. Furthermore, CBDC-based disbursement ensures real-time reconciliation between government welfare databases and redemption channels, enhancing transparency, accountability, and auditability. Thus, while subsidies remain a vital instrument of social policy, channeling them through CBDCs could substantially increase fiscal prudence and operational efficiency, aligning India’s welfare expenditure with the broader goals of digital governance and financial inclusion.

Table 4: Mapping of subsidy schemes with CBDC use cases

Subsidy Scheme	CBDC Use Case	Implementation Detail / Benefit
Food Subsidy (PDS)	Conditional e-vouchers / CBDC locked for ration shops	Disburse CBDC to beneficiary wallet; fundable only at authorised PDS merchants (MCA merchant registry). Eliminates fake benefits, reduces leakages. Real-time reconciliation between welfare database and merchant redemption.
Urea Subsidy / Nutrient Based Subsidy	Merchant-direct settlement to fertilizer dealers	Government credits subsidy to dealer via CBDC (on proof of sale/receipt; farmer pays only market price). Programmability ensures subsidy to authorised dealers; reduces ghost sales and diversion.
LPG Subsidy	Scheduled conditional top-ups / direct merchant settlement	LPG distributor whitelisting; conditional top-up on purchase; or digital coupon distribution redeemable only with registered distributors. Reduces fake claims and duplicate subsidies.
Interest Subsidies	Conditional release to lending institution / escrowed CBDC	CBDC disbursed to bank/PSP escrow link eligible borrower accounts; release upon approved verification (loan status), reducing manual reconciliation. Improves timeliness and reduces errors.
PM Annadata Aay Sanrakshan Yojna	Targeted direct transfers + monitoring	Combine Aadhaar KYC with CBDC wallet for beneficiary farmers; programmable micro-transfers for specific support. Analytics detect anomalies in disbursements.
PMEGP / Small Grants	Preloaded CBDC grants + restricted merchant use	Start-up grants disbursed to CBDC wallets can be used for approved vendor payments (equipment, inputs). Ensures funds are used for project objectives.

Design Principles for CBDC–E-Governance Interoperability

The integration of Central Bank Digital Currencies (CBDCs) with India’s e-Governance platforms is technically feasible due to the robust digital public infrastructure that already exists. India had approximately 900 million internet users as of 2025, making it the second-largest online population globally and ensuring broad digital reach for CBDC-based systems (IAMAI, 2024). Moreover, the Unified Payments Interface (UPI) has become the backbone of India’s digital economy, processing 16–19 billion transactions per month in 2024–25 across more than 660 participating banks, demonstrating the scalability of re-

Digital Innovation and Transformation with Emerging Trends for Sustainable Development

al-time digital payments (NPCI, 2025). Similarly, Aadhaar, India's digital identity system, recorded 2,707 crore authentications in 2024–25, confirming its capability as a reliable KYC and beneficiary verification tool for CBDC-linked welfare delivery (UIDAI, 2025).

Despite these advantages, CBDC adoption remains nascent. The Reserve Bank of India's e-Rupee pilot has expanded steadily, with retail CBDC outstanding reaching ₹1,016 crore by March 2025, up from ₹234 crore a year earlier, though still negligible compared to the ₹36.8 lakh crore worth of notes in circulation (RBI, 2025). This highlights the early stage of implementation, with pilots largely confined to select banks, payment firms, and limited user groups. While India's Direct Benefit Transfer (DBT) system has already demonstrated fiscal efficiency by saving approximately ₹3.48 lakh crore through reduced leakages (Ministry of Finance, 2024), CBDCs could extend these benefits further by enabling programmability, conditional transfers, and real-time audit trails.

However, challenges remain. UPI's entrenched dominance and attractive user incentives set a high bar for CBDC adoption, requiring the RBI to provide unique value propositions such as offline transaction capability or programmable subsidies. Additionally, privacy and cybersecurity risks—heightened by India's scale of Aadhaar-linked transactions—must be addressed through strong governance frameworks, secure wallet infrastructure, and transparent data-protection policies (Shu et al., 2023). Finally, institutional alignment across RBI, NPCI, UIDAI, and state e-Governance departments is critical for seamless interoperability, requiring standardized APIs, consent frameworks, and AML/KYC harmonization.

In conclusion, India has the foundational infrastructure for integrating CBDCs with e-Governance, but achieving scale will depend on solving adoption, security, and policy challenges. The feasibility is high from a technical perspective but contingent on regulatory design, public trust, and stakeholder coordination.

RBI Specific Design and Policy Considerations**Table 5: RBI's design considerations for CBDC**

Dimension	Option 1	Option 2	Key Implications
Scope	Retail CBDC (for individuals & households)	Wholesale CBDC (for interbank & institutional settlements)	Retail promotes inclusion and everyday use; wholesale improves efficiency in financial markets.
Model	Token-based (digital cash, transferable like banknotes)	Account-based (CBDC accounts managed by intermediaries or RBI)	Token model ensures cash-like anonymity; account model offers better traceability and compliance.
Distribution	Direct issuance by RBI to public	Indirect issuance via commercial banks & payment intermediaries	Direct improves central control but is resource-heavy; indirect leverages existing financial infrastructure.
Privacy & Data	Higher anonymity (cash-like experience)	Controlled transparency (auditability & AML compliance)	Balance needed between user trust, financial integrity, and regulatory oversight.

India's CBDC design rests on four dimensions. Retail CBDCs support inclusion, while wholesale CBDCs improve interbank efficiency. A token model offers cash-like anonymity, whereas an account model ensures traceability. Direct issuance by RBI centralises control but is resource-heavy, while indirect issuance via banks uses existing infrastructure. Finally, balancing anonymity and transparency is essential to build trust while meeting regulatory needs. (Bank für Internationalen Zahlungsverkehr, 2022)

Proposed operational framework for CBDC enabled e-Governance interoperability in India

India possesses strong technical building blocks for CBDC–e-Governance interoperability—widespread internet penetration, an extensive real-time payments rail (UPI), and a mature digital identity system (Aadhaar)—but that CBDC adoption is still at pilot scale (e-Rupee outstanding \approx ₹1,016 crore as of Mar-2025), signalling the need for a carefully staged interoperability framework. Empirical indicators (high UPI transaction volumes and large Aadhaar authentication counts) imply that an interoperable design should prioritise (a) API-level integration with existing rails to reuse proven settlement and merchant acceptance pathways, (b) identity-bound wallets that leverage Aadhaar for KYC while enforcing strict data-minimization and consent mechanisms, (c) programmable token features for conditional welfare disbursement (to reduce leakage), and (d) offline/low-connectivity modes for rural inclusion. Security and privacy analyses further recommend layered cryptographic protections, role-based access to transaction metadata, and independent audit trails to maintain trust and meet AML/CFT obligations (Mancini-Griffoli et al., 2018; Tian, Zhao & Oliver, 2023). International experiments on multi-CBDC bridges also counsel adoption of interoperable messaging standards and modular architectures to enable future cross-border use cases (BIS/mBridge). Based on the data, a pragmatic framework therefore combines an incremental pilot-to-scale roadmap, standardised APIs and data governance protocols, clear liability and operational roles across RBI/NPCI/banks/state e-Gov units, and a continuous security-testing regime—measures supported by both IMF and BIS guidance and by empirical cybersecurity studies of CBDC risk. (See Mancini-Griffoli et al., 2018; Tian et al., 2023; Eichen-green, Gupta & Marple, 2022.)

To implement a CBDC-enabled, medical-only welfare disbursement system, we propose a ten-step operational framework that converts policy intent into secure, auditable delivery. First, clearly define objectives and gather requirements: the welfare department must specify eligibility rules, beneficiary cohorts, covered medical expense categories and reporting needs, and convene stakeholders (RBI/regulatory leads, welfare department, partner banks/PSPs, healthcare providers, wallet/tech vendors and beneficiaries). Second, onboard banking partners to provide restricted medical accounts or prepaid/virtual medical cards and configure merchant-category (MCC) restrictions; ensure payment gateway integration with approved hospitals, pharmacies and diagnostic centres. Third, automate fund transfers (one-time or recurring) into designated medical accounts with programmed withdrawal rules that block non-medical merchants. Fourth, implement MCC and merchant-whitelisting so payments are accepted only at MCCs such as hospitals (8011), pharmacies (5122) and medical equipment suppliers (5047), with out-of-category transactions flagged. Fifth, register beneficiaries via a secure portal (Aadhaar-linked KYC where appro-

priate), provide clear user guidance and consent forms, and support card/wallet activation through in- person or digital onboarding. Sixth, deploy real-time transaction monitoring and alert- ing integrated with banks and the welfare dashboard so suspicious or non-compliant transactions generate immediate notifications to both beneficiary and administrator. Seventh, establish an approvals and reimbursement workflow for major or pre- approved medical expenses, with medical validation by licensed practitioners or third- party assessors. Eighth, run periodic audits and analytics—quarterly reconciliations, pattern-analysis for misuse, and cross-checks with provider invoices—backed by dashboards for the welfare department and independent audit capability. Ninth, define a graduated misuse policy (repayment, suspension/reduction of benefits, and legal escalation for fraud) and a clear grievance redressal mechanism. Finally, institutional- ize continuous improvement through beneficiary feedback channels, a helpline, peri- odic policy reviews, and phased technical upgrades (including offline/low- connectivity modes and enhanced cryptographic protections). The technical stack should combine bank APIs, CBDC wallet interfaces, MCC enforcement at the acquir- er/issuer level, real-time analytics, and strong data-governance rules (data minimiza- tion, purpose limitation, and audit logging) to ensure compliance, privacy and opera- tional resilience. This end-to-end framework balances control and user accessibility while enabling transparent, programmable, and auditable use of public funds for med- ical purposes.

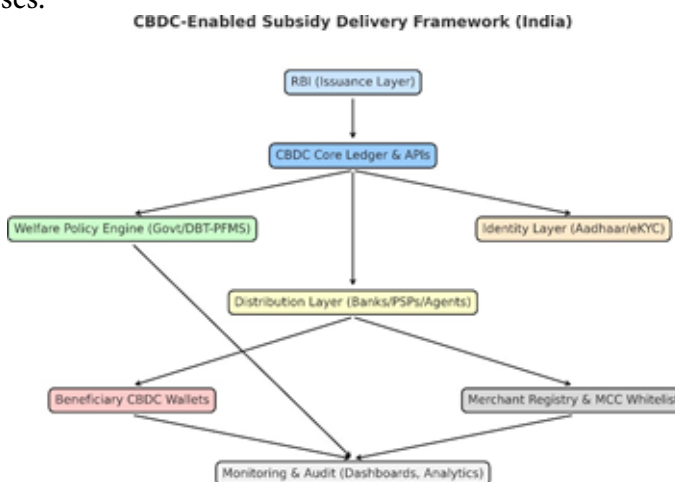


Figure 9: CBDC enabled Subsidy Delivery Framework for India

Food Subsidy Distribution Mechanism through CBDC

A Central Bank Digital Currency (CBDC)–enabled framework for the Public Distribution System (PDS) can substantially enhance efficiency, transparency, and targeting in India’s food subsidy delivery. Beneficiary identification would be achieved through Aadhaar or Jan Dhan-linked e-KYC, with each eligible household provided a CBDC wallet in the form of a mobile app, QR-based solution, or prepaid CBDC card for offline use. These wallets would be synchronised with the PDS database to ensure that only authorised beneficiaries receive allocations. Monthly subsidies could then be issued as programmable CBDC tokens or conditional e-vouchers, credited directly to beneficiary wallets and restricted in

their usage through merchant category codes (MCCs), allowing redemption exclusively at PDS-authorized ration shops. On the merchant side, all ration shops would be registered in a government-approved CBDC merchant database and equipped with compatible point-of-sale (POS) systems or QR-based payment interfaces linked to NPCI-UPI rails. Each transaction would undergo automated validation, checking beneficiary eligibility, merchant authenticity, and product category before funds are transferred in real time from the beneficiary's CBDC wallet to the merchant's account. This design enables seamless reconciliation of government subsidy allocations with merchant redemptions while preventing diversion and fraudulent claims. Importantly, the CBDC ledger provides an immutable audit trail, ensuring end-to-end traceability for regulators and auditors. Such an architecture also allows the government to dynamically adjust allocations, pause disbursements in cases of misuse, and improve governance through real-time data insights. By eliminating cash handling, reducing leakages, and ensuring inclusion through offline wallet options for rural beneficiaries, this model not only strengthens fiscal efficiency but also aligns with global recommendations on programmable CBDCs for welfare delivery.

Wholesale CBDC model for the Interest Subvention Scheme

A pragmatic solution to enhance the efficiency and integrity of interest subsidy disbursements is the deployment of wholesale Central Bank Digital Currency (wCBDC). Unlike retail CBDCs, which are designed for mass adoption by households and individuals, wholesale CBDCs are purpose-built for high-value transfers between financial institutions and central banks. This makes them particularly well-suited for subsidy schemes where the immediate recipients are lending institutions (commercial banks, NBFCs, or PSPs) rather than end consumers.

Under such a framework, the government would transfer interest subsidy allocations in the form of wCBDC into escrow accounts maintained by eligible institutions directly on the central bank's digital ledger. These funds could then be programmed for conditional release, triggered automatically upon the verification of borrower eligibility and loan repayment status via integrated e-governance platforms such as the Public Financial Management System (PFMS). By leveraging programmability, the wCBDC would ensure that subsidies are credited precisely in line with verified claims, thereby eliminating manual reconciliation delays, reducing errors, and preventing leakages.

Furthermore, since all transactions are settled on the central bank's ledger, real-time finality, transparency, and auditability are achieved, allowing regulators and auditors to trace disbursements seamlessly. This reduces both settlement risk and operational inefficiency, while reinforcing compliance with fiscal governance norms. In this manner, adopting a wholesale CBDC for institutional-facing subsidy schemes would not only align India with global best practices in digital financial infrastructure (such as the BIS mBridge initiative and China's wholesale e-CNY pilots) but would also create a dual-track model where retail CBDCs are employed for household welfare schemes and wholesale CBDCs for institution-level transfers. Such a calibrated approach balances innovation with systemic stability, while ensuring that fiscal transfers are executed with greater accuracy, timeliness, and accountability.

Comparative Retail vs Wholesale CBDC Delivery Framework

Table 6: CBDC-Based Subsidy Delivery: Retail vs Wholesale Framework

Subsidy Scheme	Current Allocation (₹ Crore, 2025–26)	CBDC Type	Proposed Mechanism	Rationale
Food Subsidy (PDS)	₹ 2,03,420	Retail CBDC	Conditional e-vouchers credited to beneficiary wallets; spendable only at authorised ration shops (MCC whitelisting).	Direct-to-household transfer; prevents leakage and diversion.
Urea Subsidy	₹ 1,18,900	Wholesale CBDC	CBDC credited to fertiliser companies/dealers' escrow accounts, released on verified sales.	High-value institutional disbursement; prevents diversion and ensures dealer accountability.
Nutrient-Based Subsidy (NBS)	₹ 49,000	Wholesale CBDC	Direct CBDC to fertiliser firms, conditional on verified nutrient supply transactions.	Institutional transfer; reduces fraudulent claims and subsidy misuse.
LPG Subsidy	₹ 12,100	Retail CBDC	Conditional CBDC tokens credited to households; redeemable only with authorised LPG distributors.	Household-facing scheme; ensures targeted benefit delivery.
Interest Subsidies	₹ 27,840	Wholesale CBDC	wCBDC transferred to banks' escrow wallets; automated release linked to loan repayment schedules.	Institutional transfer; reduces reconciliation errors, ensures timely settlement.
PM Annadata Aay Sanrakshan Yojna	₹ 6,941	Retail CBDC	Conditional CBDC credits to farmers' wallets; redeemable for agricultural inputs or credited to bank accounts.	Household/farmer-facing scheme; enhances inclusion and transparency.
PMEGP	₹ 2,954	Retail CBDC	Preloaded CBDC grants restricted to approved merchant categories (equipment, services).	Supports entrepreneurs; prevents misuse of grant funds.
Assistance to Shipbuilding, R&D	₹ 365	Wholesale CBDC	Milestone-based CBDC release to firms via escrow; triggered upon certified project completion.	Institutional R&D support; milestone-linked efficiency.
Price Stabilisation Fund	₹ 4,020	Wholesale CBDC	Programmable CBDC disbursed to authorised agencies/warehouses during market interventions.	Institutional-facing; enables rapid response to price volatility.

Conclusion

The analysis of CBDC–e-Governance interoperability in India demonstrates both the promise and the complexity of integrating digital currencies into public service delivery. While the Reserve Bank of India’s pilot projects highlight growing maturity in CBDC design, their scale remains minimal when compared with overall currency in circulation and existing digital payment ecosystems such as UPI. The feasibility of using CBDC for welfare and subsidy transfers rests on the strength of India’s digital infrastructure—Aadhaar, DBT, and real-time payments—which already enable efficiency and transparency in large-scale schemes. However, challenges such as interoperability with legacy platforms, user adoption barriers, cybersecurity risks, privacy safeguards, and the need for clear institutional coordination remain critical.

Going forward, a robust framework must combine technical innovations—API-based integration, programmable CBDC features, and offline capabilities—with strong governance mechanisms, including data protection, auditability, and regulatory clarity. By adopting an incremental pilot-to-scale approach and ensuring alignment among stakeholders such as RBI, NPCI, UIDAI, and welfare departments, India can build a model for CBDC-enabled public delivery that enhances efficiency, reduces leakages, and fosters financial inclusion. Ultimately, the success of this initiative will depend not only on technological readiness but also on public trust, stakeholder collaboration, and a regulatory environment that balances innovation with security and accountability.

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