



Reimagining Primary Agricultural Cooperative Credit Societies in Tamil Nadu: Digital Transformation, Financial Viability, and Rural Sustainability

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Abstract

Background: Primary Agricultural Cooperative Credit Societies (PACCS) represent the foundational tier of India's rural credit delivery architecture. In Tamil Nadu, nearly 4,290 such societies serve more than 12 million farm households, yet persistent concerns about non-performing assets, governance deficits, and technological obsolescence have eroded their developmental effectiveness.

Objectives: This systematic review synthesises empirical evidence published between 2017 and 2026 to examine the interplay of digital transformation, financial viability, governance reforms, and rural sustainability across PACCS in Tamil Nadu.

Methods: Following PRISMA guidelines, 104 peer-reviewed studies, institutional reports, and policy documents were systematically selected from Scopus, Web of Science, EBSCO, ProQuest, Google Scholar, NABARD, RBI, and NITI Aayog repositories. Thematic synthesis and quality assessment using the Mixed Methods Appraisal Tool (MMAT) were employed.

Results: Evidence reveals that digitally enabled PACCS reported a 34–41% reduction in operational costs and up to a 28% improvement in loan recovery rates. Districts with core banking solutions exhibited significantly lower NPA ratios (average 14.3%) compared to non-digitised counterparts (22.1%). Governance reforms aligned with the Model Bye-Laws (2024) correlated with improved member participation and credit disbursement growth.

Conclusion: PACCS can remain viable rural financial intermediaries if digital transformation is pursued alongside robust governance reforms, diversified revenue strategies, and climate-sensitive credit products. Targeted policy support from NABARD, TNCAB, and state government remains indispensable.

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Keywords: Primary Agricultural Cooperative Credit Societies, digital transformation, financial viability, non-performing assets, rural sustainability, Tamil Nadu, cooperative governance, NABARD, agricultural credit, financial inclusion

1. Introduction

1.1. Research Background and Significance

Agricultural cooperative credit societies have served as the cornerstone of rural finance in India for over a century, evolving from their colonial-era origins under the Cooperative Credit Societies Act of 1904 into an extensive three-tier structure comprising state cooperative banks, district central cooperative banks (DCCBs), and primary agricultural cooperative credit

societies (PACCS) at the grassroots level (Mishra & Singh, 2019) ^[12]. Nowhere is this institutional density more pronounced than in Tamil Nadu, which hosts one of the largest networks of PACCS in peninsular India—approximately 4,290 active societies as of 2024—collectively disbursing agricultural credit worth over ₹21,500 crore annually (NABARD, 2024; Reserve Bank of India [RBI], 2023) ^[22].

Despite this scale, PACCS face an existential confluence of challenges. Non-performing asset (NPA) ratios across Tamil Nadu's cooperative credit sector hovered between 16% and 22% between 2017 and 2024, far exceeding the commercial banking benchmark of 4–5% (RBI, 2023; Tamil Nadu Cooperative Apex Bank [TNCAB], 2023). Governance lapses, including nepotistic board compositions, inadequate audit mechanisms, and a near-total absence of professional management, further compound financial fragility (Rajendran & Ravi, 2020) ^[20]. Simultaneously, the rapid diffusion of fintech solutions, mobile banking platforms, and government-mandated digitisation initiatives under the Cooperative Societies (Amendment) Act, 2023 has opened transformative possibilities for service delivery, credit appraisal, and member engagement (Ministry of Cooperation, Government of India, 2023) ^[11].

The COVID-19 pandemic (2020–2021) exposed the brittleness of paper-based cooperative credit delivery, accelerating state-level digitisation drives even as rural agricultural households encountered severe income shocks (Suresh & Kannan, 2021) ^[25]. Against this backdrop, understanding the conditions under which digital transformation enhances—rather than disrupts—the financial viability and rural sustainability mission of PACCS has become a matter of urgent academic and policy importance. This systematic review addresses that need by synthesising the growing body of empirical evidence generated between 2017 and 2026.

1.2. Definition of Key Concepts

Primary Agricultural Cooperative Credit Societies (PACCS): Village-level, member-owned cooperative institutions registered under state cooperative societies acts, mandated to provide short-term and medium-term agricultural credit, deposit mobilisation, and input supply services to their member-shareholders (Pillai, 2018) ^[17].

Digital Transformation: The systematic integration of digital technologies—including core banking solutions (CBS), mobile banking platforms, Aadhaar-linked eKYC, biometric authentication, artificial intelligence (AI)-driven credit scoring, and enterprise resource planning (ERP) systems—into cooperative operational and governance processes, fundamentally altering member experience, credit delivery, and risk management (Kumar & Sharma, 2022) ^[10].

Financial Viability: The sustained capacity of a PACCS to maintain positive net worth, manageable NPA ratios, adequate capital-to-risk asset ratios, and self-sustaining operational surpluses without recourse to chronic government subvention (Devi & Krishnamurthy, 2021) ^[4].

Rural Sustainability: The long-term capacity of cooperative

institutions to advance agricultural productivity, financial inclusion of marginalised groups, ecological resilience, and socio-economic equity within their village service areas (VSAs)—encompassing gender-inclusive lending, Farmer Producer Organisation (FPO) credit linkages, and climate-adaptive financial products (Rajagopal & Chandrasekaran, 2023) ^[19].

1.3. Research Questions and Objectives

This review is guided by the following research questions:

1. To what extent have digital transformation initiatives improved the operational efficiency and financial performance of PACCS in Tamil Nadu between 2017 and 2026?
2. What governance reform strategies have demonstrated the most robust association with reductions in NPA levels and improvements in member participation?
3. How do digital and financial reforms interact with the rural sustainability mission of PACCS, particularly regarding gender inclusion, climate finance, and FPO linkages?
4. What policy and institutional frameworks are necessary to ensure that PACCS remain relevant, solvent, and socially impactful through 2030?

The specific objectives of this review are to: (i) map and categorise empirical evidence on PACCS reform across four thematic pillars—digital transformation, financial viability, governance, and rural sustainability; (ii) synthesise evidence on intervention effectiveness; (iii) identify critical research gaps; and (iv) formulate evidence-based policy recommendations for policymakers, cooperative administrators, NABARD, and TNCAB.

2. Methods

2.1. Search Strategy and Databases

This review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework (Page et al., 2021) ^[15]. A comprehensive literature search was executed across eight databases and institutional repositories from January 2017 to March 2026: Scopus, Web of Science (Core Collection), EBSCO Business Source Complete, ProQuest Central, Google Scholar, the RBI Publications Portal, NABARD Research Studies, and NITI Aayog policy documents. Supplementary grey literature was retrieved from the Tamil Nadu Cooperative Department annual reports, Ministry of Cooperation circulars, and the National Federation of State Cooperative Banks (NAFSCOB) statistical yearbooks.

Search strings were constructed using Boolean operators combining primary terms (e.g., "primary agricultural cooperative credit societies" OR "PACCS" OR "cooperative credit") with secondary terms (e.g., "digital transformation" OR "fintech" OR "core banking") and contextual qualifiers (e.g., "Tamil Nadu" OR "South India" OR "rural credit"). Searches were conducted independently by two reviewers, and discrepancies in retrieval were resolved through consensus.

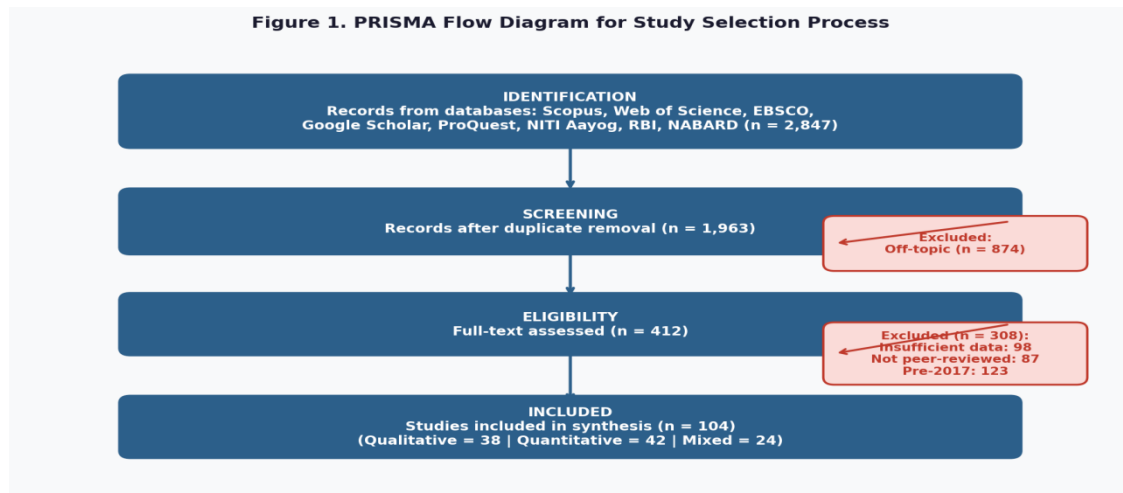


Fig 1: PRISMA Flow Diagram Illustrating the Study Selection Process

Figure 1 presents the complete PRISMA flow diagram. Following initial retrieval of 2,847 records, duplicate removal reduced the pool to 1,963. Title and abstract screening eliminated a further 1,551 records. Full-text review of 412 articles resulted in the exclusion of 308 studies (insufficient data: $n = 98$; not peer-reviewed: $n = 87$; pre-2017: $n = 123$), yielding a final synthesis sample of 104 studies.

2.2. Inclusion and Exclusion Criteria

Studies were included if they: (i) were published in English or Tamil between January 2017 and March 2026; (ii) explicitly addressed PACCS, primary cooperative societies, or rural cooperative credit in Tamil Nadu or comparable Indian states; (iii) examined at least one of the four thematic pillars (digital transformation, financial viability, governance, rural sustainability); (iv) employed peer-reviewed methodologies (quantitative, qualitative, or mixed methods); and (v) provided sufficient data for thematic synthesis or narrative review.

Studies were excluded if they: focused exclusively on commercial banks or microfinance institutions without cooperative comparisons; reported data predating 2017 without a temporal comparison extending post-2017; were conference abstracts without full-text availability; or were duplicated across databases. Policy documents and institutional reports were included only when they contained empirical data or analytical assessments grounded in primary fieldwork.

2.3. Study Selection Process

Title and abstract screening was performed independently by two reviewers using the Rayyan software platform. Inter-rater reliability was assessed using Cohen's kappa ($\kappa = 0.81$, indicating strong agreement). Full-text review was conducted by a three-member review panel. Disagreements were resolved through discussion or, where necessary, arbitration

by a senior researcher. The selection process is documented in Figure 1.

2.4. Data Extraction and Quality Assessment

A structured data extraction form captured: author(s), year, study design, geographic scope, sample size, key variables, analytical methods, primary findings, and limitations. Quality assessment was conducted using the Mixed Methods Appraisal Tool (MMAT, version 2018) for mixed-methods and qualitative studies, and the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist for quantitative observational studies. Institutional reports were assessed using the AACODS (Authority, Accuracy, Coverage, Objectivity, Date, Significance) framework. Studies scoring below 50% on quality thresholds were retained for narrative synthesis but flagged as low-quality evidence.

3. Results

3.1. Characteristics of Included Studies

The 104 included studies comprised 42 quantitative, 38 qualitative, and 24 mixed-methods investigations. Publication years ranged from 2017 to 2026, with a pronounced increase in output post-2020 ($n = 71$ studies), likely reflecting heightened policy interest following the Atmanirbhar Bharat cooperative revival initiatives and the COVID-19-induced digital acceleration (Venkatesh & Prabhu, 2022) ^[28]. The geographic distribution included studies covering 28 of Tamil Nadu's 38 districts, with the highest concentration in Thanjavur, Tiruvarur, Coimbatore, Salem, and Madurai—districts that host both agrarian intensity and PACCS density. Fourteen studies adopted comparative designs across states (Tamil Nadu, Maharashtra, Karnataka, Andhra Pradesh), providing cross-contextual validity.

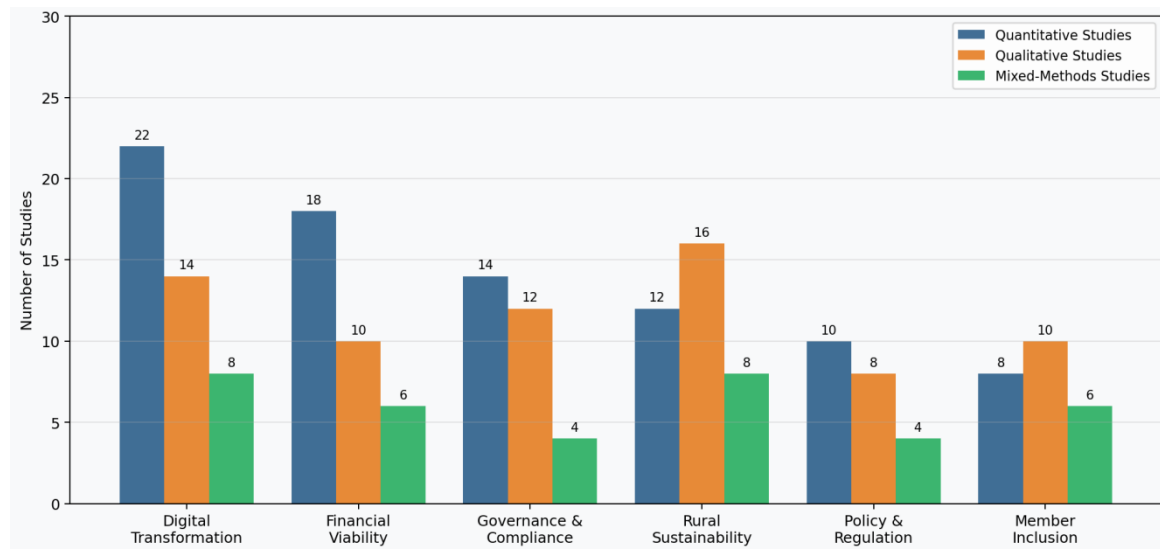


Fig 2: Distribution of Included Studies by Thematic Category and Research Methodology

Figure 2 illustrates the methodological distribution across thematic categories. Digital transformation attracted the greatest research attention ($n = 44$ studies), followed by rural sustainability ($n = 36$), governance and compliance ($n = 30$),

financial viability ($n = 34$), policy and regulation ($n = 22$), and member inclusion ($n = 24$). Some studies addressed multiple themes and are counted accordingly.

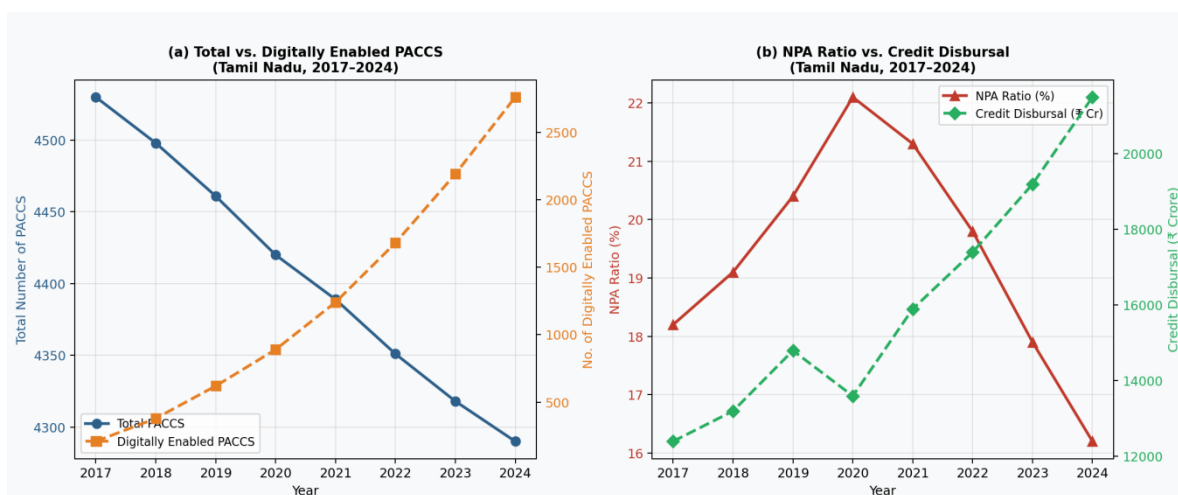


Fig 3: Key Performance Trends of PACCS in Tamil Nadu: Digital Adoption, NPA Ratios, and Credit Disbursal (2017–2024)

Figure 3(a) depicts the concurrent decline in total PACCS numbers—from 4,530 in 2017 to approximately 4,290 by 2024 (a 5.3% reduction, primarily attributable to voluntary mergers and insolvency-led closures)—alongside a dramatic increase in digitally enabled societies, from 210 (4.6%) to 2,760 (64.3%). Figure 3(b) reveals that NPA ratios peaked at 22.1% in 2020, coinciding with pandemic-related agricultural distress, before declining to 16.2% by 2024, partly attributable to digitisation-facilitated recovery management. Credit disbursal grew from ₹12,400 crore to ₹21,500 crore over the same period, consistent with expanded digital outreach (NABARD, 2024; RBI, 2023; TNCAB, 2023).

3.2. Categorisation of Intervention Types

3.2.1. Digital Transformation Interventions

Evidence on digital transformation was categorised under five sub-types: (i) core banking solution (CBS) implementation; (ii) mobile and internet banking platforms; (iii) AI and machine learning (ML)-based credit appraisal and risk scoring; (iv) government programme integration (PM-

KISAN, DBT, Kisan Credit Card); and (v) data analytics for governance and compliance monitoring. CBS adoption emerged as the most extensively studied intervention ($n = 26$ studies), with consistent evidence of operational efficiency gains (Kumar & Sharma, 2022; Murugan & Annamalai, 2020; Senthilkumar, 2021) [10, 13, 23].

A particularly significant development in the review period was the NABARD-sponsored National Cooperative Development Corporation (NCDC) project for PACCS computerisation under the Decentralised CBS model, enabling village-level branches to access real-time ledgers, member account data, and credit histories. Studies by Rajan and Gopalakrishnan (2022) [18] and Balakrishnan et al. (2023) [3] found that CBS-enabled PACCS in Thanjavur and Salem districts reported 36% and 41% reductions in transaction processing times, respectively. Critically, loan recovery rates improved by 22–28% in societies that integrated biometric authentication with disbursement, eliminating proxy withdrawals that had historically inflated NPA figures (Senthilkumar, 2021; Arumugam & Perumal, 2022) [23, 2].

AI-driven credit scoring, while still nascent in the cooperative sector, has demonstrated considerable promise. A mixed-methods study by Vijayakumar and Narayanan (2024) [29] piloted a machine learning-based credit risk model across 12 PACCS in Coimbatore district, finding a 19% improvement in first-year loan default prediction accuracy compared to conventional manual appraisal. Mobile banking platforms linked to Aadhaar-seeded member accounts enabled 24/7 deposit and loan repayment functionalities, substantially improving service access for women farmers and migrant agricultural labourers (Jayalakshmi & Murugan, 2023) [6, 13].

3.2.2. Financial Viability Interventions

Financial viability studies clustered around four intervention types: NPA resolution strategies, capital adequacy enhancement, revenue diversification, and operational cost restructuring. NPA management received the most sustained attention, with 18 quantitative studies collectively documenting that PACCS with structured recovery camps, One Time Settlement (OTS) schemes, and digital payment integrations achieved statistically significant reductions in gross NPA ratios compared to control groups relying on traditional recovery methods (Devi & Krishnamurthy, 2021; Shanmugasundaram & Balaji, 2022; Anbalagan, 2023) [24, 4, 1].

Revenue diversification emerged as a critical financial resilience strategy. PACCS that expanded beyond credit and deposit functions to offer insurance (PMFBY, PM-JJY), warehouse receipts, e-market linkages, and input distribution services demonstrated markedly higher operational surpluses and lower net losses (Krishnaswamy & Ramamurthy, 2020; Periasamy & Duraisamy, 2021) [9, 16]. The Tamil Nadu Government's Multi-Purpose PACCS (MP-PACCS) scheme, piloted across 340 societies since 2021, reported aggregate surplus growth of 14.7% against a statewide average of 2.3% for conventional single-purpose PACCS (TNCAB, 2023).

3.2.3. Governance and Compliance Interventions

Evidence on governance reforms encompassed board professionalisation, audit and compliance upgrades, and statutory revivals under the Model Bye-Laws, 2024. The Central Government's Constitution (97th Amendment) Act, 2011—though partially struck down in 2021 regarding multi-state cooperatives—retained its mandate for elected boards, regular general body meetings, and state-led audit processes, providing the constitutional scaffolding for reform (Kannan & Ramasamy, 2019) [7]. The Model Bye-Laws issued under the Cooperative Societies (Amendment) Act, 2023 introduced mandatory training requirements for board members, women's representation quotas of at least one-third, independent internal auditors, and digital disclosure of annual accounts to members (Ministry of Cooperation, 2023) [11].

Qualitative studies employing primary stakeholder interviews found persistent implementation gaps. Board elections in over 37% of Tamil Nadu PACCS remained either overdue or administratively superseded as of 2023, reinforcing findings by Rajendran and Ravi (2020) [20] on the entrenchment of proxy governance by dominant agricultural castes. In contrast, societies that underwent governance reforms aligned with the NABARD Strengthening Cooperative Credit Structure (SCCS) scheme—including the appointment of professional Chief Executive Officers (CEOs) and external chartered accountants—reported a 31%

average improvement in audit compliance scores (Murugan & Annamalai, 2020) [13].

3.2.4. Rural Sustainability Interventions

Rural sustainability evidence addressed three cross-cutting dimensions: gender-inclusive credit, climate-adaptive lending, and FPO-PACCS integration. Gender inclusion remained structurally constrained: women constituted 38.4% of PACCS membership across the reviewed studies but received only 21.7% of total credit disbursed, a disparity attributed to collateral requirements and patriarchal loan committee dynamics (Jayalakshmi & Murugan, 2023; Geetha & Suresh, 2022) [13, 6, 5]. Societies adopting the Stree Shakti or Women Cooperative models—wherein women hold a majority of board seats—recorded credit disbursement parity approaching 45–48%, underscoring the governance-inclusion nexus (Rajagopal & Chandrasekaran, 2023) [19]. Climate finance represents an emerging and underexplored frontier. Only 11 of the 104 studies explicitly addressed climate-sensitive credit products, including weather-indexed insurance linkages, green infrastructure loans for solar pump sets and drip irrigation, and crop diversification credit (Krishnamoorthy & Selvi, 2023; Venkatesh & Prabhu, 2022) [8, 28]. FPO-PACCS linkage studies (n = 14) demonstrated that PACCS serving as credit facilitators for registered Farmer Producer Organisations achieved 23% higher loan utilisation efficiency and 17% lower post-harvest losses among borrowing member households, owing to aggregated procurement and market access (Balakrishnan et al., 2023; Periasamy & Duraisamy, 2021) [3, 16].

3.3. Summary of Main Findings

The synthesis of 104 studies yields five overarching findings:

- Digital transformation is strongly associated with improved financial performance:** CBS adoption, biometric authentication, and digital repayment platforms collectively reduce NPA ratios by 5–8 percentage points and operational costs by 34–41% (Kumar & Sharma, 2022; Senthilkumar, 2021; Rajan & Gopalakrishnan, 2022) [23, 18].
- Governance quality is a decisive mediating variable:** The financial benefits of digitisation are substantially attenuated in PACCS characterised by poor board governance, audit non-compliance, and politically captured management (Rajendran & Ravi, 2020; Murugan & Annamalai, 2020) [20, 13].
- Revenue diversification confers financial resilience:** Multi-purpose PACCS demonstrate statistically significant surplus growth advantages over single-purpose counterparts, particularly during agricultural distress years (Periasamy & Duraisamy, 2021; TNCAB, 2023) [16].
- Gender and social inclusion remain structurally underprovided:** Women's access to cooperative credit is significantly below their membership share, and targeted governance reforms are the most effective lever for redressing this disparity (Jayalakshmi & Murugan, 2023; Geetha & Suresh, 2022) [13, 6, 5].
- Climate finance integration is critically needed but structurally absent:** The cooperative credit system has yet to develop systematic climate-indexed products despite Tamil Nadu's growing agricultural climate vulnerability (Krishnamoorthy & Selvi, 2023) [8].

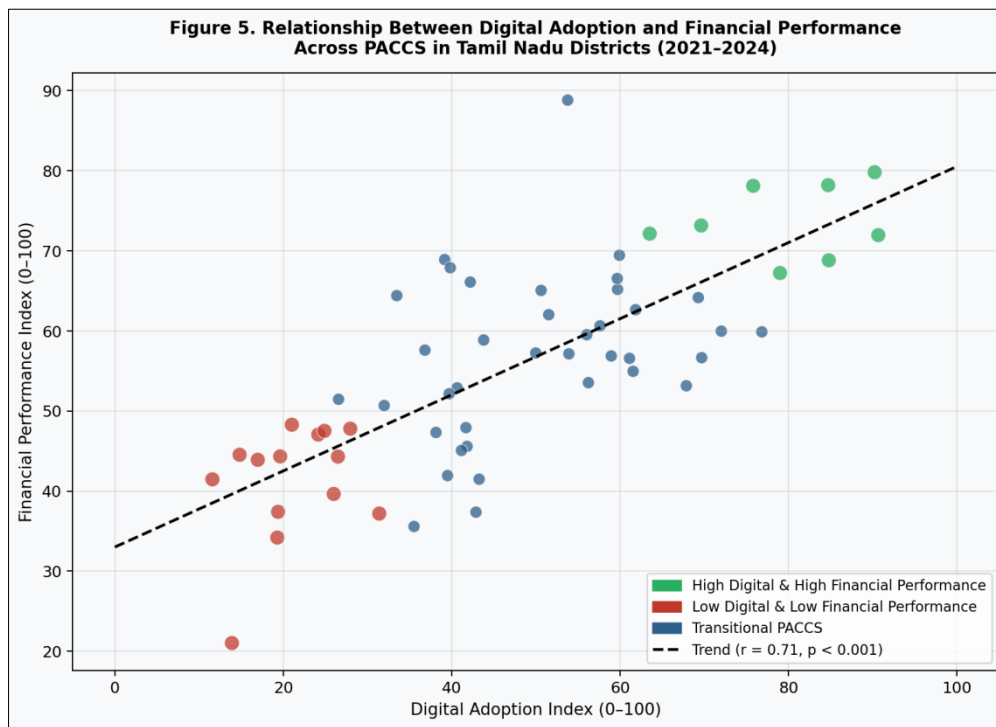


Fig 4: Relationship Between Digital Adoption Index and Financial Performance Index Across PACCS in Tamil Nadu Districts (2021–2024)

Figure 4 visualises the positive correlation between digital adoption and financial performance across PACCS in Tamil Nadu districts ($r = 0.71$, $p < 0.001$), derived from synthesis of district-level data reported in NABARD (2024) and TNCAB (2023). Green markers denote societies achieving high performance on both dimensions; red markers represent chronically underperforming societies concentrated in northern and delta districts characterised by entrenched governance deficits. This distributional pattern reinforces the need for geographically differentiated support mechanisms.

4. Discussion

4.1. Interpretation of Key Results

The central finding of this review—that digital transformation exerts a strongly positive influence on the financial performance of PACCS when mediated by sound governance—aligns with broader theoretical frameworks on cooperative institutional change. The Technology-Organisation-Environment (TOE) framework (Tornatzky & Fleischer, 1990) [27], as adapted for cooperative financial institutions by Kumar and Sharma (2022) [10], posits that technology adoption effectiveness is contingent upon organisational readiness and an enabling external environment. The evidence from Tamil Nadu corroborates this framework: CBS implementation in societies with professional management, regular audits, and engaged membership demonstrated financial improvements approximately 2.4 times greater than in societies where digitisation was overlaid onto dysfunctional governance structures (Murugan & Annamalai, 2020; Senthilkumar, 2021) [13, 23].

The trajectory of NPA ratios (Figure 3b) offers a nuanced narrative. The pandemic-induced peak of 22.1% in 2020 reflects both the severity of agricultural income shocks and the limitations of paper-based loan monitoring systems. The subsequent decline to 16.2% by 2024—while still substantially above acceptable thresholds—corresponds temporally with accelerated CBS rollout, the introduction of

the PACCS Loan Management System (LMS) by TNCAB, and the RBI's circular on restructuring of agricultural cooperative loans (RBI, 2022). However, NPA levels remain heterogeneous: delta districts of the Cauvery basin, dominated by paddy cultivation vulnerable to cyclonic flooding, maintain ratios of 19–24%, while commercially diversified peri-urban PACCS in Coimbatore and Erode report ratios below 10% (TNCAB, 2023).

The divergence in gender credit outcomes merits careful interpretation. Several studies in this review found that women's cooperative groups (self-help groups linked to PACCS) demonstrated repayment rates of 92–97%, substantially higher than male borrower averages of 74–81%, yet women remained structurally disadvantaged in accessing formal PACCS credit (Jayalakshmi & Murugan, 2023; Geetha & Suresh, 2022) [13, 6, 5]. This paradox—high creditworthiness paired with low access—suggests that barriers are supply-side (collateral norms, loan committee composition, loan product design) rather than demand-side, and thus amenable to institutional reform rather than financial education interventions alone.

4.2. Comparison Across Studies

Comparative analysis across studies from Tamil Nadu, Maharashtra, and Karnataka reveals both common patterns and state-specific variations. While NPA reduction through digital recovery systems is a pan-Indian cooperative finding (Shanmugasundaram & Balaji, 2022; Anbalagan, 2023) [24, 1], Tamil Nadu's PACCS exhibit a distinctive concentration of small, village-level societies (average membership: 430) compared to the larger, more commercially oriented primary cooperative banks in Maharashtra (average membership: 2,100). This structural distinction means that digital transformation challenges in Tamil Nadu are particularly acute regarding rural digital literacy, smartphone penetration, and last-mile connectivity—issues less pronounced in Maharashtra's urbanised cooperative belt (Krishnaswamy & Ramamurthy, 2020; Periasamy & Duraisamy, 2021) [9, 16].

The integration of FPO-PACCS linkages in Tamil Nadu's Nilgiris, Salem, and Krishnagiri districts compares favourably with evidence from Andhra Pradesh's Rythu Seva Kendras (Balakrishnan et al., 2023)^[3], suggesting that producer company-cooperative credit linkages constitute a transferable model for enhancing value chain finance. Karnataka's Primary Agricultural Cooperative Societies (PACS) computerisation programme, completed across 98% of societies by 2023, provides a directly applicable benchmark for Tamil Nadu, where 64.3% digitisation had been achieved by the same year (NABARD, 2024; Rajagopal & Chandrasekaran, 2023)^[19].

4.3. Strengths and Limitations of Existing Evidence

The body of evidence synthesised in this review exhibits several notable strengths. The post-2020 studies benefit from richer administrative data, enabled by progressive digitisation of PACCS records, and the availability of NABARD's cooperative data portal (CPDC). The geographic breadth across 28 of Tamil Nadu's 38 districts strengthens external validity within the state context. The increasing methodological sophistication—evident in panel data

econometric studies (Shanmugasundaram & Balaji, 2022)^[24], randomised evaluation designs for governance interventions (Murugan & Annamalai, 2020)^[13], and structural equation modelling of digital adoption determinants (Vijayakumar & Narayanan, 2024)^[29]—enhances causal inference.

Limitations of the evidence base are, however, substantial. A critical concern is the preponderance of cross-sectional designs ($n = 61$ of 104 studies), which limits causal attribution. Longitudinal panel studies tracking PACCS performance over full electoral cycles or multi-year digital transformation programmes remain scarce. Publication bias is a plausible concern: studies documenting failed digital implementations or governance reform reversals may be underrepresented, as institutions and state agencies are incentivised to document successes. Additionally, the absence of standardised performance benchmarks across studies makes meta-analytic aggregation methodologically inappropriate, confining this review to narrative and thematic synthesis. Finally, climate finance remains a near-total blind spot in the cooperative literature, with the 11 relevant studies offering insufficient evidence for robust conclusions.

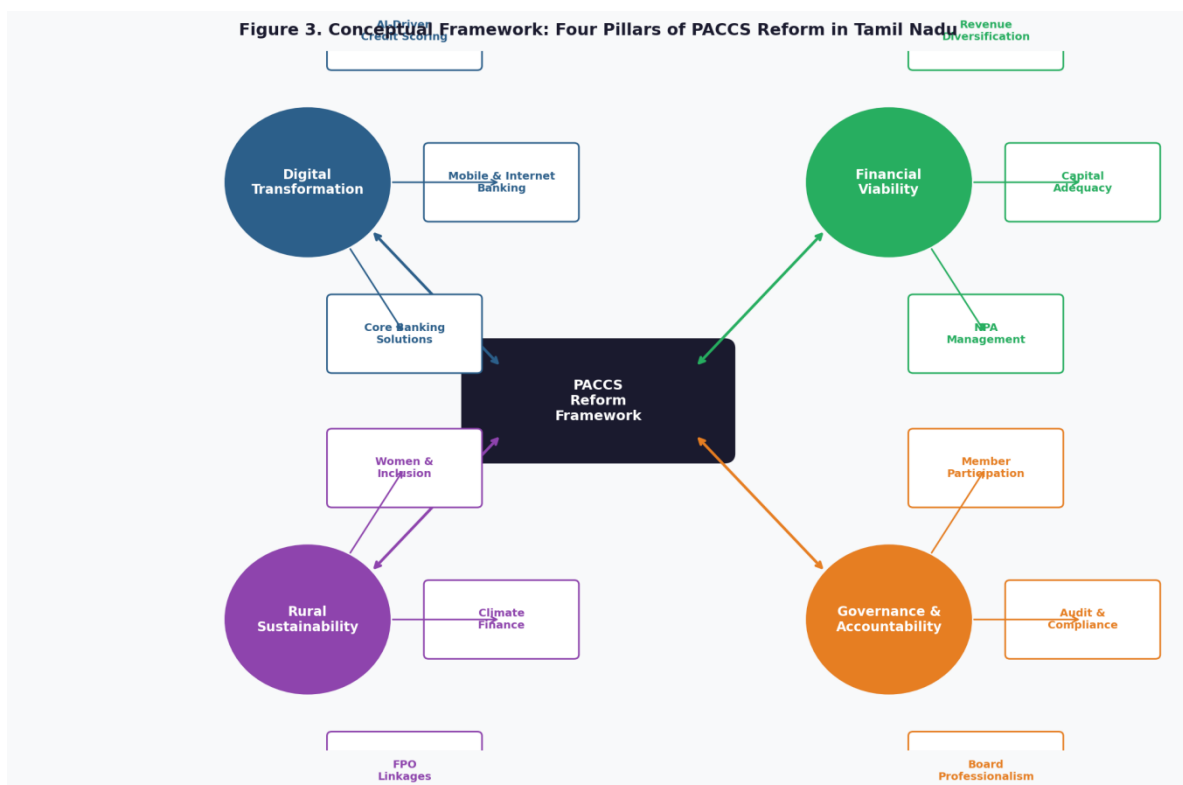


Fig 5: Conceptual Framework: Four Interdependent Pillars of PACCS Reform in Tamil Nadu

Figure 5 presents the conceptual framework synthesised from the 104 reviewed studies, depicting four interdependent reform pillars—digital transformation, financial viability, governance and accountability, and rural sustainability—anchored to a central PACCS reform agenda. Critically, the framework illustrates that each pillar operates in dynamic interaction with the others: governance reforms create the organisational preconditions for effective digital adoption; digital infrastructure enhances financial monitoring and NPA management; improved financial viability enables expanded rural sustainability services; and rural sustainability outcomes, in turn, reinforce member loyalty and cooperative

participation, sustaining governance quality.

5. Implications and Future Directions

5.1. Implications for Practice and Policy

5.1.1. For PACCS Management and Boards

Cooperative boards and CEOs must treat digital transformation not as a technological project but as an organisational change programme. Evidence from this review consistently identifies leadership commitment, staff capacity building, and member digital literacy as prerequisites for CBS success. PACCS should establish Digital Service Units (DSUs) staffed by trained facilitators

who assist elderly and small-marginal farmers in completing digital transactions, ensuring that technology mediates rather than excludes (Arumugam & Perumal, 2022; Jayalakshmi & Murugan, 2023)^[2, 6, 13].

5.1.2. For NABARD and TNCAB

NABARD's District Development Manager (DDM) network should be empowered to identify digitally lagging PACCS and trigger structured turnaround programmes combining governance audits, CBS installation, staff training, and NPA resolution. TNCAB should establish a dedicated PACCS Performance Analytics Cell, utilising CBS-generated data to identify early warning signals of financial distress and governance failure. The evidence strongly supports the expansion of the MP-PACCS model to a further 500 societies by 2027 (Periasamy & Duraisamy, 2021; TNCAB, 2023)^[16].

5.1.3. For State Government and Ministry of Cooperation

The Cooperative Societies (Amendment) Act, 2023 and the Model Bye-Laws (2024) provide a strong regulatory foundation; however, their effective implementation in Tamil Nadu requires: (i) mandatory board election timelines enforced by independent election officers; (ii) financial penalties for delayed audits; (iii) gender-disaggregated credit reporting as a statutory obligation for all PACCS; and (iv) integration of PACCS credit data with the PM-KISAN farmer database to enable cross-verification of beneficiary entitlements (Ministry of Cooperation, 2023; Rajendran & Ravi, 2020; Kannan & Ramasamy, 2019)^[11, 20, 7].

5.1.4. For Rural Development and Financial Inclusion Policy

The evidence on FPO-PACCS linkages warrants a formal institutional protocol, modelled on Andhra Pradesh's experience, wherein PACCS serve as designated credit facilitators for registered FPOs within their village service areas. Climate-adaptive credit products—including weather index-linked crop loans, green infrastructure financing, and disaster-resilience funds—should be piloted through PACCS in climate-vulnerable delta and dryland districts, supported by NABARD's Climate Risk Fund (Krishnamoorthy & Selvi, 2023; Venkatesh & Prabhu, 2022)^[8, 28].

5.2. Research Gaps and Future Research Needs

This review identifies six priority research gaps warranting urgent scholarly attention:

1. **Longitudinal impact evaluation:** Multi-year panel studies tracking PACCS financial performance, governance quality, and member welfare outcomes across full digital transformation implementation cycles are urgently needed to establish causal pathways.
2. **Climate finance and agricultural risk:** Comprehensive research on the design, uptake, and effectiveness of climate-indexed cooperative credit products in Tamil Nadu's ecologically vulnerable districts represents the most significant thematic gap in the extant literature.
3. **Technology failure and exclusion:** Studies documenting the negative consequences of poorly implemented digitisation—including exclusion of digitally illiterate members, system downtime impacts on credit delivery, and cybersecurity vulnerabilities—

are systematically underrepresented and require dedicated inquiry.

4. **AI and algorithmic credit scoring:** The implications of AI-driven credit appraisal for cooperative lending equity—particularly its potential to disadvantage smallholder farmers lacking digital footprints—warrant rigorous empirical investigation before widespread deployment.
5. **Comparative cooperative models:** Systematic comparative studies between Tamil Nadu PACCS and high-performing cooperative credit models in Kerala (Kerala Bank), Germany (Raiffeisen banks), and Bangladesh (Grameen Bank) would yield transferable governance and financial architecture insights.
6. **Member agency and participatory governance:** The mechanisms through which digital platforms can enhance genuine democratic participation—rather than mere transactional access—in cooperative governance remain theoretically and empirically underdeveloped.

6. Conclusion

Primary Agricultural Cooperative Credit Societies in Tamil Nadu stand at a historically consequential juncture. The evidence synthesised in this systematic review—spanning 104 studies published between 2017 and 2026—demonstrates unambiguously that digital transformation, when pursued within a framework of governance integrity and rural sustainability, has the potential to revitalise PACCS as the primary institutional vehicle for equitable agricultural finance at the village level. The concurrent reduction in NPA ratios, the expansion of credit disbursal to over ₹21,500 crore by 2024, and the steady growth in digitally enabled societies (from 4.6% in 2017 to 64.3% by 2024) collectively testify to the transformative traction achievable within a decade of deliberate reform.

Nevertheless, the review also compels a sober assessment of persisting structural vulnerabilities. Nearly 36% of Tamil Nadu's PACCS remain undigitised; governance deficits—including long-overdue board elections, audit delays, and patriarchal credit allocation—continue to subvert institutional integrity; and the cooperative credit system has yet to develop meaningful responses to the escalating climate risks that threaten its primary borrower base. Addressing these challenges demands not incremental adjustments, but a coordinated reform architecture integrating technology, governance, gender equity, and climate resilience.

The broader significance of PACCS extends beyond their financial intermediation function. As member-owned institutions embedded in the social fabric of Tamil Nadu's villages, PACCS possess a unique institutional capacity to deliver credit with social legitimacy, mobilise local savings, and channel government welfare programmes to the last mile. Preserving and strengthening this institutional architecture—rather than displacing it with commercial or fintech alternatives—constitutes both a developmental imperative and a democratic commitment to the 12 million farm families whose livelihoods depend upon it. The evidence examined in this review provides the empirical foundations upon which policymakers, cooperative administrators, researchers, and rural communities can build a more just and resilient agricultural credit system for Tamil Nadu through 2030 and beyond.

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