

Beyond Account Ownership: Assessing the Depth and Quality of Digital Financial Inclusion in Rural Bihar through Digital Payment Adoption

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Abstract

The rapid diffusion of digital payment infrastructure has changed the institutional architecture of financial inclusion in India. Yet the existence of a bank account, mobile phone, debit card or digital-payment application does not necessarily indicate that a household is meaningfully included in the formal financial system. This paper develops a multidimensional framework for examining the depth and quality of digital financial inclusion among rural households in Bihar, with a proposed empirical application to Lakhisarai district. The study moves beyond an account-ownership perspective by distinguishing financial access, digital-payment adoption, usage intensity, digital capability, trust and security, financial autonomy, and economic outcomes such as formal saving and access to formal credit. The conceptual framework integrates the Technology Acceptance Model, the financial inclusion literature, the digital-divide perspective, and a capability-oriented view of financial participation. The research proposes a mixed-method household study using a multi-stage sample of approximately 640 households. The sample calculation begins with Cochran's formula for an unknown population proportion at a 95 percent confidence level and five percent margin of error, producing a minimum of 384 completed observations; an assumed design effect of 1.5 and a ten percent non-response allowance yield a field target of approximately 640 households. A structured questionnaire is developed around household characteristics, account access, mobile and internet connectivity, digital literacy, UPI/AePS usage, trust and security, savings, borrowing, financial autonomy and perceived outcomes. The proposed quantitative analysis uses descriptive statistics, reliability analysis, exploratory factor analysis, principal component analysis, correlation, logistic regression, ordinary least squares or generalized linear models as appropriate, and diagnostic tests for multicollinearity, heteroskedasticity and model specification. The paper does not fabricate empirical results. Instead, it specifies testable hypotheses and a transparent analysis plan capable of generating evidence on whether digital payment adoption is associated with deeper financial inclusion. The research contributes to the literature by shifting attention from the number of accounts and transactions towards the quality of financial participation and by placing gender, digital capability, connectivity reliability and institutional trust at the centre of rural digital-finance analysis.

Keywords: digital financial inclusion; UPI; digital payments; rural Bihar; financial capability; digital literacy; financial access; financial autonomy; gender; household finance; Lakhisarai.

Introduction

Financial inclusion has evolved from a narrow concern with physical banking access into a broader question of whether individuals and households can use appropriate financial services effectively, safely and affordably. This change is particularly important in economies where digital public infrastructure increasingly performs functions previously undertaken through bank branches, cash transactions and paper-based procedures. India is a prominent case. The combination of bank-account expansion, Aadhaar-linked identification, mobile connectivity, business correspondents and interoperable digital-payment infrastructure has substantially altered the ways in which households interact with formal finance.

The Unified Payments Interface (UPI) is central to this transformation. NPCI's current statistics show that UPI processed about 24.51 billion transactions in August 2026, with a transaction value of approximately ₹29.82 lakh crore. These figures illustrate the scale of the national digital-payment ecosystem, but aggregate transaction volume cannot by itself establish whether rural households have achieved meaningful financial inclusion. A large transaction count may coexist with unequal participation, dependence on assisted transactions, low financial literacy, inactive accounts, weak consumer protection and uneven connectivity.

The distinction between access and effective use is supported by international evidence. The World Bank's Global Findex 2021 India brief reported high account ownership but also a substantial difference between account ownership and digital-payment use, together with an inactivity problem. The 2025 Global Findex expands the measurement agenda further by incorporating comparable indicators of mobile-phone ownership, internet use and digital safety. This development is analytically important because digital financial inclusion increasingly depends on the interaction between financial infrastructure and digital capability.

Official Indian data also indicate the continuing expansion of basic financial accounts. The Department of Financial Services reported 70.46 million PMJDY beneficiaries in Bihar as of 16 September 2026, including more than 61.41 million accounts at rural or semi-urban centre bank branches. Such figures demonstrate the scale of formal account access, but they do not answer the more demanding question of whether households regularly use accounts for saving, payments, borrowing, insurance, pension or other financial-management purposes.

This paper therefore starts from a different proposition: the central empirical problem is not simply whether rural households have entered the formal financial system, but how deeply they participate in it. A household that owns an account but relies on another person to conduct every digital transaction is not situated in the same position as a household that can independently make payments, verify transactions, save, borrow formally and respond to fraud. Similarly, a household that receives a government transfer digitally but immediately withdraws the entire amount in cash represents a different form of financial participation from a household that uses digital infrastructure to maintain savings and manage multiple financial products.

The research problem is especially relevant for Bihar because the state combines a large rural population with rapid expansion of formal financial infrastructure and persistent constraints involving education, digital capability, income, connectivity and financial-service access. The June 2026 source article supplied for this study identified these issues in Lakhisarai and reported a gap between formal access and actual digital-payment usage. It also identified infrastructure, behavioural, socioeconomic and institutional barriers. The present paper retains the regional relevance of that work but changes the

research architecture: instead of restating the earlier survey, it proposes a multidimensional model of depth and quality, a more explicit theoretical framework, a validated questionnaire and a rigorous statistical strategy.

The main research question is consequently: to what extent does digital-payment adoption translate into effective financial inclusion among rural households, and which socioeconomic, technological and behavioural factors determine that transition?

Background and Context

The institutional environment for financial inclusion in India includes the Pradhan Mantri Jan-Dhan Yojana (PMJDY), Aadhaar-enabled services, RuPay cards, business correspondents, mobile banking and UPI. PMJDY is formally designed to provide basic savings accounts and connect eligible account holders to remittance, credit, insurance, pension and direct-benefit-transfer channels. Its design demonstrates that account opening is only one element in a larger financial-inclusion architecture.

The scale of PMJDY is substantial. Current Department of Financial Services statistics show 59.31 crore beneficiaries nationally as of 16 September 2026, with 33.04 crore rural/urban female beneficiaries reported across the banking system. Bihar alone recorded 70,461,623 PMJDY beneficiaries in the statewise account-opening report dated 16 September 2026. These figures should be interpreted as administrative measures of account participation, not as direct measures of active or high-quality financial inclusion.

The digital-payment ecosystem has simultaneously expanded. NPCI's UPI statistics show a progression from a relatively new payment infrastructure to a system processing tens of billions of transactions monthly. The implication for rural finance is not merely that cash can be replaced by electronic transfers. Digital payment infrastructure can potentially lower transaction costs, support remittances, create transaction records, facilitate small-business payments and connect households more closely with formal financial institutions. Yet each of these mechanisms depends on user capability and institutional reliability.

The World Bank's 2025 Global Findex is particularly relevant to this research design because it treats connectivity as part of the financial-inclusion environment. The India microdata include variables on digital payments, mobile-phone use, online bill payment and other forms of digital financial activity. The survey was conducted in 2024 and is nationally representative. Its measurement structure provides a useful benchmark for designing a district-level questionnaire, while the proposed Lakhisarai study would add greater local detail on transaction reliability, trust, autonomy and assisted usage.

Recent academic evidence also supports the need for a usage-oriented framework. A 2025 case study of rural Aligarh used binary logistic regression to identify demographic and socioeconomic correlates of UPI adoption. A 2026 study using NSS-based evidence examined household access and use of payment cards in rural India. Other recent research has examined gender differences, community norms and digital-finance vulnerability. Together, these studies indicate that rural digital finance is shaped not by technology alone but by education, income, gender, employment, social norms, connectivity and institutional conditions.

Statement of the Research Problem

The conventional measurement of financial inclusion often privileges indicators of access: number of accounts, number of branches, number of cards, or availability of payment infrastructure. Such

indicators are essential but insufficient. The core problem is that access may not lead to active usage, independent capability or improved financial outcomes.

Three analytical gaps follow. First, there is a measurement gap. Account ownership is easier to record than financial capability, autonomy and quality of usage. Second, there is an explanatory gap. Even when digital payments are available, individuals differ in adoption because of age, education, income, gender, digital literacy, trust and social environment. Third, there is an outcome gap. It remains necessary to distinguish between the use of digital payments as a convenient payment mechanism and the broader transformation of household financial behaviour.

The proposed study addresses these gaps by treating digital financial inclusion as a latent, multidimensional construct rather than a binary variable. This allows the research to investigate not only whether a household uses digital payments, but also whether that use is frequent, diversified, independent, trusted and associated with formal savings or credit behaviour.

Literature Review

Financial Inclusion: From Access to Effective Participation

The financial-inclusion literature has progressively moved from supply-side access towards usage and welfare outcomes. The original policy concern was whether excluded populations could reach financial institutions. Subsequent work recognised that physical access does not ensure use. More recent research therefore considers account activity, digital payments, savings, borrowing, insurance and financial resilience. The Global Findex series has been particularly influential in operationalising these dimensions across countries.

In the Indian context, the rapid expansion of bank accounts has made the distinction especially important. The Global Findex 2021 India brief reported 78 percent adult account ownership, while digital-payment use remained substantially lower. It also reported no gender gap in account ownership but a gender gap in digital-payment usage. The 2025 Findex extends the measurement framework into digital connectivity and safety, reinforcing the argument that financial inclusion is increasingly inseparable from digital inclusion.

For rural Bihar, the implication is that the empirical unit should not be treated as 'banked' versus 'unbanked' alone. A richer classification can identify households with high access but low usage, high usage but low capability, and high capability with diversified financial outcomes. Such differentiation is essential for targeted policy and for doctoral-level empirical analysis.

Digital Payments and Financial Inclusion

Digital payment systems may affect financial inclusion through transaction-cost reduction, increased convenience, improved traceability and greater integration with formal institutions. UPI's interoperability reduces the need for users to maintain multiple proprietary payment relationships and can facilitate small-value payments between individuals and merchants. Digital transactions may also create records that can support formal financial relationships, although the existence of a transaction record does not automatically create access to formal credit.

Recent empirical research supports an association between digital-payment adoption and rural financial inclusion but also highlights heterogeneity. Haque, Azeez and Akhtar (2025) used logistic regression in rural Aligarh and found that age, gender, education, occupation and income were associated with UPI use, while some other demographic variables were not significant. This reinforces the importance of modelling adoption as a probabilistic outcome rather than assuming uniform take-up.

A 2026 study in the Indian Growth and Development Review used a difference-in-differences design across 200 villages in four states and reported associations between higher UPI adoption and outcomes including business registrations, savings accounts, female-owned enterprises, informal borrowing and digital-credit access. Because the study covered Maharashtra, Karnataka, Uttar Pradesh and Gujarat rather than Bihar, its results should not be directly transferred to Lakhisarai. Nevertheless, its mechanism-oriented design is useful for the present study because it links digital payments with household and local economic outcomes rather than treating transaction volume as the endpoint.

The present research therefore focuses on a question left open by much of the literature: whether similar mechanisms operate in a low-income rural Bihar setting after accounting for digital capability, connectivity and household characteristics.

Technology Acceptance Model

The Technology Acceptance Model (TAM) provides a useful explanation for digital-payment adoption. Davis (1989) proposed perceived usefulness and perceived ease of use as central determinants of technology acceptance. Applied to rural digital finance, perceived usefulness may refer to convenience, speed, accessibility and transaction benefits, while perceived ease of use concerns the ability to navigate applications, authenticate transactions and recover from errors.

TAM is valuable but incomplete for the present research because financial services contain risks and institutional dependencies not present in many ordinary technology-adoption contexts. A person may perceive UPI as useful but avoid it because of fear of fraud. Another person may find it easy to use but lack a smartphone or stable network. The present framework therefore treats ease of use and usefulness as behavioural mechanisms embedded within a broader system of infrastructure, trust and social capability.

Recent research on rural women and UPI adoption continues to apply TAM and related models, suggesting that perceived utility and usability remain relevant while social context shapes actual adoption. This supports the inclusion of both individual perceptions and community-level conditions in future extensions of the proposed model.

Digital Divide and Capability Perspective

The digital divide should not be understood only as a binary difference between people who have internet access and those who do not. It has at least three layers: access, skills and outcomes. A household may possess a smartphone but lack data affordability, digital skills or confidence. Similarly, two users with equivalent connectivity may experience different financial outcomes because of differences in education, gender, employment or social support.

A capability-oriented perspective therefore asks what people are actually able to do with available financial and digital resources. In this study, capability includes the ability to independently initiate a transaction, verify a beneficiary, protect authentication credentials, interpret transaction messages and seek redress. These measures transform digital literacy from a general education variable into a concrete financial capability construct.

Gender and Digital Financial Inclusion

Gender is not simply a demographic control variable. It can influence device ownership, mobility, financial decision-making, access to information and exposure to digital training. Earlier evidence from India showed that account ownership can become relatively equal even while usage remains gendered. Recent research has further examined community norms and peer effects in women's digital financial

adoption, finding that local social environments can affect uptake and that restrictive mobility norms can weaken the influence of peer use.

This literature suggests that the proposed questionnaire should distinguish account ownership from control and independent usage. Questions on who owns the phone, who knows the PIN, who conducts transactions and who makes financial decisions can provide a more meaningful measure of women's financial autonomy than account ownership alone.

The Bank Sakhi model also illustrates the potential importance of local female intermediaries. Community-based agents may reduce distance and social barriers while creating trusted points for assisted transactions. However, whether such models generate durable independent capability should be tested rather than assumed.

Trust, Security and Transaction Reliability

Digital finance creates a new category of financial risk: the user must trust not only the institution but also the technology, authentication mechanism and transaction interface. Failed transactions, delayed confirmations, fraudulent links and mistaken transfers can undermine confidence. For households with limited liquidity, even a temporary uncertainty about whether money has been debited or credited may be consequential.

Trust should therefore be operationalised through several indicators: confidence in platform security, confidence in banks and payment providers, perceived risk of fraud, experience of failed transactions, knowledge of complaint mechanisms and confidence in recovering money after an error. These variables may mediate the relationship between infrastructure and usage.

This is particularly relevant in rural settings where local financial relationships are often based on personal familiarity. A digital system may be technically reliable but socially unfamiliar. Assisted banking agents, local merchants and family members can therefore act as trust intermediaries, while also creating dependence if users never develop independent skills.

Rurality, Infrastructure and Financial Behaviour

Rural financial behaviour is embedded in local economic structures. Agricultural income is often seasonal, small businesses may operate with thin cash margins, and informal borrowing may provide flexible liquidity. Digital payments can support these activities, but their effect depends on whether formal financial institutions offer products aligned with rural cash-flow patterns.

Connectivity is similarly uneven. The presence of a network signal is not equivalent to reliable transaction connectivity. A household may report that mobile internet exists while experiencing frequent payment failures. The questionnaire therefore measures both availability and reliability. Distance to bank branches and banking correspondents is included as a physical-access variable even within a digital-finance study because digital and physical channels frequently operate together.

Synthesis of the Literature

The literature supports six propositions that guide the proposed model. First, account ownership is necessary but not sufficient. Second, digital-payment adoption is shaped by socioeconomic and behavioural characteristics. Third, digital literacy is a central capability. Fourth, gender and community norms influence usage. Fifth, trust and transaction reliability condition continued adoption. Sixth, the economic consequences of digital finance should be measured separately from payment frequency. These propositions lead directly to the conceptual model and hypotheses presented below.

- **Research Gap and Novelty**

The present study is deliberately differentiated from the supplied June 2026 article. The earlier paper focused on an overview of digital payments and financial inclusion in Bihar with special reference to Lakhisarai and included a household survey, descriptive results and discussion of barriers. The current research instead proposes a doctoral-level measurement and explanatory framework centred on the depth of financial inclusion. Its novelty is fourfold.

- It treats digital financial inclusion as a multidimensional latent construct rather than a simple adoption indicator.
- It separates access, adoption, capability, trust and financial outcomes and proposes explicit measurement for each.
- It integrates Technology Acceptance Model mechanisms with a financial-capability and digital-divide perspective.
- It proposes a reproducible sampling, reliability, factor-analysis and regression protocol that can be independently implemented and audited.

The study also responds to recent literature. A 2026 national study using rural household data highlights payment-card access and usage as distinct outcomes. A 2026 study of gender and regional barriers uses PCA and decomposition techniques to distinguish structural and digital barriers. Recent work on women's digital finance further emphasises peer effects and community norms. The proposed research incorporates these advances at the district level while keeping the empirical design focused on rural Bihar.

- **Conceptual Framework**

The proposed framework consists of six blocks: socioeconomic resources, digital access, perceived usefulness/ease of use, digital capability, trust and security, and financial outcomes. The framework assumes that socioeconomic resources and infrastructure affect capability and perceived usability; these in turn influence adoption and intensity of digital payments; usage then potentially affects savings, formal borrowing and financial resilience.

The model can be represented as:

Socioeconomic resources + Digital infrastructure → Digital capability + Perceived usefulness/ease of use → Digital-payment adoption and intensity → Financial outcomes

Trust, security, gender norms and transaction reliability are proposed as cross-cutting moderators or mediators within this pathway.

The model deliberately avoids claiming a causal pathway before data are collected. Cross-sectional survey data can establish associations and conditional relationships but are not sufficient on their own to prove that digital payments caused changes in savings or credit behaviour. Causal claims would require longitudinal, quasi-experimental or experimental identification.

- **Objectives of the Study**

- To measure the level of digital financial inclusion among rural households in Lakhisarai district.
- To distinguish financial access from active, independent and diversified digital-finance usage.
- To construct a multidimensional Digital Financial Inclusion Index.
- To examine the influence of education, income, age, gender, occupation, smartphone access and digital literacy on digital financial inclusion.

- To estimate the relationship between digital-payment intensity and formal saving behaviour.
- To examine the association between digital financial inclusion and reliance on informal credit.
- To investigate the role of trust, transaction reliability and perceived security in continued digital-payment use.
- To examine gender differences in access, capability and independent financial usage.
- To identify the major barriers to deeper and safer digital financial participation.
- To develop evidence-based policy implications for improving the quality of rural financial inclusion.
- **Research Questions**

What proportion of rural households have access to formal financial and digital-payment services?

To what extent does account ownership translate into active and independent digital financial usage?

Which socioeconomic and technological variables explain differences in the depth of digital financial inclusion?

How strongly are digital literacy and perceived ease of use associated with digital-payment adoption?

What is the relationship between digital-payment intensity and formal savings behaviour?

Is digital financial inclusion associated with lower reliance on informal borrowing after controlling for household characteristics?

How do transaction failures, fraud concerns and grievance-redressal knowledge affect trust?

How do gender and community conditions shape independent digital financial participation?

- **Hypothesis**

Code	Hypothesis
H1	Higher digital literacy is positively associated with the Digital Financial Inclusion Index (DFII).
H2	Perceived ease of use is positively associated with digital-payment adoption.
H3	Perceived usefulness is positively associated with digital-payment adoption.
H4	Reliable internet connectivity is positively associated with digital-payment usage intensity.
H5	Higher education is positively associated with effective digital financial inclusion after controlling for other household characteristics.
H6	Higher household income is positively associated with digital-payment adoption and usage intensity.
H7	Frequent transaction failures are negatively associated with trust in digital financial services.
H8	Trust in digital financial services is positively associated with continued digital-payment usage.
H9	Greater digital financial inclusion is positively

	associated with formal savings behaviour.
H10	Greater digital financial inclusion is negatively associated with reliance on informal borrowing, conditional on income and other socioeconomic characteristics.
H11	Women and men differ in independent digital-financial usage after controlling for education, income, age, occupation and connectivity.
H12	The association between mobile-phone access and digital-payment adoption is stronger among respondents with higher digital literacy.

• Research Methodology

Research Design

The proposed study uses a mixed-method, cross-sectional design with a structured household survey as its primary quantitative instrument and a small qualitative component for contextual interpretation. The quantitative component is intended to estimate prevalence, construct indices and test hypotheses. The qualitative component can involve semi-structured interviews with banking correspondents, Bank Sakhis, small merchants and selected respondents to clarify mechanisms behind observed statistical relationships.

Because the purpose is doctoral research, the field protocol should be pre-specified before data collection. Questionnaire items, sampling rules, inclusion criteria, coding conventions and primary hypotheses should be fixed before looking at the inferential results wherever feasible. This reduces researcher degrees of freedom and strengthens the credibility of the empirical findings.

Study Area

Lakhisarai district is proposed as the principal study area. The district provides a useful setting for examining the transition from traditional banking to digitally mediated finance because the source article documented an expanding network of financial outlets alongside persistent usage barriers. The current study does not assume that the earlier findings represent the entire district today; rather, they provide the rationale for conducting a fresh, independently sampled survey.

For stronger representativeness, the district can be stratified into blocks according to population, connectivity and financial-infrastructure characteristics. If administrative data are available, blocks may be grouped into relatively higher, medium and lower digital-access strata before village selection.

Population and Unit of Analysis

The target population comprises adults aged 18 years or above residing in rural households of the selected study area. The primary unit of analysis is the individual adult respondent for questions concerning personal digital-finance use, while household-level variables are used for income, assets, savings, borrowing and household financial resilience. One knowledgeable adult should be selected per household using a pre-defined selection procedure rather than allowing the field investigator to choose the most convenient respondent.

Where gender analysis is central, the design should avoid systematically interviewing only household heads. A within-household respondent-selection rule can improve the ability to capture women's independent digital-finance experiences.

Sample Size Calculation

For a large or unknown population proportion, Cochran's formula is appropriate as a starting point:

$$n_0 = Z^2 p(1 - p) / e^2$$

At a 95 percent confidence level, $Z = 1.96$. In the absence of a reliable current estimate of the relevant population proportion, $p = 0.50$ is used because it produces the maximum variance. With a margin of error $e = 0.05$:

$$n_0 = (1.96^2 \times 0.50 \times 0.50) / 0.05^2 \approx 384.16$$

Thus, approximately 385 completed observations are required under simple random sampling. Because a multi-stage cluster design is proposed, a design effect of 1.50 is applied:

$$n_1 = 384.16 \times 1.50 \approx 576.24$$

Allowing for 10 percent non-response:

$$n_2 = 576.24 / 0.90 \approx 640.27$$

The proposed field target is therefore approximately 640 completed household interviews. This is a planning figure, not a claim that 640 households have already been surveyed. The final sample size should be recalculated if reliable estimates of population variance, cluster size, expected response rate or design effect become available.

Parameter	Assumption	Result
Confidence level	95%	$Z = 1.96$
Expected proportion	50%	Maximum variance
Margin of error	5%	$e = 0.05$
Initial Cochran sample	Large/unknown population	384.16
Design effect	1.50	576.24
Non-response allowance	10%	≈ 640
Recommended field target	Completed observations	640 households

Sampling Strategy

A four-stage sampling procedure is proposed. First, select four rural blocks using stratified random sampling so that different levels of digital and banking access are represented. Second, select eight villages from each block, preferably using probability proportional to size where village population data are available. Third, prepare or obtain household lists within selected villages. Fourth, select twenty households per village using systematic random sampling. This produces $4 \times 8 \times 20 = 640$ target households.

The exact number of blocks and villages may be revised after consultation with official sampling frames. The essential requirement is that selection probabilities be documented. Replacement households should not be chosen merely because the originally selected household is inconvenient; a written replacement protocol should be established in advance.

If the study intends to compare gender groups, investigators should monitor completed interviews by sex and avoid a sample in which one group is severely underrepresented. Gender balance should not be artificially imposed in a way that destroys the population representation; instead, the sampling plan should record the population composition and use weights if necessary.

Data Sources

Primary data will be generated through the household questionnaire. Secondary sources should include RBI publications, NPCI payment statistics, PMJDY administrative statistics, Government of Bihar or JEEViKA documentation, the World Bank Global Findex 2025 dataset and relevant district-level demographic or infrastructure data. Administrative sources should be used for contextual indicators rather than being merged with household-level responses unless compatible identifiers and methodological justification exist.

The 2025 Global Findex is especially useful for benchmarking because it provides nationally comparable indicators of account ownership, digital payments, mobile-phone access, internet use and financial behaviour. The India dataset contains 3,000 survey cases, but those cases are not a substitute for a Lakhisarai probability sample; they provide a national benchmark against which local patterns can be discussed.

• Questionnaire Design

The questionnaire is designed to be interviewer-administered and should be translated into Hindi and, where necessary, locally understandable language. A back-translation procedure should be used for key Likert-scale items. The questionnaire should be piloted on approximately 30–50 respondents outside the final sample. Pilot data should be used to identify ambiguous wording, excessive length and items with weak variability.

Section A: Respondent Profile

Code	Question	Response/Coding
A1	Age	Completed years
A2	Sex/Gender	1 Male; 2 Female; 3 Other/Prefer not to say
A3	Marital status	Categorical
A4	Education	No schooling; primary; middle; secondary; higher secondary; graduate+
A5	Main occupation	Agriculture; wage labour; salaried; business; homemaker; student; other
A6	Household size	Number
A7	Monthly household income	Predefined income bands
A8	Household headship	Male/Female/Joint/Other
A9	Social-group category	Collected only if necessary and ethically justified; coded confidentially
A10	Village/block	Administrative code, not public respondent identifier

Section B: Financial Access

- Do you personally have a bank account?

- How many active bank accounts do you personally use?
- Do you have a RuPay/debit card?
- Do you have access to a bank branch within your village or nearby?
- Do you use a Business Correspondent/Bank Mitra/Bank Sakhi?
- Have you received a government transfer directly into your account?
- Do you use an ATM or micro-ATM?
- How long does it normally take you to reach a formal banking point?

Section C: Digital Connectivity

Code	Item	Coding
C1	Own or regularly use a mobile phone	0 No; 1 Yes
C2	Own/use a smartphone	0 No; 1 Yes
C3	Regular internet access	0 No; 1 Yes
C4	Network reliability	1 Very poor to 5 Very good
C5	Electricity availability	Hours/day or categorical
C6	Data affordability	1 Very difficult to 5 Very easy
C7	Phone primarily controlled by respondent	0 No; 1 Yes
C8	Someone else usually operates the phone for financial transactions	0 No; 1 Yes

Section D: Digital Payment Adoption and Intensity

Code	Question	Coding
D1	Have you ever used UPI?	0 No; 1 Yes
D2	Have you used AePS?	0 No; 1 Yes
D3	Have you used mobile banking?	0 No; 1 Yes
D4	How often do you make digital payments?	Never; monthly; weekly; several times/week; daily
D5	Main digital-payment purpose	P2P; merchant; bill; education; government; business; other
D6	Approximate monthly number of digital transactions	Numeric band
D7	Do you independently initiate transactions?	Never to always
D8	Do you check transaction confirmation yourself?	Never to always
D9	Do you maintain transaction records/notifications?	Never to always

Section E: Digital Financial Literacy

Use a mixture of self-assessment and objective knowledge questions. Objective items should be scored separately to avoid confusing confidence with actual capability.

- Can you explain what a UPI PIN is used for?
- Can you identify the correct beneficiary before confirming a payment?
- Do you know that a UPI PIN should not be shared with another person?
- Can you recognise a suspicious payment link or message?
- Can you check whether money has actually been debited or credited?
- Do you know where to report an unauthorised transaction?
- Can you independently change or protect your authentication credentials?
- Can you use your bank's digital channel without assistance?

Section F: Perceived Usefulness and Ease of Use

Respondents rate each statement from 1 = strongly disagree to 5 = strongly agree.

- Digital payments save me time.
- Digital payments reduce the need to carry cash.
- Digital payments make it easier to pay distant persons or businesses.
- Digital payments are useful for managing household expenses.
- Digital payment applications are easy for me to understand.
- I can learn a new digital payment function without much difficulty.
- I can complete a digital payment without help.
- I can recover from a minor payment error without depending entirely on another person.

Section G: Trust, Security and Reliability

- I trust the banking system to process digital payments correctly.
- I feel that my money is secure when I use digital payments.
- I am confident that I can obtain help if a digital transaction fails.
- I worry about fraud when using digital payments.
- I have experienced a failed or delayed digital transaction.
- I know how to complain about an unauthorised transaction.
- Frequent network or server problems reduce my willingness to use digital payments.
- I would continue using digital payments even after a minor technical problem.

Section H: Savings and Credit Behaviour

Variable	Illustrative measure
Formal saving	Whether respondent saved in bank/formal instrument during past 12 months
Saving frequency	Monthly/quarterly/irregular/none
Saving purpose	Emergency, education, agriculture, business, household, other
Formal borrowing	Bank/MFI/SHG/cooperative/other formal source
Informal borrowing	Moneylender/friends/relatives/employer/trader
Credit dependence	Share of borrowing obtained informally
Financial resilience	Ability to meet an unexpected expense without selling productive assets or relying entirely on emergency borrowing

Section I: Financial Autonomy and Gender

- Who usually controls the mobile phone used for financial transactions?
- Who knows the financial application's PIN?
- Who usually decides how household savings are used?
- Can you independently make a digital payment?
- Can you independently check your bank balance?
- Can you independently resolve a failed transaction?
- Do you need permission from another household member to use digital financial services?

Section J: Perceived Economic Outcomes

- Digital payments have reduced my transaction costs.
- Digital payments have made receiving money easier.
- Digital payments have improved my ability to keep financial records.
- Digital payments have helped me interact with formal financial institutions.
- Digital payments have made it easier to save.
- Digital payments have helped my household or business manage payments.
- Digital finance has increased my confidence in using formal financial services.

Operationalisation of Variables

Construct	Suggested indicator	Scale	Role
DFII	Composite of access, usage, capability, trust and outcomes	0–100	Primary dependent variable
UPI adoption	Ever used UPI	Binary	Dependent in logit model
Usage intensity	Frequency/diversity of digital payments	Count/ordinal	Dependent
Digital literacy	Objective knowledge score	0–10 or standardised	Independent
Perceived usefulness	Mean of usefulness items	1–5	Independent
Ease of use	Mean of usability items	1–5	Independent
Trust	Mean of trust/security items	1–5	Mediator/independent
Connectivity	Reliability score	1–5	Independent
Education	Highest education level	Ordinal	Control/independent
Income	Monthly household income	Continuous/bands	Control/independent
Gender	Respondent gender	Categorical	Control/moderator
Formal saving	Saved formally in past 12 months	Binary/amount	Outcome
Informal credit	Any informal	Binary/continuous	Outcome

	borrowing / share		
Financial autonomy	Independent control/usage score	0–100	Outcome/mediator

• Construction of the Digital Financial Inclusion Index

The principal dependent construct, DFII, should not be created simply by adding every questionnaire item. First, items should be grouped into theoretically meaningful dimensions: access, adoption/intensity, capability, trust/security and financial outcomes. Reliability analysis should be conducted for multi-item scales. Exploratory factor analysis can then test whether the empirical structure supports the theoretical grouping.

A normalised index can be constructed using min-max scaling:

$$X^* = (X - X_{\min}) / (X_{\max} - X_{\min})$$

The dimensions can then be combined using equal weights or data-derived weights. Equal weighting is transparent; PCA weights may capture covariance but can make the index less intuitive. A doctoral thesis should report both a principal specification and a robustness specification where feasible.

The final index should be transformed to a 0–100 scale. The study should report the component scores separately so that a high overall score cannot hide a serious weakness in one dimension. For example, a respondent might have excellent access but poor autonomy. Reporting only the aggregate index would conceal that distinction.

• SPSS Data Management and Analysis Plan

Data Coding

Each questionnaire should receive a unique non-identifying study code. Personal identifiers should be stored separately from analytical data. Missing responses should be coded distinctly from legitimate zero values. Reverse-coded Likert items should be identified before scale construction. A codebook should document variable name, label, value labels, missing-value rules and source questionnaire item.

Descriptive Statistics

- Frequency and percentage distributions for categorical variables.
- Mean, median, standard deviation, minimum and maximum for continuous variables.
- Cross-tabulations of digital-payment adoption by gender, age, education and income.
- Distribution of DFII scores by block or village where sample design permits.
- Separate reporting of account ownership, active usage and independent usage.

Reliability Analysis

Cronbach's alpha should be calculated for multi-item constructs such as perceived usefulness, ease of use, trust and financial autonomy. Alpha should not be treated as a mechanical pass/fail test. Corrected item-total correlations and the effect of item deletion should be inspected. If the construct is multidimensional, alpha for a combined scale may be misleading; subscale reliability should therefore be examined separately.

Exploratory Factor Analysis

EFA can be used to assess whether the proposed questionnaire dimensions emerge empirically. Before extraction, the Kaiser-Meyer-Olkin measure and Bartlett's test of sphericity should be examined. Principal axis factoring with an oblique rotation such as oblimin is appropriate when constructs are

expected to correlate. Factor loadings, communalities and cross-loadings should be reported transparently.

Correlation Analysis

Pearson correlation may be used for approximately continuous variables, while Spearman correlation is suitable for ordinal or non-normal measures. Correlation should be used to examine association, not causation. High correlations among predictors should trigger multicollinearity diagnostics before regression interpretation.

Logistic Regression

A binary logistic model is proposed for UPI adoption:

$$\text{logit}(\pi_i) = \beta_0 + \beta_1 \text{DigitalLiteracy}_i + \beta_2 \text{Education}_i + \beta_3 \text{Income}_i + \beta_4 \text{Gender}_i + \beta_5 \text{Connectivity}_i + \beta_6 \text{Age}_i + \beta_7 \text{Usefulness}_i + \beta_8 \text{Trust}_i + \epsilon_i$$

Odds ratios, 95 percent confidence intervals and p-values should be reported. Model fit may be assessed using likelihood-ratio statistics, pseudo- R^2 measures, classification diagnostics and calibration measures. The analysis should avoid overreliance on classification accuracy when the outcome is imbalanced.

OLS / GLM for DFII

If the DFII behaves approximately continuously, OLS may be used to estimate conditional associations. Robust standard errors should be considered if heteroskedasticity is present. If the index has strong boundary effects or non-normal residuals, generalized linear modelling or fractional-response models may be considered depending on the final construction of the dependent variable.

Savings Model

For a binary formal-saving outcome, logistic regression is appropriate. If monthly savings amount is collected and contains many zeros, a two-part model may be more suitable: first estimate the probability of saving, then estimate the amount among savers. This avoids treating zero-saving households as if their saving amount were simply a normally distributed continuous observation.

Informal Credit Model

The study may estimate a binary model for whether the household used informal credit during the previous twelve months. If a continuous share of borrowing from informal sources is collected, fractional regression may be considered. The model should control for income, occupation, household size, asset position and access to formal financial institutions to reduce confounding.

Moderation Analysis

H12 proposes that digital literacy may moderate the relationship between mobile-phone access and digital-payment adoption. An interaction term can be introduced:

$$\text{Adoption} = \beta_0 + \beta_1 \text{Phone} + \beta_2 \text{Literacy} + \beta_3 (\text{Phone} \times \text{Literacy}) + \text{Controls} + \epsilon$$

The interaction should be interpreted using predicted probabilities or marginal effects rather than by comparing the coefficient alone.

Mediation Analysis

A theoretically interesting extension is to test whether trust mediates the association between transaction reliability and continued usage. Such an analysis should be described as an associational mediation unless the design supports temporal ordering. Cross-sectional mediation cannot establish that the proposed causal sequence actually occurred.

Multicollinearity

Variance inflation factors and tolerance statistics should be inspected. Education, income, smartphone ownership and digital literacy may be correlated. High VIF values should prompt consideration of

theoretically justified variable reduction, factor scores or alternative specifications. Variables should not be removed solely to improve statistical significance.

Heteroskedasticity and Specification

Residual plots and appropriate tests should be used for OLS models. Robust standard errors can provide protection against heteroskedasticity. RESET-type specification diagnostics may be considered, but model changes should be theoretically justified. Clustered standard errors may be appropriate because households within villages are not statistically independent.

Robustness Checks

- Re-estimate adoption models with alternative definitions of active use.
- Compare equal-weighted and PCA-weighted DFII specifications.
- Estimate models with and without subjective trust measures.
- Run gender-stratified models where sample sizes permit.
- Check whether results change after excluding respondents who rely entirely on assisted transactions.
- Use village or block fixed effects where the design and sample size permit.
- Apply sampling weights if unequal selection probabilities occur.

Proposed Statistical Decision Matrix

Research question	Dependent variable	Suggested test/model	Key predictors
Who adopts UPI?	UPI adoption (0/1)	Binary logistic regression	Literacy, education, income, age, gender, connectivity, usefulness
What determines usage intensity?	Transaction-frequency score	OLS/ordinal/count model as appropriate	Literacy, phone access, connectivity, trust, income
What determines DFII?	DFII 0–100	OLS/GLM	Education, income, literacy, gender, connectivity, trust
Does digital inclusion relate to formal saving?	Formal saving (0/1)	Logistic regression	DFII + controls
Does digital inclusion relate to informal credit?	Informal borrowing (0/1)	Logistic regression	DFII + controls
What shapes trust?	Trust score	OLS/GLM	Failures, security concerns, literacy, experience
Does literacy modify phone access effects?	UPI adoption	Interaction logistic model	Phone × literacy
Are gender differences present?	Usage/autonomy	Group tests + multivariate models	Gender + controls

- **Reliability, Validity and Research Quality**

Content validity should be established through review by subject experts in economics, financial inclusion and survey methodology. Construct validity can be assessed using factor analysis and convergent patterns among related measures. Criterion-related validity can be explored by comparing the proposed index with observable behaviours such as active digital use or formal savings, while recognising that such comparisons are not independent validation if the same items are used in both measures.

The pilot survey should be conducted before the main fieldwork. Interviewer training should include neutral questioning, privacy, fraud-sensitive questions and respondent consent. Supervisors should re-contact a small percentage of households to verify that interviews occurred and that key screening questions were correctly recorded.

Common-method bias is a potential issue because many independent and dependent variables are collected from the same respondent at the same time. The questionnaire can reduce this problem by separating sections, mixing objective and subjective measures, using behavioural questions where possible and avoiding leading wording. Statistical diagnostics may be reported as supplementary evidence rather than as a substitute for good survey design.

Ethical Considerations

Digital financial research involves sensitive information. The survey should not collect PINs, passwords, full bank-account numbers, OTPs or other authentication credentials. Questions about income, debt and gendered household decision-making should be asked privately where possible. Participants should be informed that participation is voluntary, refusal will have no effect on access to public services, and they may stop the interview at any time.

Data should be anonymised before analysis. A separate encrypted linkage file, if needed for follow-up, should be accessible only to authorised researchers. The study should obtain institutional ethical approval or the appropriate university-level clearance before fieldwork begins.

- **Expected Contribution and Interpretation Framework**

Because the present manuscript is a research design and full article framework rather than a report of newly collected data, it does not claim empirical confirmation or rejection of the hypotheses. Once field data are collected, the interpretation should follow a disciplined sequence. First, describe the sample. Second, establish measurement reliability and validity. Third, report descriptive patterns. Fourth, estimate the main models. Fifth, conduct diagnostics and robustness checks. Sixth, interpret the magnitude and uncertainty of coefficients rather than relying only on statistical significance.

A statistically significant coefficient should not automatically be described as economically large. For logistic models, predicted probabilities or marginal effects should be reported where possible. For continuous models, effect sizes should be translated into meaningful units. Confidence intervals should accompany point estimates. Where results are null, the discussion should distinguish between evidence of no association and insufficient statistical precision.

The discussion should also avoid treating a district-level sample as representative of all Bihar unless the sampling design justifies that inference. Lakhisarai is a case study setting. Comparisons with national Findex statistics or other Indian studies should be framed as contextual comparisons, not direct estimates of the same population.

- **Policy Implications**

The proposed framework has implications for the design and evaluation of financial-inclusion programmes. If the empirical results show that account ownership is high but independent usage is low, policy evaluation should place greater emphasis on capability and active use. If digital literacy is strongly associated with usage, training interventions may warrant evaluation. If transaction failures and weak grievance awareness are associated with low trust, infrastructure reliability and consumer protection become central policy variables. If gender differences remain after controlling for education and income, interventions may need to address household-level device access and social norms rather than simply providing accounts.

The distinction between assisted and independent digital use is especially important. Assisted transactions can be an effective bridge to inclusion, particularly for older or less literate users, but dependence on another person may also reduce privacy and autonomy. A mature financial-inclusion strategy should therefore recognise assisted services as an access mechanism while measuring whether users acquire the capability to perform key tasks themselves.

The research also has implications for digital-credit policy. Digital payment history should not automatically be equated with creditworthiness. Formal credit requires appropriate underwriting, consumer protection and products suited to rural cash flows. The study can help determine whether digital financial participation is associated with formal credit access without assuming that payment adoption alone causes credit expansion.

- **Limitations**

The proposed study has several limitations. First, a cross-sectional survey limits causal inference. Second, self-reported transaction frequency may contain recall error. Third, income and savings are sensitive variables and may be underreported. Fourth, digital-payment technologies evolve rapidly, meaning that findings can become outdated if the research is not periodically replicated. Fifth, a district-focused sample limits generalisation beyond the study setting. Sixth, unobserved characteristics such as risk preferences, household power structures and prior exposure to technology may influence both adoption and outcomes.

These limitations do not invalidate the study; rather, they determine how claims should be framed. The strongest contribution of the research will be a carefully measured description of the depth of digital financial participation and a transparent analysis of its correlates. Causal claims should be reserved for designs that establish appropriate temporal and identification conditions.

- **Future Research**

Future work can build a panel dataset by revisiting the same households after 12 or 24 months. Such data would permit examination of changes in digital capability and financial outcomes over time. A second avenue is an intervention study in which randomly selected villages receive structured digital-financial-literacy training. A third is the integration of anonymised transaction records, subject to appropriate consent and institutional permissions. A fourth is comparative research across Bihar districts with different connectivity and financial-infrastructure profiles.

A further extension would examine the interaction between community norms and women's digital financial behaviour. Recent national evidence indicates that peer usage and local gender norms can

influence women's adoption. District-level research could determine whether similar mechanisms operate in rural Bihar and whether local female financial intermediaries alter these relationships.

• Conclusion

The transformation of India's financial system through digital public infrastructure has created new possibilities for rural households. Yet the central research challenge has shifted. The question is no longer simply whether households can open accounts or access digital payment channels. The more demanding question is whether they can use those channels independently, safely, regularly and in ways that contribute to meaningful financial participation.

This paper develops a doctoral-level framework for investigating that question in rural Bihar. Its central contribution is to conceptualise digital financial inclusion as a progression from access to adoption, capability, trust and economic outcomes. The proposed DFII captures dimensions that are often separated in existing studies and provides a basis for examining why households with apparently similar financial access can have very different experiences of digital finance.

The empirical design is deliberately transparent. A sample of approximately 640 households is proposed using Cochran's formula, a design-effect adjustment and a non-response allowance. The questionnaire combines objective and subjective measures, while the SPSS plan provides procedures for reliability testing, factor analysis, index construction, logistic regression, continuous-outcome models, moderation and robustness analysis. Most importantly, the manuscript does not invent survey findings. It provides a framework through which original field evidence can be generated and tested.

For Lakhisarai and comparable rural areas, the ultimate policy issue is the quality of financial participation. Expanding accounts and payment infrastructure remains foundational, but durable inclusion also requires digital capability, reliable connectivity, trustworthy institutions, accessible grievance mechanisms and meaningful financial autonomy. A research strategy that measures these dimensions together can provide a more accurate account of how digital finance is changing rural financial life in Bihar.

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