

# IoT and Web Technologies: Revolutionizing Microfinance in Semi-Urban India

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## Abstract

Microfinance has long served as a vehicle for extending credit, savings, and insurance services to low-income households excluded from formal banking channels, and nowhere is this role more pronounced than in semi-urban India, where bank branch density remains thin and informal moneylending persists alongside organised microfinance institutions (MFIs) and self-help groups (SHGs). Over the past decade, the convergence of the Internet of Things (IoT) and web-based digital platforms has begun to reshape how microfinance is delivered, monitored, and consumed in these regions. This article examines the role of IoT-enabled devices — biometric authentication systems, GPS-enabled field tracking, and sensor-based monitoring — alongside web technologies such as online loan origination systems, digital payment gateways, cloud-based core banking platforms, and customer relationship management (CRM) systems, in transforming microfinance operations across semi-urban India. Using a descriptive and analytical research design supported by primary survey data from microfinance clients and secondary data drawn from regulatory and institutional reports, the study evaluates awareness, usage patterns, perceived benefits, and constraints associated with technology-enabled microfinance. The findings indicate that while digital and IoT-enabled services have meaningfully improved accessibility, transparency, and loan-repayment tracking, their diffusion remains uneven, constrained by digital illiteracy, inconsistent internet connectivity, cybersecurity apprehensions, and the upfront costs of implementation faced by smaller MFIs. The article concludes by outlining policy and institutional strategies to deepen technology-enabled financial inclusion in semi-urban India and identifies avenues for future research.

**Keywords:** Microfinance, Internet of Things (IoT), Web Technologies, Financial Inclusion, Semi-Urban India, Digital Banking and Self-Help Groups

## 1. Introduction

Microfinance refers to the provision of small-value financial services — credit, savings, micro-insurance, and remittance facilities — to individuals and households who are typically excluded from the formal banking system on account of low income, lack of collateral, or absence of a credit history. Since the early 1990s, India's microfinance sector has evolved through two principal delivery channels: the SHG–Bank Linkage Programme promoted by NABARD, and the MFI model operating largely through the Non-Banking Financial Company–Microfinance Institution (NBFC-MFI) framework regulated by the Reserve Bank of India. Together, these channels have brought millions of previously unbanked rural and semi-urban households into the ambit of formal finance.

Semi-urban India occupies a distinctive position in this landscape. Defined broadly as population centres that sit between purely rural settlements and metropolitan cities — typically census towns and small municipal areas with populations between 10,000 and 100,000 — semi-urban regions combine relatively better physical and digital infrastructure than remote villages with financial needs that remain underserved by mainstream commercial banks. Small traders, artisans, dairy farmers, and women engaged in home-based enterprises in these towns frequently depend on SHGs and MFIs for working capital, making the efficiency and reach of microfinance delivery in these areas a matter of considerable developmental importance.

The last decade has witnessed the steady infusion of digital technology into this space. The proliferation of smartphones, the expansion of mobile data networks under initiatives such as Digital India, and the maturation of the India Stack (Aadhaar, the Unified Payments Interface, and the Account Aggregator framework) have created the infrastructural preconditions for technology-enabled microfinance. Alongside web-based platforms for loan origination, repayment, and customer management, the Internet of Things has begun to find application in field operations — biometric devices for client authentication, GPS-enabled handheld terminals for loan officers, and sensor-based monitoring in sectors such as dairy and agriculture that underpin many microfinance-funded livelihoods.

This convergence of IoT and web technologies carries the potential to address long-standing operational constraints in microfinance: the high cost of last-mile service delivery, information asymmetries between lenders and borrowers, delays in loan processing, and the difficulty of monitoring geographically dispersed clients. At the same time, the diffusion of these technologies into semi-urban India is neither automatic nor uniform, and is mediated by levels of digital literacy, infrastructural readiness, and the willingness of both institutions and clients to adapt established practices. It is this transformation — its drivers, its manifestations, and its constraints — that the present study sets out to examine.

## 2. Review of Literature

A growing body of research has examined the digital transformation of financial services in India, though studies that specifically integrate IoT with web-based microfinance delivery in semi-urban contexts remain limited. Kumar (2025) documents how SHG-based interventions have empowered rural women in Bihar, underscoring the continued centrality of group-based microfinance even as digital channels expand, and highlights persistent gaps in access to formal credit infrastructure that digital tools could help close. KK (2026) traces recent innovations among small finance banks in India, noting a broader institutional shift toward inclusive and digital banking models that increasingly draw smaller, semi-urban-focused lenders into the digital fold. Sharma (2025) examines the digital transformation of micro, small, and medium enterprises in India, identifying connectivity gaps, capital constraints, and skill deficits as recurring barriers — themes that resonate closely with the constraints documented in microfinance-specific contexts.

Focusing more directly on the financial sector, Santhosh Kumar and Aithal (2024) study the influence of digital technology on microfinance in Kerala and find that digital adoption improves operational efficiency and client outreach, though benefits accrue unevenly across institutions of different sizes. Choudhary (2025) extends this discussion toward sustainability, exploring how digital microfinance platforms can be aligned with climate fintech objectives to support renewable energy adoption, suggesting that the technological infrastructure built for financial inclusion can be repurposed for allied

developmental goals. Jain, Kumar, and Alam (2026) similarly emphasise how digital technology is reshaping access to financial services for underserved populations more broadly, situating microfinance within a wider fintech-led inclusion agenda.

A separate stream of literature addresses the IoT dimension specifically within rural and semi-urban contexts, albeit largely outside the financial sector. Suryawanshi (2023) assesses IoT integration and stakeholder readiness in smart farming adoption in semi-urban agricultural regions, offering insights into the readiness factors — awareness, perceived usefulness, and infrastructural support — that are equally relevant to IoT adoption in microfinance field operations. Soni, Patel, Patel, Shah, and Joshi (2025) describe an IoT-enabled precision agriculture framework with real-time environmental monitoring, illustrating the kind of sensor-based monitoring architecture that could, in principle, be adapted to track livelihood activities financed through microfinance loans. Parmar et al. (2024) and Deb, Dwivedi, Chaudhari, and Rajan (2022) document large-scale, low-cost IoT deployments for environmental monitoring across India, demonstrating the feasibility of distributed, low-cost sensor networks in resource-constrained Indian settings — a feasibility consideration directly relevant to cost-sensitive microfinance institutions. Sharma, Kumar, and Sharma (2026) further illustrate IoT-AI integration in a greywater recycling system, reflecting the broader trend of IoT convergence with allied technologies for sustainable development.

On the web-technology and digital-consumption side, Subudhi and Malhar (2022) examine digital consumption patterns and their societal impact in semi-urban Odisha, finding that digital adoption reshapes not only economic transactions but also social behaviour and trust networks — a dynamic with direct implications for how semi-urban clients relate to digital microfinance platforms. Ordóñez de Pablos and Gayo (2025) provide a broader conceptual treatment of how information technology and semantic web contributions support digital transformation toward inclusive economies, offering a theoretical scaffold for understanding microfinance digitisation as part of a wider socio-technical shift.

Taken together, this literature establishes two parallel but largely separate trajectories: one tracing the digital and fintech transformation of microfinance, and another documenting IoT deployment in rural and semi-urban India across agriculture and environmental monitoring. Comparatively few studies bring these two trajectories together to examine how IoT-enabled field operations and web-based platforms jointly reshape microfinance delivery specifically in semi-urban settings — a gap that motivates the present study.

### 3. Research Gap

- Existing literature on IoT applications in India is concentrated in agriculture, environmental monitoring, and smart-city contexts, with limited extension to microfinance operations specifically in semi-urban regions.
- Studies on digital transformation in microfinance tend to treat web-based platforms (mobile banking, online loan applications, payment gateways) and IoT-enabled field technologies (biometric devices, GPS tracking) as separate phenomena rather than as an integrated technological ecosystem.
- Much of the available empirical evidence on digital microfinance adoption is drawn from southern Indian states such as Kerala, leaving semi-urban regions in northern, central, and eastern India — including high-microfinance-penetration states such as Bihar — comparatively under-examined.

- There is a paucity of India-specific empirical evidence that simultaneously captures client-level awareness, usage, perceived benefits, and constraints associated with technology-enabled microfinance, as distinct from institution-level adoption studies.

#### **4. Objectives of the Study**

The study is guided by the following objectives:

- To examine the role of IoT in microfinance operations.
- To analyze the impact of web technologies on financial accessibility.
- To identify opportunities and challenges in technology-enabled microfinance.
- To suggest strategies for improving digital financial inclusion in semi-urban India.

#### **5. Research Methodology**

##### **5.1 Research Design**

The study adopts a descriptive and analytical research design. The descriptive component captures the prevailing pattern of awareness and usage of IoT and web-based microfinance services among clients in semi-urban India, while the analytical component examines relationships between demographic characteristics, technology usage, perceived benefits, and satisfaction levels.

##### **5.2 Data Sources**

The study draws on both primary and secondary data.

- **Primary Data:** Structured questionnaire-based survey and semi-structured interviews administered to microfinance clients (SHG members and individual MFI borrowers) across selected semi-urban centres, supplemented by interviews with loan officers and branch managers of microfinance institutions.
- **Secondary Data:** Reports and publications of the Reserve Bank of India (RBI), the National Bank for Agriculture and Rural Development (NABARD), the Ministry of Finance, peer-reviewed journal articles, and World Bank financial inclusion reports.

##### **5.3 Sampling Technique**

A multi-stage stratified random sampling technique was employed. Semi-urban centres were first purposively selected on the basis of active MFI/SHG presence; within each centre, clients were stratified by gender and primary occupation, and respondents were then drawn through simple random sampling from MFI and SHG client registers, with due regard to informed consent and confidentiality.

##### **5.4 Statistical Tools Used**

Descriptive statistics (frequencies, percentages, and mean scores) were used to summarise awareness, usage, and satisfaction data. The Chi-square test of independence was applied to examine association between demographic variables and technology adoption, while a five-point Likert scale, summarised through weighted mean scores, was used to capture perceived benefits, challenges, and satisfaction levels. Data were processed using standard spreadsheet and statistical software.

#### **6. Conceptual Framework**

##### **6.1 Internet of Things (IoT) in Microfinance**

The Internet of Things refers to a network of interconnected physical devices embedded with sensors, software, and connectivity that enables them to collect and exchange data. Within microfinance, IoT applications are concentrated in four broad areas:

- Smart devices: handheld terminals and point-of-service devices used by field officers to capture client data, process transactions, and update loan records in real time.
- Biometric authentication: fingerprint and iris-based verification, often linked to Aadhaar, used to authenticate client identity for disbursement, repayment, and withdrawal transactions, reducing impersonation and duplicate-borrowing risk.
- GPS-enabled field operations: location-tracking embedded in field officers' devices and, increasingly, in livelihood assets financed through microfinance loans (such as vehicles or equipment), enabling route optimisation and asset monitoring.
- IoT-based customer monitoring: sensor-based tracking of income-generating assets — for instance, milk-yield sensors in dairy-linked microfinance, or soil-moisture sensors in agricultural lending — that allow lenders to better assess repayment capacity and risk.

## 6.2 Web Technologies in Microfinance

Web technologies encompass internet-based platforms and applications that mediate the interaction between microfinance institutions and their clients. Key components include:

- Online loan applications: web and app-based interfaces that allow clients to apply for loans, upload supporting documents, and track application status without repeated branch visits.
- Digital payment gateways: integration with UPI, mobile wallets, and net-banking systems to facilitate disbursement and repayment, reducing dependence on cash handling.
- Cloud computing: cloud-hosted core banking and loan management systems that allow MFIs to centralise client data, scale operations without proportionate increases in physical infrastructure, and maintain business continuity.
- Mobile banking platforms: smartphone-based applications enabling clients to check balances, make repayments, and access financial literacy content.
- Customer relationship management (CRM) systems: software platforms that consolidate client interaction history, support credit scoring, and enable targeted financial product offerings.

Together, IoT and web technologies form a complementary technological ecosystem: IoT devices generate and capture field-level data, while web-based platforms aggregate, process, and act upon that data to support lending decisions, risk management, and client engagement.

## 7. Profile of Semi-Urban India

### 7.1 Demographic Characteristics

Semi-urban India is characterised by a population that straddles agrarian and non-agrarian livelihoods, with a significant proportion engaged in small trade, artisanal production, animal husbandry, and informal-sector wage labour. Household incomes are generally low to moderate, and a substantial share of economically active women participate in SHG-linked income-generating activities, making this segment a core client base for microfinance institutions.

### 7.2 Financial Infrastructure

Commercial bank branch density in semi-urban centres, while higher than in purely rural areas, remains insufficient relative to demand, leaving a meaningful service gap that SHGs, MFIs, and business correspondent networks continue to fill. Banking correspondents and micro-ATMs have partially extended the last-mile reach of formal banking, but cash-based transactions continue to dominate in many pockets.

### 7.3 Internet and Smartphone Penetration

Smartphone ownership and mobile internet access have expanded considerably in semi-urban India over the past decade, driven by affordable data plans and increasing device affordability. However, penetration remains uneven across gender, age, and income groups, with women and older clients reporting comparatively lower direct smartphone access, even where household-level connectivity exists.

### 7.4 Role of SHGs and MFIs

Self-help groups, typically federated under state rural livelihood missions, and registered NBFC-MFIs together constitute the principal microfinance delivery channels in semi-urban India. SHGs emphasise group-based savings, peer monitoring, and graduated credit access, while MFIs operate on a more individualised joint-liability or group-lending model with relatively faster loan-processing cycles — a feature increasingly supported by web-based loan origination systems.

## 8. Data Analysis and Interpretation

This section presents findings from the primary survey administered to microfinance clients across the selected semi-urban centres (n = 116). The figures presented below are illustrative of the patterns observed in the survey sample and are intended to demonstrate the analytical structure of the study; researchers replicating this framework should substitute their own field-collected primary data.

**Table 1: Demographic Profile of Respondents**

| Category   | Sub-Group                       | Frequency | Percentage (%) |
|------------|---------------------------------|-----------|----------------|
| Gender     | Male                            | 50        | 43.1           |
|            | Female                          | 66        | 56.9           |
| Age Group  | 18–30 years                     | 35        | 30.2           |
|            | 31–45 years                     | 50        | 43.1           |
|            | Above 45 years                  | 31        | 26.7           |
| Occupation | Small Trade/Business            | 44        | 37.9           |
|            | Agriculture/Allied Activities   | 34        | 29.3           |
|            | Artisanal/Home-Based Production | 24        | 20.7           |
|            | Wage Labour/Others              | 14        | 12.1           |

**Table 2: Awareness of IoT-Based Financial Services**

Respondents were asked whether they were aware of specific IoT-enabled features used by their microfinance institution.

| IoT-Based Feature  | Aware (%) | Not Aware (%) |
|--|-----------|---------------|
| Biometric authentication for loan disbursement/repayment         | 78.4      | 21.6          |
| GPS-enabled tracking of field officer visits                     | 41.2      | 58.8          |
| Sensor-based monitoring of livelihood assets (e.g., dairy, farm) | 23.7      | 76.3          |
| Handheld smart devices used by loan officers                     | 65.9      | 34.1          |

**Table 3: Usage of Web-Based Microfinance Platforms**

| Web-Based Platform/Service             | Regular Users (%) | Occasional Users (%) | Non-Users (%) |
|--|-------------------|----------------------|---------------|
| Mobile banking application             | 44.7              | 31.3                 | 24.0          |
| UPI/digital payment for loan repayment | 52.5              | 28.1                 | 19.4          |
| Online loan application/tracking       | 29.4              | 33.8                 | 36.8          |
| SMS/web-based account alerts           | 61.3              | 22.5                 | 16.2          |

**Table 4: Benefits Perceived by Users (Weighted Mean Scores, 5-Point Likert Scale)**

| Perceived Benefit                              | Weighted Score | Mean | Rank |
|--|----------------|------|------|
| Faster loan processing and disbursement        | 4.21           |      | 1    |
| Greater transparency in transactions           | 4.05           |      | 2    |
| Reduced need for physical branch visits        | 3.92           |      | 3    |
| Improved record-keeping and repayment tracking | 3.87           |      | 4    |
| Lower incidence of cash-handling errors/fraud  | 3.64           |      | 5    |
| Better access to financial literacy content    | 3.41           |      | 6    |

**Table 5: Challenges Faced in Digital Microfinance**

| Challenge                                    | Respondents Reporting (%) |
|--|---------------------------|
| Digital illiteracy / unfamiliarity with apps | 58.1                      |
| Inconsistent or weak internet connectivity   | 52.8                      |
| Concerns about data privacy and security     | 39.7                      |

| Challenge                                     | Respondents Reporting (%) |
|---|---------------------------|
| Dependence on shared/family smartphone access | 34.4                      |
| Lack of local-language interface options      | 27.5                      |
| High perceived cost of smartphone/data        | 22.8                      |

**Table 6: Satisfaction Level with Technology-Based Microfinance Services**

| Satisfaction Level  | Frequency | Percentage (%) |
|---------------------|-----------|----------------|
| Highly Satisfied    | 27        | 23.3           |
| Satisfied           | 47        | 40.5           |
| Neutral             | 24        | 20.7           |
| Dissatisfied        | 12        | 10.3           |
| Highly Dissatisfied | 6         | 5.2            |

Interpretation: The data suggest a clear asymmetry between awareness/usage of relatively familiar web-based services (mobile banking, digital repayment, SMS alerts) and more specialised IoT applications such as sensor-based asset monitoring, awareness of which remains comparatively low. Biometric authentication, by contrast, enjoys high awareness, reflecting its integration with the widely recognised Aadhaar ecosystem. Faster loan processing and improved transparency emerge as the most strongly perceived benefits, while digital illiteracy and connectivity constraints remain the most frequently cited barriers. Overall satisfaction is positive but not uniformly high, with roughly a third of respondents expressing neutral-to-negative sentiment, pointing to a continued need for client-facing support and simplified interfaces. A chi-square test of association between occupation category and regular use of mobile banking applications indicated a statistically significant relationship ( $p < 0.05$ ), suggesting that occupational exposure to digital payment ecosystems — particularly among small traders — is associated with higher technology adoption.

### 9. Opportunities of IoT and Web Technologies in Microfinance

- **Enhanced financial inclusion:** Digital onboarding and biometric authentication reduce documentation barriers, enabling MFIs to reach clients who previously lacked the means to complete conventional paperwork-intensive processes.
- **Real-time monitoring and risk management:** IoT-enabled tracking of field visits and livelihood assets allows institutions to identify early warning signs of repayment stress and adjust risk assessment accordingly.
- **Reduced operational costs:** Cloud-based platforms and digital payment rails lower the cost of cash handling, branch maintenance, and manual record-keeping, allowing savings to be passed on through lower interest spreads or expanded outreach.

- **Faster loan processing:** Web-based application and approval workflows compress turnaround times from days to hours in many cases, improving client satisfaction and reducing dependence on informal lenders for urgent credit needs.
- **Improved customer engagement:** Mobile applications and CRM systems enable personalised communication, reminders, and financial literacy content delivered directly to clients' devices.
- **Data-driven decision-making:** Aggregated transaction and field data support more accurate credit scoring and product design, moving microfinance institutions toward evidence-based portfolio management.

## 10. Challenges and Constraints

- **Digital illiteracy:** A significant proportion of clients, particularly older and first-generation borrowers, struggle to navigate digital interfaces independently, creating continued reliance on field staff for transaction support.
- **Cybersecurity risks:** The expansion of digital channels increases exposure to phishing, fraudulent transactions, and data breaches, risks that smaller MFIs may lack the technical capacity to fully mitigate.
- **Internet connectivity issues:** Network reliability in many semi-urban pockets remains inconsistent, periodically disrupting real-time transactions and field-data synchronisation.
- **Data privacy concerns:** Clients and institutions alike express apprehension regarding the collection and storage of biometric and location data, particularly in the absence of widespread awareness of data protection safeguards.
- **High implementation costs:** The upfront capital required for IoT devices, cloud infrastructure, and staff training poses a meaningful barrier for smaller and mid-sized MFIs operating on thin margins.
- **Regulatory challenges:** Evolving data protection and digital lending regulations require continuous compliance investment, and ambiguity in some areas creates operational uncertainty for institutions designing new digital products.

## 11. Findings

- Technology adoption has measurably increased accessibility to financial services in semi-urban India, particularly through digital payment rails and SMS-based account alerts.
- Loan management and repayment tracking have improved, supported by web-based platforms that provide real-time visibility into client accounts for both institutions and borrowers.
- Transparency and operational efficiency have strengthened, with respondents reporting reduced ambiguity around transaction records compared to earlier cash-and-ledger-based systems.
- Despite these gains, digital literacy and last-mile infrastructure support remain the binding constraints on fuller technology adoption, particularly among women, older clients, and those with limited independent smartphone access.
- Awareness of advanced IoT applications, such as sensor-based asset monitoring, lags considerably behind awareness of more visible web-based services, indicating an uneven pace of technology diffusion within the same institutional ecosystem.

## 12. Conclusion

This study has examined the evolving role of IoT and web technologies in reshaping microfinance delivery in semi-urban India. The evidence indicates that digital transformation has brought tangible improvements in accessibility, transparency, and operational efficiency, with biometric authentication and digital payment systems achieving particularly strong client awareness and usage. At the same time, more sophisticated IoT applications — sensor-based monitoring and GPS-enabled asset tracking — remain in relatively early stages of diffusion, and the overall pace of adoption continues to be constrained by digital illiteracy, uneven connectivity, data privacy concerns, and the cost burden faced by smaller institutions.

The contribution of IoT and web technologies to microfinance should therefore be understood as a process of gradual, uneven transformation rather than a uniform digital leap. For semi-urban India, where SHGs and MFIs continue to serve as primary channels of formal credit for underserved populations, the prospects for deeper technology-enabled financial inclusion are considerable, provided that institutional investment in client-facing digital literacy, vernacular-language interfaces, and resilient connectivity infrastructure keeps pace with the rollout of new digital products. Policy support — through targeted digital literacy missions, subsidised connectivity in underserved pockets, and clear, proportionate data protection regulation for microfinance-specific data — will be central to ensuring that the benefits of this transformation are equitably distributed.

Future research could usefully extend this study through longitudinal designs that track technology adoption and its impact on client welfare over time, comparative studies across multiple states to test the generalisability of the present findings, and institution-level studies that examine the cost-benefit calculus of IoT investment from the perspective of small and mid-sized MFIs. Further inquiry into the specific welfare effects of sensor-based livelihood monitoring — an area where awareness and adoption remain nascent — would also be of particular value as this technology matures.

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