

AN ANALYTICAL STUDY ON THE IMPACT OF TECHNOLOGICAL ADOPTION AND DIGITAL FINANCIAL LITERACY ON THE EFFECTIVENESS AND SUSTAINABILITY OF RURAL MICROFINANCE INTERVENTIONS FOR FINANCIAL INCLUSION

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ABSTRACT

Financial inclusion is widely recognized as a cornerstone of rural development; however, conventional microfinance models continue to face inherent limitations in terms of scalability, efficiency, and long-term sustainability. Mobile banking, digital wallets, biometric authentication, and fintech-enabled platforms are just a few examples of the rapidly emerging and spreading digital technologies that have created revolutionary prospects to improve the operational and social efficacy of microfinance institutions (MFIs). The effectiveness and durability of rural microfinance programs are examined critically in this study in relation to the ways in which digital financial literacy (DFL) mediates technological adoption. Utilising a secondary data methodology, the analysis assesses institutional, behavioural, and infrastructure factors of adoption by referencing well-established theoretical frameworks, including the Unified Theory of Acceptance and Use of Technology (UTAUT) and the Technology Acceptance Model (TAM). The results indicate that while digital platforms improve outreach, operational effectiveness, transparency, and cost reduction, their performance is mostly dependent on users' sociocultural preparedness, financial awareness, and trust. High DFL has been demonstrated to boost trust in online transactions, reduce fraud risks, and empower under-represented groups, especially women. However, ongoing obstacles like as cultural aversion, unclear regulations, and inadequate infrastructure still prevent inclusive adoption. According to the study's findings, creating robust, transparent, and sustainable rural microfinance ecosystems that further the more general goals of financial inclusion and socioeconomic empowerment requires combining digital literacy programs with helpful legislative frameworks and user-centric fintech innovations.

KEYWORDS: *Digital Financial Literacy; Socio-Economic Empowerment; Financial Inclusion; Microfinance Sustainability; Rural Development; Fintech Adoption.*

INTRODUCTION

Financial inclusion has become a cornerstone of global development agendas, particularly in developing countries where large segments of the rural population remain excluded from formal banking services. With its emphasis on small-scale credit and savings options, microfinance has long been essential to empowering low-income people and strengthening their financial stability. However, the incorporation of digital technology and the increasing demand for digital financial literacy are reshaping microfinance interventions, making them more sustainable and effective over the long run than traditional loan models alone. The operational dynamics of microfinance institutions have changed due to the quick development of financial technologies (FinTech), such as peer-to-peer lending, crowdfunding, mobile banking, and blockchain-enabled services. These technologies have created previously unheard-of chances to increase efficiency, lower transaction costs, and reach a wider audience.

Yet, technological adoption alone does not guarantee financial inclusion. Its effectiveness primarily rests on rural clients' comprehension, trust, and capacity to use digital platforms. As a result, digital financial literacy (DFL), which is the awareness, knowledge, and abilities needed to operate financial services online, has become a crucial success factor. Higher DFL levels have been shown to improve consumer protection, reduce fraud risks, and boost trust in digital transactions—all of which contribute to inclusive financial ecosystems (Ravikumar et al., 2022; Gumilar et al., 2024). However, rural areas still confront enduring obstacles like poor internet infrastructure, a lack of technology skills, and cultural aversion to embracing digital technologies, even in the face of national initiatives like PMGDISHA and Digital India.

According to theoretical viewpoints like the Unified Theory of Acceptance and Use of Technology (Venkatesh et al., 2003), the Technology Acceptance Model (Davis, 1989), and their subsequent improvements (Dwivedi et al., 2017), user intention and behaviour towards technology adoption are influenced by perceived utility, ease of use, social influence, and facilitating conditions. These elements are especially more important in the case of rural microfinance since socioeconomic vulnerabilities, trust, and gendered financial experiences all influence adoption. Furthermore, sustainability issues are still present: digital adoption can strain operational efficiency while also improving social participation, resulting in a difficult balance between institutional viability and outreach (Fersi et al., 2023).

The effectiveness and durability of rural microfinance initiatives are impacted by the intersection of digital financial literacy and technological adoption, which must be critically examined in light of these dynamics. This study intends to make a contribution by filling in current research gaps, assessing potential and limitations, and providing information that microfinance institutions, practitioners, and policymakers can use. By placing the data in the larger context of sustainable development and financial inclusion, this study highlights the revolutionary potential of technology-enabled, literacy-driven rural finance models.

Review of Literature

Venkatesh et al. (2003) examined the need to unify various theories on technology acceptance. They examined eight popular models, such as the Theory of Planned Behaviour, Innovation Diffusion Theory, Social Cognitive Theory, and Technology Acceptance Model, and contrasted them using longitudinal data from four different organisations. System utilisation metrics and

surveys were used at various adoption stages. As a result, they put forth the Unified Theory of Acceptance and Use of Technology, which identified performance expectancy, effort expectancy, social impact, and facilitating conditions as the primary elements influencing acceptance and explained about 70% of the variance in user intention.

Singh and Padhi (2015) focused on understanding how information and communication technology aids microfinance institutions in India to improve their operations. Studying how ICT affects client management, risk management, and work efficiency was the primary goal. Using a case study approach, the authors gathered information from three organizations Cashpor, SKS, and Utkarshvia surveys, interviews, and focus groups. Although there were still problems with infrastructure, customer acceptance, and regulation, the results demonstrated that ICT improved risk management, decreased expenses, and expanded outreach.|

Suri and Jack (2016) assessed a study to evaluate the long-term influence of mobile money services on poverty alleviation and gender dynamics in Kenya. Agent density served as the primary access metric in this study, which used a nationally representative household panel survey conducted between 2008 and 2014. According to the data, mobile money lifted about 194,000 households out of poverty and greatly increased per capita expenditure. The findings also showed that households led by women saw greater benefits due to increased engagement in entrepreneurial activities, enhanced savings capacity, and financial resilience.

Dwivedi et al. (2017) conducted a critical appraisal of the Unified Theory of Acceptance and Use of Technology with the objective of advancing its explanatory capacity in the context of information systems adoption. The study used meta-analytic structural equation modelling in addition to a meta-analysis of 162 empirical studies to support the updated framework. According to the results, attitude is a crucial construct that both directly affects technology use and mediates the effects of social influence, enabling circumstances, performance expectancy, and effort expectancy on behavioural intention.

Ravikumar et al. (2022) sought to examine and validate the determinants of digital financial literacy (DFL) among adults in India who utilize digital financial services. The study used a descriptive and correlational research approach and used a structured questionnaire to gather primary data from 384 respondents. Twelve characteristics of DFL were identified through the use of exploratory and confirmatory factor analyses. These dimensions included risk awareness, financial knowledge, digital knowledge, and product quality. The results showed that while gender, income, and area of residence had no effect on DFL levels, education had a considerable impact.

Mandal and Dua (2023) set out to understand how rural communities in India are coping with the growing wave of digital financial services. Their objective was to assess the level of awareness, opportunities, and barriers faced by villagers in adopting digital transactions. The study, which used secondary data from government reports, journals, and news sources, showed that rural areas still face issues like poor internet connectivity, a lack of skills, and a fear of fraud, which impede the progress of true financial inclusion even with programs like Digital India and PMGDISHA.

Fersi et al. (2023) examined the impact of digital transformation on the efficiency of microfinance institutions. The study aimed to evaluate both operational and social efficiency when FinTech services are introduced. The authors used random and fixed effects models in conjunction with the Stochastic Frontier Analysis on a sample of 387 institutions from 69

developing nations between 2005 and 2019. The results showed that innovative institutions had higher social efficiency but lower operational efficiency, underscoring the difficulties and trade-offs associated with digital adoption.

Liu et al. (2023) explored how information and communication technologies are shaping the field of microfinance through a bibliometric study. They used descriptive statistics, co-citation, and co-word analysis with the CiteSpace program to examine 347 research publications published between 1998 and 2021. According to the analysis, mobile banking, peer-to-peer lending, and crowdfunding have emerged as major topics that are frequently brought up in discussions on financial inclusion and entrepreneurship. In order to improve sustainability in microfinance, the authors recommended that future research focus more on cutting-edge fintech like blockchain.

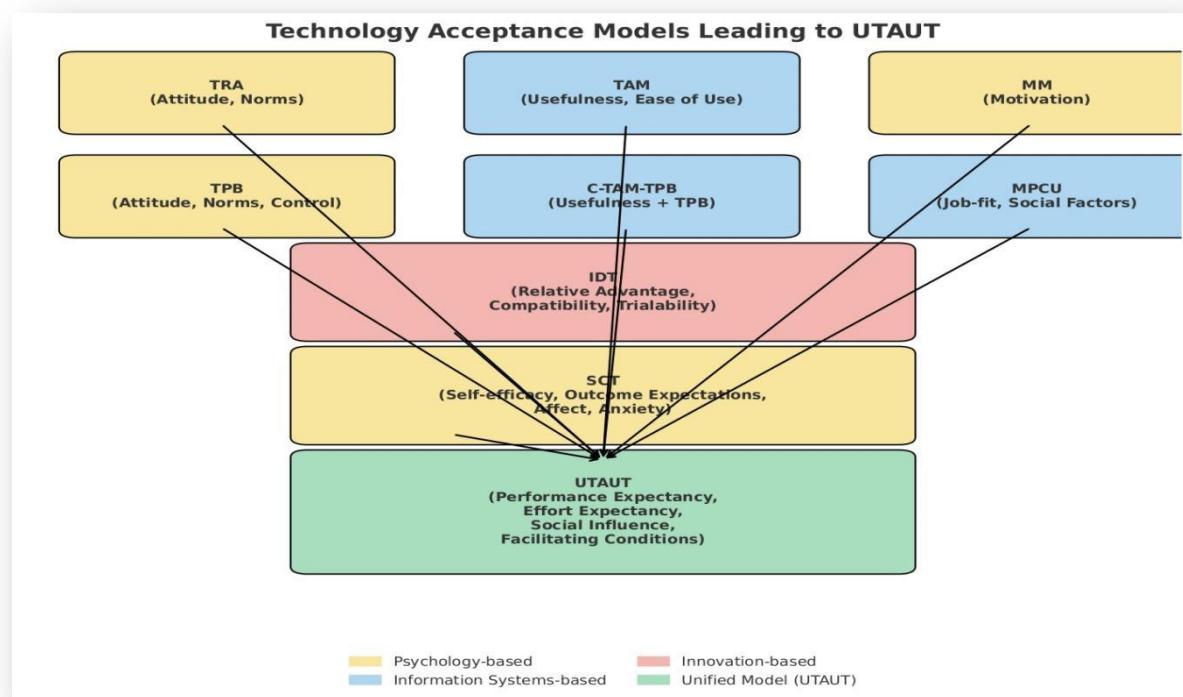
Gumilar et al. (2024) carried out a systematic literature review to investigate the relationship between digital financial literacy and digital financial inclusion in the age of digital disruption. The goal was to evaluate the ways in which literacy promotes financial well-being, reduces socioeconomic inequalities, and increases participation. 35 research in all were thoroughly examined using Scopus-indexed publications from 2020 to 2024. The results show that adoption of digital services lowers inequality, financial technology promotes welfare, and digital financial knowledge is essential for maximising inclusion—despite ongoing issues with usage and consumer protection.

Offiong et al. (2024) carried out a systematic assessment of literature on the role of FinTech in microfinance, focusing on identifying major drivers, existing research directions and new areas for future investigation. The authors employed correspondence analysis and clustering techniques to map important themes from research that were published in Web of Science and Scopus between 2010 and 2023. Their findings highlight study gaps in sustainability and regulatory challenges, while also demonstrating the importance of operational efficiency, customer experience, and financial inclusion in the adoption of FinTech.

Jena (2025) examined the factors that influence the adoption of FinTech to improve financial inclusion in rural India. Using the Technology Readiness Index, the Theory of Planned Behaviour, and the Technology Acceptance Model, the goal was to comprehend technological, psychological, and sociocultural elements. Adoption was revealed to be considerably affected by attitude, perceived ease of use, perceived behavioural control, and insecurity via a mixed methods approach that used PLS-SEM and fsQCA on survey data. The findings show how FinTech might help achieve sustainable development goals and lessen financial exclusion.

Acceptance of Information Technology Model

The Acceptance of Information Technology (AIT) Model investigates the reasons behind and methods by which people embrace new technologies. Technology intention is influenced by a number of elements, including perceived usefulness, convenience of use, and user attitudes. This approach, which is widely used in both research and practice, aids in understanding user behaviour, forecasting adoption trends, and creating plans that build community and organisational acceptance of technology.



(Source: Compiled by Author)

1. Theory of Reasoned Action (TRA)

According to the Theory of Reasoned Action, which was created by Fishbein and Ajzen, behaviour results from behavioural intention, which is influenced by two important elements: subjective norms and attitude towards the behaviour. When it comes to technology, this means that people are more likely to adopt a system if they think it will help them and if they get social pressure from peers or superiors to utilise it.

2. Technology Acceptance Model (TAM)

The Technology Acceptance Model, proposed by Davis, adapts TRA specifically for information systems. It focusses on perceived ease of use, which measures how easy the system is to use, and perceived usefulness, or the idea that technology enhances job performance. TAM is one of the most popular models in technology adoption research since both elements affect a user's propensity to utilise technology.

3. Motivational Model (MM)

The Motivational Model explains technology adoption through intrinsic and extrinsic motivation. Extrinsic motivation is the use of technology for outside benefits like better performance, recognition, or promotions, whereas intrinsic motivation is the use of technology for one's own pleasure or interest. These motivations together shape users' willingness to adopt new systems.

4. Theory of Planned Behavior (TPB)

TRA is expanded by the Theory of Planned Behaviour, which includes perceived behavioural control, or the extent to which people think they have the means, abilities, and chances to carry out the behaviour. The model's capacity to forecast technology use is enhanced by perceived behavioural control in addition to attitudes and subjective standards, particularly in situations when limitations might be present.

5. Combined TAM and TPB (C-TAM-TPB)

This hybrid model integrates TAM's perceived usefulness with TPB's attitude, subjective norms, and perceived behavioral control. By combining both perspectives, C-TAM-TPB provides a more comprehensive explanation of how individual beliefs and external influences affect technology adoption.

6. Model of PC Utilization (MPCU)

A variety of characteristics, including as job-fit, complexity, long-term effects, affect towards use, social aspects, and conducive settings, are identified by the Model of PC Utilisation, which is based on Triandis' theory of human behaviour. This concept emphasises both organisational and human effects, going beyond intention to concentrate on actual technology utilisation.

7. Innovation Diffusion Theory (IDT)

Innovation Diffusion Theory, proposed by Rogers, focuses on the characteristics of innovations that affect their adoption. Key elements include relative advantage, compatibility, ease of use, trialability, visibility, image, and voluntariness of use. This theory explains how and why new technologies spread among individuals and organizations over time.

8. Social Cognitive Theory (SCT)

Social Cognitive Theory, rooted in Bandura's work, emphasizes the role of self-belief and social influence in technology adoption. It includes outcome expectations, self-efficacy, affect, and anxiety as central constructs. The theory suggests that confidence, emotional responses, and expected benefits strongly determine technology use.

9. Unified Theory of Acceptance and Use of Technology (UTAUT)

After comparing these eight models, Venkatesh et al. proposed the Unified Theory of Acceptance and Use of Technology (UTAUT). According to this concept, performance expectancy, effort expectancy, social influence, and facilitating conditions are the four primary factors that determine user intention and behaviour. Furthermore, it incorporates modifiers like age, gender, experience, and voluntariness, making UTAUT one of the most thorough and extensively verified frameworks for researching the adoption of technology.

Objectives

- To identify challenges and barriers faced by rural communities and microfinance institutions in adopting digital financial services.
- To evaluate the relationship between technological innovations, digital awareness, and socio-economic empowerment of rural beneficiaries.

- To examine how the adoption of digital technologies (such as mobile banking, digital wallets, fintech solutions, and biometric systems) affects the reach, efficiency, and effectiveness of rural microfinance programmes.

Methodology

Based on secondary data sources, this study uses a qualitative, analytical, and descriptive research design. In order to gather information on the relationship between digital financial literacy, rural microfinance sustainability, and technology adoption, scholarly publications, government reports, institutional surveys, and policy papers were thoroughly examined. The analysis uses well-known theoretical models to analyse adoption behaviour and usage patterns, especially the Unified Theory of Acceptance and Use of Technology (UTAUT) and the Technology Acceptance Model (TAM). The World Bank, RBI, NABARD, and other microfinance publications were analysed extensively in order to pinpoint potential, problems, and policy ramifications for inclusive financial ecosystems.

Analysis and Discussion

➤ Challenges and Barriers in Adopting Digital Financial Solutions

Numerous institutional, infrastructure, and socioeconomic barriers influence the uptake of digital banking solutions in rural regions. The reality on the ground shows a number of obstacles that continue to impede the general usefulness of digital technologies, despite the fact that they have the potential to accelerate financial inclusion. These difficulties can be viewed from five main angles:

Infrastructural Limitations

In rural India, the lack of proper physical and digital infrastructure is one of the biggest problems. Many villages continue to experience inadequate mobile network coverage, frequent power outages, and inconsistent internet connection despite the growth of mobile connectivity brought about by programs like BharatNet. About 40% of rural households in developing nations do not have reliable connectivity, according to a World Bank report from 2021. This makes it challenging for mobile banking and fintech apps to function reliably. Digital solutions are still out of reach for many rural beneficiaries in the absence of dependable infrastructure.

Digital Illiteracy and Low Awareness

If you want to use technology-based solutions, you must be digitally literate. Nonetheless, most rural residents are not familiar with how to utilise smartphones, internet banking apps, or fraud prevention techniques. Less than 30% of rural adults stated that they were aware of digital payment methods like UPI, mobile wallets, or net banking, according to the NABARD Financial Inclusion Survey (2022). The biggest disadvantages affect women, the elderly, and marginalised communities, which results in incomplete or nonexistent use of digital services. The dependence on middlemen that results from ignorance can sometimes lead to more abuse and exploitation.

Policy and Regulatory Gaps

There are still gaps in the consistent application of policies, notwithstanding India's numerous efforts to encourage digital inclusion. Adoption is made more difficult by uneven consumer protection laws and regulatory ambiguity around new fintech models. Small MFIs frequently have unclear compliance obligations, especially when it comes to cyber security and data

protection. Institutions and rural clientele are still reluctant to fully embrace digital transformation in the absence of sufficient safeguards.

Institutional and Capacity Constraints in MFIs

Digital system adoption presents issues for microfinance institutions themselves. Many MFIs that are small and medium-sized do not have the funds to invest in cyber security infrastructure, biometric devices, or sophisticated digital platforms. Training frontline staff to operate and educate beneficiaries about digital tools adds further costs. According to Sa-Dhan's Bharat Microfinance Report (2023), nearly 45% of small MFIs reported difficulties in transitioning from paper-based to fully digital record-keeping due to financial and technical limitations. This constrains their ability to scale digital interventions effectively.

Cultural and Social Barriers

One important factor impeding the adoption of digital technology is cultural resistance. Because of its familiarity, instant liquidity, and perceived security, cash-based transactions are preferred by many rural recipients. Uncomfortable with new technology, distrust of financial institutions, and fear of losing money in digital systems all contribute to a decreased readiness to use digital solutions. The digital divide is made worse by gender dynamics, which add another level of complexity. Traditional household structures sometimes deny women access to digital platforms and mobile devices.

➤ Relationship between Technological Innovations, Digital Awareness, and Socio-economic Empowerment:

Technological innovations (such as mobile banking, UPI, digital wallets, biometric ID, and fintech credit scoring) and socioeconomic empowerment in rural areas are strongly correlated, but this relationship is conditional and heavily dependent on the digital awareness of beneficiaries, enabling infrastructure, and supportive institutional frameworks. I break down the relationship into four interconnected strands below: gender and social empowerment, income and entrepreneurial opportunities, access and resilience, and the mediation function of digital financial literacy.

Access, risk-sharing and household resilience

By lowering transaction costs and friction in money transfers, technological advancements improve households' capacity to withstand shocks. Mobile money improved resilience and wellbeing by facilitating households' post-shock consumption and increasing remittances, according to evidence from Kenya's mobile money revolution. Better socioeconomic outcomes can be achieved through this system, which enables cheaper, faster, and easier remittance payments.

Income generation, productivity and entrepreneurship

Fintech loans, digital markets, and digital payment systems increase the economic activity available to rural households. Fintechs and digital wallets assist micro-entrepreneurs increase sales and obtain working capital by facilitating quick payments, reducing the cost of minor transactions, and providing alternative credit evaluation (e.g., agent data, mobile usage). Although findings vary by context and supporting services, new systematic reviews and case studies from Bangladesh (bKash) demonstrate positive links between the use of digital finance and improved economic activity and financial inclusion measures.

Gender empowerment and social outcomes

Combining digital financial services with targeted design (women agents, SHG linkages, training) can boost women's economic agency. Studies on mobile money and case studies from other countries show that women who actively utilise mobile financial services have more control over their finances and decision-making. However, women only experience gender benefits when they have access to devices, are literate, and have secure, culturally relevant outlets (like female agent networks). In the absence of these facilitators, digital services could perpetuate or even exacerbate gender disparities.

The mediating role of digital financial literacy (DFL)

The key determinants of the relationship between empowerment and technology accessibility are digital awareness and capability. Research and national surveys show that the existence of digital platforms (such as UPI, wallets, and mobile banking) alone does not ensure their use or benefits; recipients need to be able to use apps, comprehend fees and security measures, and recognise fraudulent activity. According to NABARD's evaluations and more recent research from India, higher DFL levels are associated with improved loan repayment practices, increased use of digital services, and strengthened savings discipline among SHGs—all of which contribute to long-term socioeconomic benefits. Low DFL, on the other hand, negates the possibility of empowerment by causing reliance on middlemen, exclusion from digital benefits, or exposure to fraud.

Complementarity between technology and institutional support

The best empowerment results come from a combination of technology rollout and institutional measures, such as customised financial literacy programs, gender-sensitive and easily accessible agent networks, consumer protection and grievance redress, and MFIs integrating digital tools (digital book-keeping, Aadhaar-enabled payments). Fintech increases inclusion best when MFIs and regulators encourage use through cyber security, training, and pro-poor business models, according to systematic research studies.

➤ Adoption of Digital Technologies and Their Influence on Rural Microfinance

Digital transformation has reshaped the landscape of rural microfinance, enabling broader financial inclusion and sustainable development. Its impact can be understood under several dimensions:

Expansion of Outreach

Microfinance organisations are now able to reach more rural communities because to digital platforms like mobile banking, wallets, and Aadhaar-enabled services. They increase service accessibility and lessen the demand for physical branches. Beneficiaries in rural areas can now avail loans, savings, and insurance with greater ease, leading to deeper financial inclusion and participation of marginalized groups in formal financial systems.

Improved Operational Efficiency

Fintech solutions have improved productivity by facilitating real-time monitoring, automating record-keeping, and simplifying verification. Loan disbursements and credit evaluations are completed more quickly, and payback tracking is now more accurate. By reducing errors and duplication, biometric systems and centralised databases enhance institutional control. Overall,

operational sustainability is strengthened since MFIs are now able to serve more clients efficiently without incurring a corresponding rise in costs.

Enhanced Effectiveness of Service Delivery

Financial services are now more dependable and timely thanks to the advent of digital technologies. Direct account transfers enable speedy loan disbursement, and mobile wallet payback guarantees simplicity and flexibility. Transparency and accountability are increased when Self-Help Group transactions are tracked digitally. These developments improve borrower discipline, lower default rates, and increase the efficiency of microfinance interventions in addressing rural loan demands.

Cost Reduction and Financial Sustainability

Adoption of digital technology drastically lowers expenses by reducing reliance on branch operations, field workers, and paper records. Repayments made without cash further reduce the dangers associated with handling cash. Because of these savings, MFIs are able to reinvest funds in outreach and capacity-building initiatives. Digital technologies improve the long-term profitability and financial sustainability of rural microfinance organisations by reducing operating costs and increasing coverage.

Promoting Transparency and Accountability

Accountable and transparent financial procedures are guaranteed by technology-driven solutions. Clear audit trails are produced by digital records, and biometric verification reduces fraud and duplication. Recipients are made more aware of loan terms and repayment schedules through SMS alerts and notifications. These procedures increase confidence, lessen the possibility of false information, and provide clients with reliable financial data. Transparency eventually boosts borrower confidence and institutional credibility.

Empowerment of Women and Vulnerable Groups

Digital financial solutions give women, who are major recipients of microfinance, more autonomy. Their control over resources is improved by direct account transfers, and financial anonymity is offered via mobile wallets. Digital Self-Help Groups provide access to larger loans and promote group decision-making. With the help of these resources, women may boldly take on leadership roles in the community and pursue business, fostering long-term socioeconomic empowerment for marginalised communities in rural areas.

Risk Mitigation and Security Concerns

Digital technologies enhance borrower risk evaluations while lowering risks associated with manual error, theft, and cash handling. However, recipients are vulnerable to fraud and phishing attempts due to a lack of cyber security understanding in rural areas. Therefore, technology creates digital vulnerabilities while reducing conventional hazards. To protect rural clients, these issues must be addressed with digital literacy training and more robust consumer protection policies.

Building Long-Term Sustainability

By improving scalability, digital technologies allow MFIs to grow their services without incurring additional expenses. Innovation is encouraged by collaborations with government organisations and fintech companies, and effective platforms enhance financial planning and repayment discipline. But sustainability requires integrating technology with efforts to promote

digital literacy and enhance rural infrastructure. A more robust and future-ready rural microfinance ecosystem is produced by inclusive techniques, which guarantee equitable benefits.

Future Implications and Suggestions

The strategic integration of digital technology with inclusive financial literacy initiatives will become more and more important for the viability of rural microfinance. To close the gap between urban and rural areas, it is crucial to fortify rural digital infrastructure and guarantee reasonably priced connectivity. Cyber security measures must be given top priority in future regulations to shield vulnerable groups from online threats. Collaborative efforts among governments, MFIs, and fintech innovators should focus on designing low-cost, user-friendly platforms. Initiatives to increase capacity, especially those aimed at women and under-represented groups, will also strengthen socioeconomic empowerment. A holistic framework that merges technological adoption with human-centric interventions can ensure resilient, transparent, and scalable rural microfinance systems.

CONCLUSION

Digital technology usage has become a driving force behind the expansion of financial inclusion through rural microfinance initiatives. The way microfinance institutions provide services to rural populations has been completely transformed by digital solutions, which allow for more outreach, lower operating costs, increase efficiency, and improve transparency. Technologies like digital wallets, biometric verification, and mobile banking have not only made financial services more accessible but also given women and other marginalised groups more influence, which has aided in socioeconomic progress. But there are certain difficulties with the shift. Cyber security risks, limited digital literacy, and infrastructure limitations all continue to impede inclusive adoption. Strong policy frameworks, reasonably priced digital infrastructure, and capacity-building are still essential for removing these obstacles. Equally important is the need to design simple, secure, and situation-specific solutions that resonate with the realities of rural communities.

The long-term viability of rural microfinance will be guaranteed by a well-rounded strategy that blends technology innovation with community involvement and human-centric development. The industry has the potential to be a potent driver of inclusive growth, bridging financial gaps and making a significant contribution to the larger objectives of rural empowerment and national development, thanks to strategic alliances between MFIs, fintech companies, and government programs.

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