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Financial Technology *for* Rural Transformation

Bridging the Financial Inclusion Divide

Edited By

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Financial Technology for Rural Transformation: Bridging the Financial Inclusion Divide

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PREFACE

In the past few years, financial inclusion has moved from the margins of India's policy debate to its centre. Bank accounts have grown in numbers, digital payments have become routine, and public digital infrastructure has changed the way citizens receive subsidies, save, and borrow. Yet access and usage are not the same thing. In North East India, particularly Assam, geographical constraints, frequent floods, and uneven digital literacy, continue to impede the success of financial inclusion.

"Financial Technology for Rural Transformation: Bridging the Financial Inclusion Divide" presents these issues empirically through twenty-five chapters focusing on the role of financial technology in the promotion of financial inclusion and rural development. The volume examines the adoption and usage of technology among farmers, weavers, artisans, small manufacturers, students, women, and bank customers across the region. It also spotlights the importance of financial literacy, trust, gender, infrastructure, and individual behaviour in determining the successful adoption of financial technology.

The volume is organised into five major themes: conceptual and empirical foundations; digital financial literacy and payment behaviour; FinTech adoption among specific communities and enterprises; regional and sectoral development, including agriculture and agro-based industries; and the emerging role of artificial intelligence in banking and inclusive finance. The contribution consists of primary surveys, secondary data analysis, conceptual discussion, and different research methods. The collection also gives an opportunity for young researchers to contribute their results and views on financial inclusion in the North East Region of India.

The chapters offer different findings and viewpoints. Some research highlights the benefits of financial services, while others discuss the challenges of limited awareness, unequal access, and difficulties in technology adoption. In nutshell, they comment that the success of financial inclusion greatly depends on proper infrastructure, awareness, and public trust.

We hope this volume will be useful to researchers, academicians, policymakers, bankers and others interested in financial inclusion, financial technology, and rural development. We sincerely thank all contributing authors for their valuable contributions and patience, the reviewers for their constructive comments, and Research Collab for making the ideas into publication.

Nagaon, Assam

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Dr. Rita Marak
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FOREWORD

The rapid advancement of Financial Technology (FinTech) has brought significant changes to the financial sector. Digital payments, mobile banking, online lending, and technology-enabled financial services are transforming the ways in which individuals and businesses access and use financial resources. In this changing environment, FinTech has emerged as an important instrument for promoting financial inclusion, strengthening rural entrepreneurship, and supporting sustainable economic development. The edited volume "*Financial Technology for Rural Transformation: Bridging the Financial Inclusion Divide"* addresses this important and contemporary subject with particular relevance to Assam and the North Eastern Region of India.

Financial inclusion is vital for equitable growth and economic development. Although FinTech offers affordable and accessible financial services, rural communities still face challenges such as inadequate banking facilities, limited digital infrastructure, low financial literacy, and restricted access to institutional credit. Appropriate technological solutions, supported by awareness and adequate safeguards, can help bridge these gaps.

This is particularly relevant to Assam and the North Eastern Region, where agriculture, rural livelihoods, and micro-enterprises play important economic roles. Digital payments, mobile banking, digital lending, and technology-enabled insurance can empower farmers, women entrepreneurs, artisans and small businesses. However, cybersecurity, digital fraud, data privacy, and the digital divide require careful attention.

The present volume explores key themes, including digital financial inclusion, rural entrepreneurship, agricultural finance, women's empowerment, financial literacy, artificial intelligence, and insurance inclusion. Its interdisciplinary approach and regional focus can enhance understanding of rural challenges and promote practical solutions.

I believe this volume will be a valuable resource for students, researchers, academicians, policymakers and development practitioners. It can encourage further research and informed policies to strengthen financial inclusion and rural development. Ultimately, FinTech must go beyond technological advancement to empower people, reduce inequalities, and improve rural livelihoods.

I congratulate the editors, **Shujan Ghosh**, **Dr. Rita Marak** and **Dr. Dipankar Baidya**, of the Department of Commerce, Nagaon University, on this meaningful academic initiative. I also appreciate the contributors for exploring the opportunities and challenges of financial technology and rural transformation. I hope this volume will inspire further research and contribute to building an inclusive, resilient and sustainable rural economy.

I wish the editors and the volume every success.

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First and foremost, we extend our sincere thanks to all contributing authors for their rigorous scholarship, willingness to engage with reviewer's comments, and patience through successive rounds of revision have given this book its depth and diversity of perspective. Each chapter reflects the care and expertise its author brought to the task and we are deeply grateful for their trust in this project.

We appreciate the anonymous reviewers for their constructive comments and suggestions, which greatly enhanced the quality of the volume. The time they gave to this work, often without recognition, remains one of the quite foundations of scholarly publishing.

We gratefully acknowledge the Faculty of Commerce and Management, Nagaon University, for providing an intellectually supportive environment for smooth carrying out the project.

We also express heartfelt appreciation to the editorial and production team at Research Collab for their professionalism, guidance, and faith in this project, from the initial proposal through to publication.

Nagaon, Assam
October 2026

Shujan Ghosh
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DISCLAIMER

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--Chapter--

Financial Inclusion and Rural Development: A Conceptual Understanding

Tulika Borah[1]

ABSTRACT

Financial inclusion and rural development are two interrelated processes that contribute to the country's socio-economic development, especially in remote areas such as India's Northeast. This chapter provides an overview of financial inclusion and rural development, including their main components and dimensions. Rural development, in turn, is a complex process that includes economic, social, human, institutional, infrastructural, livelihood, and sustainability dimensions. The chapter also explains how financial inclusion promotes rural development by improving farm and non-farm household income, enhancing the level of living, enabling access to credit, developing agriculture, promoting rural entrepreneurship and employment, reducing poverty, empowering women, building financial resilience, and adopting digital financial services. Furthermore, the chapter describes the opportunities for and challenges to financial inclusion and rural development in India's Northeast. The chapter highlights the government's pro-poor financial inclusion programs and policies that promote financial inclusion, such as the Prime Minister's Development Initiative for North East (PM-DevINE), the North East Sustainable Livelihoods Development and Institutional Strengthening Project (NESIDS), and the Pradhan Mantri Gram Sadak Yojana.

Keywords: Financial inclusion, Rural development, Development Scheme, Northeast India, Conceptual understanding

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INTRODUCTION

Even today, many people in rural India, especially in the Northeast, don't have proper access to banking and financial services. The reasons can be low financial literacy, lack of physical infrastructure, gender inequality, and limited access to smartphones *(Kuberjee,2025)*. Financial inclusion is the effort that makes financial services accessible to everyone. Financial inclusion is not limited to opening a bank account; it includes savings, credit, insurance, digital services, government initiatives, and many more. Rural development means improving the lives of rural people by giving them opportunities that they don't have currently. Rural development does not mean only earning a high income; it also covers

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health, quality of life, education, and opportunities that urban people have. Financial inclusion and rural development are interconnected with each other, as financial inclusion helps to develop rural areas. For example: Financial inclusion provides credit facility which help farmers buy agricultural products at low interest rates, and it helps them to earn more.

When people have knowledge about financial services and access to them, they develop eventually. In India, most of the population belongs to rural areas where they do not have access to these services, so it's very important to give them access to these services.

This chapter discusses the concept of financial inclusion and rural development, the indicators of financial inclusion, government initiatives towards rural development, specifically towards northeast and lastly the challenges faced by the Northeast. The Northeastern region has been given special focus in this chapter because of its distinct geographical challenges such as hilly terrain, remoteness, and flood-prone areas, which make access to financial services more difficult compared to other parts of the country, and therefore require region-specific solutions.

FINANCIAL INCLUSION

Financial inclusion refers to the accessibility of different financial services such as savings accounts, insurance, loans, or credit to every section of society at an affordable price. It aims to bridge the gap between rural people and financial services. Financial inclusion is the promise that every person, regardless of location, gender, or income, can access and meaningfully use affordable financial services *(Ghosh, 2025)*. In India, Financial inclusion has moved from policy rhetoric to measurable progress over the past decade. Account ownership, digital payments, and targeted welfare transfers have helped bring millions into the formal financial system, fundamentally reshaping how citizens receive subsidies, save, borrow, and transact. According to the World Bank's Global Findex, account ownership in India rose from roughly 35% in 2011 to nearly 78% in 2021 - a dramatic increase that reflects years of coordinated public policy and private sector innovation *(Dubey, 2025)*.

The formal definition of financial inclusion is given by *Rangarajan Committee (2008)* as "Financial inclusion may be defined as the process of ensuring access to financial services and timely and adequate credit where needed by vulnerable groups such as weaker sections and low-income groups at an affordable cost" *(Jitendra Asati IES, 2009)*.

1. Dimensions of Financial Inclusion

Financial inclusion is a multidimensional concept, and its effectiveness can be assessed along the following key dimensions *(Kandpal,2024)*:

- **Access:** Access means the availability of financial services to everyone. Ensuring that financial services such as banking, insurance, and credit are available to everyone. This involves the establishment of physical banking outlets in underserved areas and the provision of digital financial services *(Drishtiias,2025)*.
- **Availability:** The financial services need to be available for different segments of customers. They can't differentiate among customers by their financial condition.
- **Affordability:** These financial services need to be affordable for everyone so they can use them. If the cost of financial services or products is high, then every section of society cannot afford that facility; therefore, these services or products must be affordable for the development of society.
- **Usage:** Beyond access, it's crucial that individuals actively use financial services to achieve financial stability and growth. This includes engaging with banking services, utilizing credit responsibly, and taking advantage of insurance products (*Dristiias*, 2025).

2. Major Financial Services under Financial Inclusion

Financial inclusion encompasses a range of financial services which are essential for rural development. These services are designed to meet the needs of individuals, particularly from low-income groups, and rural backgrounds. It includes savings, credit, insurance, and pensions etc.

a. **Savings:** Saving is the basic facility provided by the bank. It allows individuals to safely store their money and earn interest. People or customers can save their money in the banks by opening an account in the bank and earn interest on their money. The account can be of different types, such as
   - ❖ Savings account: A savings account is one of the most common types of bank accounts; it is primarily used for saving money. The interest rate on this account is low, but you can easily withdraw cash from this account.
   - ❖ Current account: A current account is used by businesses for unlimited transactions. This account typically does not earn interest *(Geek for Geeks, 2025).*
   - ❖ Recurring deposit account: A recurring deposit account is an account where you can save money for a specific period of time by depositing a fixed amount of rupees every basis. In this account, the interest rate is higher than a savings account but lower than fixed deposit accounts.
   - ❖ Fixed deposit account: A fixed deposit account is a popular investment instrument that allows customers to fix their money for a specific period at a high interest rate.

b. **Credit:** Credit is the facility that helps people borrow money from a financial institution at an interest rate. There are two parties involved in this transaction: one is the lender banks, or other and another party is borrower, the customer of the bank. Some benefits of credit facilities are as follows:
   - ❖ It helps customers get money from a bank at a low interest rate.
   - ❖ It promotes entrepreneurship and self-employment.
   - ❖ It helps to reduce dependence on informal moneylenders.

c. **Insurance:** Insurance is a financial protection against potential losses in exchange for a premium. People can buy insurance from different insurance companies to protect against any financial loss. People can insure different things such as their or their family members' health, life, vehicles, business, etc. There are typically three parties involved in an insurance policy
   - ❖ Insurer: The insurance company that provides an insurance policy or pays when insurance is claimed.
   - ❖ Insured: The person or entity whose risk is covered by the insurance policy.
   - ❖ Policyholder: The person who owns the policy and pays the premium. Sometimes the insured and policyholder are the same person.

   We can classify insurance into two broad categories, viz. general insurance and life insurance. Of which, general insurance can be categorised into different types such as Health Insurance, Motor Insurance, Travel Insurance, Home Insurance, Fire Insurance, Marine Insurance, Commercial Insurance, etc.

d. **Pension:** A pension plan is a retirement savings benefit offered by employers to their employees. Employers make regular contributions to a pool of money set aside to fund payments to eligible employees after they retire *(Peter Gratton, 2025)*. Some benefits of a pension are as follows:
   - ❖ It helps earn money in their old age
   - ❖ It helps to reduce dependency on others.
   - ❖ It encourages a saving habit.

e. **Payments and remittances:** A payment service encompasses a broad range of financial services that facilitate the transfer of funds between parties within the same country or internationally. A remittance service is a specialized type of payment service focused on the cross-border transfer of funds from one individual to another, typically to family members or friends in another country. The purpose of remittance services is primarily to send money internationally, usually from migrant

workers to their home countries. The amounts tend to be smaller and are sent with the primary purpose of personal financial support *(Rashid, 2024)*.

f. Digital financial services: Digital financial services are a technology which help customers use financial services online through their mobile. It helps to reach remote areas where physical bank branches are limited. Nowadays. these services are widely used because of their convenience and ease of use. Some digital financial services are given below:

- ❖ Mobile banking: It helps customers transfer their money, pay bills, check balance through online without going to the bank.
- ❖ UPI (Unified Payments Interface): It helps to use banking facilities through mobile apps like Google Pay, Paytm, etc.
- ❖ PoS Terminals: These are the machines used by supermarkets or petrol pumps to swipe cards.
- ❖ E-wallet: It is an app where we can store our money and then make payments.

RURAL DEVELOPMENT

Rural development is the process of improving the quality of life and economic well-being of people living in rural areas, often relatively isolated and sparsely populated areas. Often, rural regions have experienced rural poverty, poverty greater than urban or suburban economic regions due to lack of access to economic activities, and lack of investments in key infrastructure such as education *(Moseley, Malcom J, 2003)*. Rural development is not a one-time achievement; it is a continuous process. It takes time and continuous improvement. Its main aimis to bridge the gap between rural and urban life.

Unlike growth, which focuses on increasing income, rural development is a much bigger concept. Rural development not only focuses on increasing income but also improving quality of life, basic, necessities, and access to different opportunities, just like in urban areas.

1. Dimensions of Rural Development

Rural Development is a very vast topic which includes different dimensions of a society. And development is possible when all the dimensions are developed properly.

- ❖ **Economic development:** Economic development is one of the important dimensions of society. It is associated with income generation, agricultural development, and employment opportunities in rural areas. The main focus here is to develop the financial position of people living in rural areas. It includes
- ❖ **Social factors:** The social dimension refers to the quality of life of the people who live in rural areas. The main focus of this dimension is improving the quality of life of the people lives in rural areas. This includes whether they have access to education, healthcare facility, toilets, safe drinking water, waste management, etc.
- ❖ **Human aspects:** This dimension means how we can develop human capital. We can develop human capital through training, learning skills, and literacy programs.
- ❖ **Livelihood:** The livelihood dimension focuses on diversifying and strengthening the sources of income, and moving beyond agriculture because agriculture is based on weather conditions. This dimension promotes alternative livelihood options such as animal husbandry (dairy, poultry, livestock rearing), fishery, handicrafts, bamboo cultivation (specifically for the Northeast), handloom weaving, etc.
- ❖ **Sustainable Development:** The sustainable development dimension ensures that the process of rural development does not come at the cost of environmental degradation or depletion of natural resources because these resources are also for future generations. This involves promoting environmentally responsible practices such as organic and eco-friendly farming methods, efficient water and irrigation management, forest conservation, and proper waste management systems in rural areas.

2. Financial Inclusion as a Driver of Rural Development

Financial inclusion acts as a driver of rural development, meaning it helps rural areas to move forward. This section examines the various ways in which financial inclusion contributes to rural development, including household savings, access to credit, agricultural development, entrepreneurship, and women empowerment, etc. They are

- **Financial Inclusion and Household Savings:** Financial inclusion encourages households to save more and save in bank accounts, not in their homes. According to the World Bank Global Findex (2021), around 78% of Indian adults now have a bank account compared to 53% in 2014 *(Scribed, 2025)*. In banks, they get interest on their money without doing anything. Other than banks, there are many ways to save money, like mutual funds, pensions, and government initiatives like Pradhan Mantri Jan Dhan Yojana (PMJDY).
- **Financial Inclusion and Access to credit:** Credit plays an important role in rural development. With the help of credit, people can buy or enjoy different things like attending university, buying assets, opening a business, doing agriculture, etc. Government also helps; they introduce different schemes for lower-income groups so they can also get credit and improve their lifestyle. Government-backed credit schemes, such as the Kisan Credit Card (KCC) for farmers and the Pradhan Mantri Mudra Yojana (PMMY) for micro-entrepreneurs, have played a significant role in expanding formal credit access in rural India.
- **Financial Inclusion and Agricultural Development:** Agriculture is the pillar industry of most rural regions, and the Northeastern region is no exception. Therefore, financial inclusion is critical to the development of this sector. Through financial access, farmers are able to purchase farm produce, equipment, fertilizers, and pesticides to increase productivity. Access to credit in the form of crop loans, for example, is advantageous to farmers because it helps them purchase production materials with ease and at lower interest rates. Additionally, agricultural credit schemes such as the Kisan Credit Card facilitate agricultural production and minimize the adverse impact of crop failure and prevent default.

  Agricultural insurance schemes such as the Pradhan Mantri Fasal Bima Yojana provide financial compensation to farmers who experience loss due to insect infestation, flood, and other environmental hazards. Flooding, for instance, has been a persistent environmental hazard in the Assam region, affecting agricultural production significantly. On the other hand, Agri-FinTech products provide farmers with access to market information, weather forecasts, and online trading platforms to aid in selling their produce profitably. Farmers are also able to use credit and insurance products to invest in irrigation systems, storage, and processing facilities, among other related activities, thereby increasing their profit margins and marketability.
- **Financial Inclusion and Rural Entrepreneurship:** Financial inclusion plays an important role in promoting entrepreneurship in rural areas by providing credit and financial services to start or expand small businesses. In the absence of financial assistance, low-income groups in rural areas do not have the courage to start a business. Because local moneylenders charge high interest rates.

  The government also provides some schemes to encourage rural entrepreneurship. In the Northeast, this has particular relevance given the region's rich base of traditional skills and local resources — such as bamboo craft, handloom weaving, and organic farming — which can be transformed into viable business ventures with adequate financial backing.
- **Financial Inclusion and Employment Generation:** Financial inclusion makes a crucial contribution to employment generation in rural areas. It provides direct and indirect opportunities for employment generation.

Direct employment is when individuals use credit to start a business, which leads to hiring more workers to operate. Indirect employment is created by the impact that a new job can have on further economic activity; for example, successful rural businesses generate demand for the goods and services of local suppliers and so on.

- **Financial Inclusion and Poverty Reduction:** Poverty reduction is one of the significant results of financial inclusion. Financial inclusion has given access to formal financial services like savings, credit, mutual funds and investment. Without financial services, they save money at homes, which does not earn any interest and can be lost or stolen, and if they want to borrow, then they need to depend on local moneylenders, which charge high interest.

  Similarly, access to affordable credit enables poor households to invest in income-generating business, or buy agriculture products, which helps them overcome poverty.
- **Financial Inclusion and Women's Empowerment:** Financial inclusion plays an important role in empowering rural women economically and socially through mechanisms like Self Help Group (SHG). Earlier, women in rural areas had limited access to financial services and often depended on males in the family.
- **Financial Inclusion and Financial Resilience**: Digital Financial Inclusion and Rural Transformation: Fintech can change the game by delivering accessible, affordable, and user-friendly financial services directly to rural doorsteps. Digital tools like mobile banking, biometric verification, and Aadhaar-enabled payments have the power to reach even the most remote corners.

GOVERNMENT INITIATIVES TOWARDS RURAL DEVELOPMENT FOR NORTH-EAST REGION

North East Region consists of eight states, and they are: Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura. North-East India is the gateway to South-East Asia *(Tasung,2024)*. Nevertheless, this region's development is weak due to its geographical location, political reasons, and climate. However, the government of India has taken some initiatives for the development of this region. They are:

1. **Ministry of Development of North Eastern Region (MDoNER):** The Ministry of Development of North Eastern Region (MDoNER) is also providing financial assistance to the eight North Eastern States to take up developmental projects, linked to infrastructure development, connectivity, communication, etc. Under the five Central Sector Schemes of NESIDS (Roads), NESIDS (OTRI), PM-DevINE, Schemes of North Eastern Council (NEC) and Special Development Packages (SDPs) *(Ministry of Development of North-East Region, 2025).*
2. **The Ministry of Road Transport and Highways (MoRT&H):** The Ministry of Road Transport and Highways, which is primarily responsible for the development and maintenance of National Highways, has constructed 16,207 Km of National Highways in the NER. As on 01.04.2025, 12 railway projects (08 New Line and 04 Doubling) of total length of 777 Km costing Rs. 69,342 crores falling partly/fully in NER have been sanctioned by the Ministry of Railways, out of which 278 km have been commissioned and an expenditure of Rs. 41,676 crores has been incurred up to March 2025 *(Ministry of Development of North-East Region, 2025).*
3. **Pradhan Mantri Gram Sadak Yojana:** Under the Pradhan Mantri Gram Sadak Yojana, 17,637 road works of 89,436 Km and 2398 bridges have been sanctioned in NER, out of which 16,469 road works of 80,933 Km and 2108 bridges have been completed. For providing high-bandwidth capacity internet/broadband connectivity and mobile services to remote and rural villages in the NER, a number of steps and projects have been taken up with funding from the Digital Bharat Nidhi (DBN) *(Ministry of Development of North-East Region, 2025).*

4. **Ude Desh ka Aam Nagrik (UDAN):** The Ministry of Civil Aviation had launched the Regional Connectivity Scheme – Ude Desh ka Aam Nagrik (UDAN) scheme to enhance regional air connectivity from unserved and underserved airports in the country and make travel affordable to the masses. A total of 90 routes have been operationalized in the NER under the Regional Connectivity Scheme (RCS), connecting 12 airports and heliports across the NE states *(Ministry of Development of North-East Region, 2025).*
5. **Prime Minister's Development Initiative for North East Region (PM-DevINE):** The Prime Minister's Development Initiative for North East Region (PM-DevINE) was announced as a new Central Sector Scheme, with 100% Central funding, in the Union Budget 2022-23 and approved by the Union Cabinet on 12th October, 2022, with a total outlay of Rs.6,600 crore for 4 years period from 2022-23 to 2025-26. The objectives of the PM-DevINE Scheme are to fund infrastructure projects convergently, in the spirit of PM GatiShakti, support social development projects based on the felt needs of the NER, enable livelihood activities for youth and women, and to fill the development gaps in various sectors *(Ministry of Development of North-East Region, 2025)*.
6. **North East Special Infrastructure Development Scheme" (NESIDS):** North East Special Infrastructure Development Scheme" (NESIDS) has been approved by the Government of India as a new Central Sector Scheme on 15.12.2017. Under the Scheme guidelines of NESIDS, 100% central funding is provided to the State Governments of the North Eastern Region for the projects of physical infrastructure relating to water supply, power and connectivity enhancing tourism and social infrastructure relating to primary and secondary sectors of education and health. NESIDS (Roads) – to be administered by the North Eastern Council (NEC) *(NESRIP | Public Works (Roads) | Government of Assam, India, 2026)*.
7. **Mission Organic Value Chain Development for North Eastern Region (MOVCDNER)**: The Mission Organic Value Chain Development for North Eastern Region (MOVCDNER) is the Government of India's 100% central sector scheme for consolidating organic farming across the eight North-Eastern states — Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura. Launched in 2015-16 by the Department of Agriculture & Farmers Welfare (DA&FW), MOVCDNER funds the full organic value chain end-to-end — pre-production, production, post-production and brand-building — anchored on Farmer Producer Companies (FPCs) at the cluster level with NPOP / APEDA third-party certification. It is the NE-specific complement to PKVY (all-India PGS-India clusters) and NMNF (natural farming standalone scheme since 25 November 2024), designed to convert the region's natural advantage in low-chemical agriculture into a premium-priced, export-ready organic value chain *(AgriBot, 2026)*.
8. **Mukhyamantri Mahila Udyamita Abhiyan**: The Government of Assam will provide Seed Capital of Rs. 10,000/- in the first year to set up a business and Rs. 25,000/- in the next 2 years as subsidized loans, of which Rs. 12,500/- is a nonrefundable government subsidy and Rs. 12,500/- is a bank loan that is refundable and financial assistance of Rs. 50,000/- in 3rd year under its Mukhyamantri Mahila Udyamita Abhiyan to woman members of Self-Help Groups. Read here the complete details of the scheme *(Tabassum, 2026)*.

CHALLENGES FACED BY THE NORTH EAST

North-East India, also called 'Seven Sisters' along with Sikkim. This region is underdeveloped in comparison with the mainland of India. This region faced different challenges, few of them are listed below:

1. **Unemployment:** Unemployment, particularly among the youth, represents another significant challenge facing Northeast India. Despite being home to several universities and educational institutions, the region struggles to provide adequate employment opportunities for its educated

youth. This mismatch between education and employment creates frustration and leads to a phenomenon known as educated unemployment *(PolSci Institute,2025)*.

2. **Access to essential services:** Despite progress in various sectors, access to essential services remains uneven across Northeast India. Healthcare services are often concentrated in urban areas, leaving rural populations to travel long distances for medical treatment. Many specialized medical services are unavailable locally, forcing people to seek treatment in other states, which is both expensive and inconvenient *(BANotes.Org, 2023).*
3. **Lack of industry:** If agriculture is large but low-yielding, industry is the opposite: small and stunted despite real potential. The region holds significant natural resources and a strategic location bordering Southeast Asia, yet it remains industrially backward, creating various socio-economic problems. Manufacturing contributes far less to output than it does nationally *(PolSci Institute,2025)*.
4. **Infrastructure:** Perhaps no challenge is more fundamental to Northeast India's economic struggles than its infrastructure deficit. The region's mountainous terrain and strategic location near international borders have made infrastructure development both costly and complex. However, without adequate infrastructure, other economic activities remain severely constrained *(PolSci Institute,2025)*.
5. **Outmigration phenomenon:** One of the most visible signs of Northeast India's economic challenges is the large-scale outmigration of its population, particularly young people, to other parts of India. Cities like Delhi, Mumbai, Bangalore, and Pune have significant populations of people from Northeast India working in various sectors-from hospitality and beauty services to technology and healthcare *(BANotes.Org, 2023)*.
6. **The human cost of migration:** Migration comes with significant personal and social costs. Young people often face cultural shock, discrimination, and homesickness when they move to other parts of India. Despite constitutional protections, people from Northeast India sometimes face racial discrimination and stereotyping in metropolitan cities. This experience can be traumatic and affects their mental health and overall well-being *(BANotes.Org, 2023)*.

CONCLUSION

Financial inclusion and rural development are dependent on each other. Financial inclusion has helped rural areas develop through savings, credit, insurance, and digital financial services. Financial inclusion in rural India remains a complex challenge, but the government has also taken some steps to support rural development. Various schemes like Pradhan Mantri Gram Sadak Yojana, Ude Desh ka Aam Nagrik (UDAN), North East Special Infrastructure Development Scheme (NESIDS), Mukhyamantri Mahila Udyamita Abhiyan, etc. provided by the government to help rural people. However, challenges like unemployment, migration, and infrastructure remain, especially in the Northeast.

Despite the efforts being made, there are still certain areas in rural areas, especially in the Northeast region, that do not have access to the financial and infrastructural facilities required. It is crucial to focus on overcoming the difficulties posed by the geographical location of rural areas in the future. Efforts such as developing digital infrastructure, financial literacy, and methods like self-help groups and community-based development will help in promoting financial inclusion. The focus on overcoming the problems of rural areas and the use of technological advancements will enable the northeast region to move towards financial inclusion, thus bringing about an inclusive rural society.

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Financial Technology for Rural Transformation: Bridging the Financial Inclusion Divide

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--Chapter--

Beyond Access: Digital Financial Inclusion and the Outcomes Gap in India

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ABSTRACT

Digitalisation is reshaping access to financial services in India. Government initiatives such as the Pradhan Mantri Jan-Dhan Yojana (PMJDY) have expanded access to formal bank accounts, while the Unified Payments Interface (UPI) has made digital payments more accessible. At the same time, increasing smartphone and internet use has created new opportunities for participation in the formal financial system. However, greater access to financial services does not necessarily result in their effective use. This article examines the development of digital financial inclusion in India and considers whether increased access and digital financial usage are translating into meaningful financial benefits. Drawing on existing studies and secondary information from official sources, the article examines the expansion of financial and digital services, patterns of digital financial usage and the constraints affecting participation. Particular attention is given to financial and digital literacy, trust, cybersecurity, gender and rural–urban differences. The analysis indicates that while access to formal financial services has expanded considerably, gaps remain between account ownership and active usage and between digital payment participation and broader financial well-being. Existing evidence also suggests that digital financial participation may influence consumption and financial well-being, although evidence of sustained improvements in household savings and financial resilience remains limited. The article argues that the next phase of financial inclusion should focus not only on expanding access but also on ensuring effective, equitable and informed usage through stronger financial education, consumer protection and inclusive digital infrastructure.

Keywords: Digital Financial Inclusion; Financial Inclusion; UPI; PMJDY; Financial Education; Financial Well-being

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INTRODUCTION

Financial inclusion has become a central piece of India's development story. In the early stages, the focus was mostly on pulling underserved populations into the formal banking system, expanding bank branches and offering basic financial services. But the spread of mobile phones, internet access and

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digital payment systems has changed what this actually means in recent years. Financial inclusion today isn't just about whether someone has a bank account. It's also about whether they can actually access and use financial services through digital channels as part of their everyday life.

The Pradhan Mantri Jan-Dhan Yojana (PMJDY), launched in 2014, was a major push to widen access to formal banking *(Government of India, Department of Financial Services, 2014)*. It aimed to give households basic banking facilities and link them to savings accounts, credit, insurance, pensions and government transfers. Linking bank accounts to Aadhaar and mobile services also laid much of the groundwork for India's digital financial system. The rise of the Unified Payments Interface (UPI) pushed this even further, reshaping how people and businesses send and receive money. Meanwhile, growing smartphone and internet access has brought digital finance within reach of far more people than before.

The scale of this expansion is evident from the available data: PMJDY accounts grew from 14.72 crore in March 2015 to 51.95 crore in March 2024 *(Government of India, Department of Financial Services, 2024)*. The Reserve Bank of India's Financial Inclusion Index also climbed from 64.2 in March 2024 to 67.0 in March 2025, pointing to gains in access, usage and quality *(Reserve Bank of India, 2025b)*. These figures show that formal financial services have spread widely. But access alone doesn't mean people are actually using these services regularly, or that they're financially better off as a result. Someone can have a bank account, a smartphone and UPI access, and still lack the knowledge, confidence or resources to put any of it to real use.

That's really the crux of why the distinction between access and actual use matters. The number of accounts opened or digital transactions made tells us how far financial services have reached. But it doesn't provide a full picture. How much people actually use these services depends on income, education, gender, location, financial and digital literacy, connectivity, and trust. There's still fairly limited evidence on whether India's rapid digital finance expansion has translated into lasting gains in household savings, financial resilience or overall financial well-being.

This article examines India's digital financial inclusion landscape, focusing on the gap between access, actual usage and meaningful financial outcomes. Drawing on existing research and secondary evidence, it looks at the growth of financial infrastructure, digital payments and connectivity, along with the factors shaping how people participate. It also considers the challenges and policy responses involved in turning wide digital access into financial inclusion that's genuinely meaningful and lasting.

REVIEW OF LITERATURE

Research on financial inclusion in India has increasingly moved past the simple question of whether people have access to formal financial services. More recent work also asks how these services are actually used and whether they make any real difference to households. Earlier studies focused more heavily on banking infrastructure and account ownership, particularly in rural areas. *Chavan and Kamra (2022)* find that access to formal banking in rural India has expanded considerably, but the use of accounts for withdrawals and payments, formal credit and digital financial services remain uneven. *Venumuddala (2020)* similarly finds that financial inclusion varies with household income, assets, occupation and geographical characteristics. Taken together, these studies suggest that simply having financial institutions and bank accounts available doesn't mean people are actually making effective use of them.

A similar issue appears in the broader literature on rural financial inclusion. *Keshari and Tiwari (2026)*, reviewing 107 studies, find that research has focused more on access than on actual usage, service quality and FinTech adoption. Their review points to education, financial literacy, gender, digital infrastructure, mobile connectivity and trust as the key factors shaping financial inclusion. *Mahesh et al. (2023)* look at a range of initiatives such as PMJDY, UPI, Aadhaar-enabled payment systems, Direct

Benefit Transfer, e-KYC, digital banking and the SHG-Bank Linkage Programme and find that digital financial services can help extend formal finance to rural and marginalised groups, supporting women's participation and rural entrepreneurship along the way. Their study, however, doesn't establish whether this wider access has actually brought improvements in household savings, consumption or financial well-being.

As digital finance has grown, researchers have also started digging into why people choose to use, or not use, these services. *Jena (2025)*, drawing on the Technology Acceptance Model, Theory of Planned Behavior and Technology Readiness Index, finds that attitudes, perceived ease of use, perceived behavioural control and perceptions of insecurity all shape FinTech adoption. *Asif et al. (2023)* find something similar for rural populations, where trust and usability matter a great deal. Trust shows a strong relationship with financial inclusion. The point is fairly straightforward: giving people the technology doesn't mean they'll use it. How safe, convenient and understandable the service feels can matter just as much.

Subhashini et al. (2026) identify financial and digital illiteracy, lack of trust, fear of fraud, risk aversion and gender-related exclusion as the main demand-side barriers. On the supply side, inadequate telecommunications infrastructure, cybersecurity concerns, regulatory limitations and the cost of digital financial services continue to pose problems. *Patel et al. (2023)* also find differences in mobile-payment adoption between rural and semi-urban areas, with education and internet connectivity shaping adoption. All this evidence suggests that digital infrastructure can open up opportunities for participation, but the mere availability of technology doesn't guarantee people can actually use it effectively.

The growth of UPI adds another layer to this discussion. *Cornelli et al. (2024)* link UPI's rapid adoption to factors like interoperability, ease of use, low transaction costs, an open technological architecture and supportive regulation. UPI has widened the scope for participation in formal financial services, though technical problems, connectivity constraints, security concerns and limited consumer awareness can still get in the way. *Sharma (2025)* looks at UPI's growth and its relevance for MSMEs, while *Arya and Gupta (2026)* link UPI's expansion to improvements in financial inclusion. Much of this work, though, tends to focus on transaction growth and broader financial indicators rather than what these changes actually mean for individual households.

Studies on PMJDY offer further evidence of the gap between access and actual participation. *Singh and Deep (2025)* look at the efficiency of banks implementing PMJDY and find that public sector banks perform better than private sector banks on this front. Using household-level evidence from Gubbi Taluk in Karnataka, *Singh and Naik (2018)* find that PMJDY expanded formal banking access, especially among women, small and marginal farmers and people with limited education. A considerable share of respondents did not actively operate their accounts, and awareness and use of RuPay cards remained limited. *Haque et al. (2025)*, drawing on evidence from rural Aligarh, find that age, gender, education, occupation and income all influence UPI usage. What stands out in their study is that PMJDY account ownership wasn't a statistically significant predictor of UPI usage. This suggests that simply opening a formal bank account doesn't, on its own, lead to participation in digital finance.

Financial literacy comes up more often in studies that look at what financial inclusion actually means for people's financial lives. *Kamble et al. (2024)*, using data from 45,540 adults across 21 Indian states, find positive and statistically significant relationships between financial inclusion, digital financial literacy and financial well-being. Interestingly, their findings also show that despite widespread account ownership, far fewer respondents reported regular saving, formal borrowing or using mobile phones for financial transactions. This highlights the gap between owning an account and actually making meaningful use of it. *Tulcanaza-Prieto et al. (2025)*, working with evidence from Ecuador, find similar positive relationships between financial literacy, financial inclusion and financial

well-being. Their study sits outside India, but it still adds weight to the argument that financial capability needs to be factored in when assessing the real benefits of financial inclusion.

Only a small slice of the literature looks directly at economic outcomes. *Agarwal et al. (2024)*, using transaction-level data covering more than 9,00,000 consumers, find that greater digital-payment adoption following demonetisation was associated with higher consumer spending. A one-percentage-point increase in the share of spending conducted digitally was linked to roughly a 0.81% increase in total spending. This is a useful shift in the discussion, moving away from account numbers and transaction volumes and toward actual household behaviour. That said, the study mainly looks at consumption and doesn't address longer-term outcomes like savings, financial resilience or financial well-being.

Taken as a whole, the existing literature gives fairly strong evidence that PMJDY, UPI and other digital financial services have widened access to formal finance in India, and that usage itself is shaped by financial and digital literacy, income, education, gender, trust, security and connectivity. What's less clear is what happens after people gain access and start using these services. Research on outcomes, particularly consumption and financial well-being does exist, but it's still fairly limited compared to the literature on access and adoption. Very few studies actually follow the whole chain from digital access to actual usage and then on to household-level financial outcomes. Much of the available evidence still leans on account numbers, transaction volumes or aggregate measures of financial inclusion. What remains unanswered is whether India's massive expansion of digital financial access has actually translated into lasting financial gains for households.

INDIA'S DIGITAL FINANCIAL INCLUSION LANDSCAPE

India's financial inclusion process has changed a great deal over time. Initially, the focus was on expanding physical banking facilities and bringing underserved households into the formal banking system. But with the spread of digital payments, mobile phones and internet services, the scope of financial inclusion has widened considerably. It now covers not just access to a bank account but also whether people can actually use financial services through digital channels. The National Strategy for Financial Inclusion (NSFI) 2019–2024 reflects this broader thinking, paying attention to usage, financial literacy, customer protection and digital connectivity. Even so, poor connectivity, inadequate infrastructure, socio-cultural barriers and low account usage continue to get in the way.

The Pradhan Mantri Jan-Dhan Yojana (PMJDY), launched in 2014, was a major step toward expanding formal banking access. The programme aimed to give households basic banking facilities and connect them to savings accounts, credit, insurance, pensions and government transfers. Linking bank accounts to Aadhaar and mobile services also helped build the foundation of India's digital financial system. Since its launch, PMJDY's reach has grown substantially. The number of accounts rose from 14.72 crore in March 2015 to 51.95 crore in March 2024. RuPay cards issued to beneficiaries climbed from 13.15 crore to 35.35 crore, while deposits in PMJDY accounts increased from ₹14,641 crore to ₹2,32,502 crore. Average deposits per account also rose from about ₹996 to ₹4,475 *(Government of India, Department of Financial Services, 2024)*. These numbers show just how much formal banking access has expanded, but they do not tell us how often these accounts are actually being used.

Household-level research gives a clearer sense of this issue. *Singh and Naik (2018),* studying Gubbi Taluk in Karnataka, found that a sizeable share of PMJDY account holders didn't actively operate their accounts. Around one-quarter of farmers and about one-third of non-farmers fell into this category, and even those who did use their accounts tended to transact fairly infrequently. Business Correspondents and Business Facilitators helped cut down the distance and cost involved in reaching

banking services. This points to something worth noting: even as digital finance expands, some form of local, human assistance still matters, especially for people less familiar with formal banking.

Physical banking infrastructure remains relevant for the same reason. RBI data for December 2025 show 1,70,189 banking outlets staffed by banks' own personnel, alongside 11,75,250 fixed-point Business Correspondent outlets *(Reserve Bank of India, 2025c)*. These networks offer services like cash-in and cash-out facilities and can help people who find digital services difficult to navigate. The same data show about 7,304 lakh Basic Savings Bank Deposit Accounts, of which around 4,024 lakh belonged to women, holding a total of ₹3,45,477 crore, including ₹2,06,095 crore in women's accounts *(Reserve Bank of India, 2025c)*. Women's participation in formal savings has clearly grown, though holding a deposit account doesn't necessarily mean women have equal access to, or use of, other financial services, particularly formal credit.

Digital connectivity is another major piece of this picture. The Comprehensive Modular Survey: Telecom 2025 found that about 85.5 percent of Indian households had at least one smartphone, and 86.3 percent had internet access at home. Among people aged 15–29, mobile-phone usage stood at roughly 97.1 percent and internet use at around 94.3 percent *(National Statistical Office, 2025)*. These numbers point to widespread connectivity, especially among younger people, though gaps remain. Smartphone ownership among mobile-phone users aged 15 and above was lower for women than men in both rural and urban areas *(National Statistical Office, 2025)*. And having a device or internet connection doesn't automatically mean someone has the knowledge or confidence to use digital financial services.

UPI has been at the heart of India's rapid growth in digital payments, linking bank accounts to mobile-based payment services and making it far easier to transfer money or pay merchants. UPI transactions grew from roughly 13,11,295 lakh in 2023–24 to 18,58,660 lakh in 2024–25, and then to 24,16,169 lakh in 2025–26. In value terms, this went from ₹200.0 lakh crore to ₹260.6 lakh crore and then ₹314.2 lakh crore *(Reserve Bank of India, 2026)*. UPI has, in short, become a regular part of how payments happen in India.

This growth needs to be seen alongside other digital payment systems too, such as IMPS, NEFT, AePS and cards. *Asopa and Chaudhary (2025)* find a strong correlation between UPI activity and the Financial Inclusion Index — though this doesn't prove that UPI's growth actually caused improvements in financial inclusion. Their analysis rests on a small number of observations, and several parts of India's financial system were expanding at the same time. So, what the findings really show is that the two moved together, not that one drove the other.

The RBI's Financial Inclusion Index offers a broader lens on this progress, since it accounts for access, usage and quality together. The Index rose from 64.2 in March 2024 to 67.0 in March 2025, with gains across all three dimensions *(Reserve Bank of India, 2025b)*. Still, account ownership is not the same as active participation. The Global Findex Database 2025 reports that 16 percent of account owners in India didn't have an active account in 2024 *(World Bank, 2025)*. This suggests the real challenge going forward is less about whether people have access and more about whether they keep using financial services once they have it.

Financial and digital literacy remain central to this next stage. Someone can have a bank account, a smartphone and UPI access, and still hold back from using digital services because of limited knowledge, fear of fraud or doubts about security. Trust and consumer protection matter too, especially as more transactions move online. Gender and rural–urban gaps add another layer to all this. PMJDY and Business Correspondent networks have widened women's participation in formal banking, but differences in access to devices, digital skills, information and financial decision-making can still shape how much they actually benefit from digital finance.

India now has a much larger formal banking base, extensive Business Correspondent networks, widespread digital connectivity and a rapidly expanding digital payment system. These figures show the scale of the change, but they don't tell us whether households are actually better equipped to save,

manage financial risks or cope with unexpected financial pressure. Account ownership, smartphone access and UPI transactions are useful markers of expansion, but they aren't measures of financial well-being on their own. The next stage of India's financial inclusion journey needs to look more closely at how people use the services already available to them, and whether that use leads to lasting financial benefit.

ANALYSIS AND CRITICAL DISCUSSION

India has made considerable progress in expanding financial access through PMJDY, digital banking, UPI and wider digital connectivity. The bigger question, though, is what this expansion has actually meant for households themselves. Having access to a financial service and genuinely benefiting from it are not the same thing. The evidence in this article points to three connected but distinct stages: access, usage and outcomes.

PMJDY is a good example of the gap between access to financial services and their actual use. The sharp rise in bank accounts has brought many previously excluded households into the formal financial system, but that doesn't mean all of them use their accounts regularly. Evidence from Gubbi Taluk shows that a sizeable share of PMJDY account holders didn't actively operate their accounts, and awareness and use of RuPay cards remained limited. The Global Findex evidence tells a similar story. The Global Findex Database 2025 reports that 16% of Indian account owners did not have an active account in 2024 *(World Bank, 2025)*. So, the expansion of bank accounts is a real achievement, but account ownership on its own can't tell us whether households are actually participating in the financial system in any meaningful sense.

The same issue shows up in UPI's growth. The huge jump in UPI transactions shows that digital payments have become widely used, but more transactions don't necessarily mean better financial well-being. A digital payment can just replace a cash payment without changing how much a household saves, where it borrows from, or how well it can absorb an unexpected financial shock. So, the correlation between UPI activity and the Financial Inclusion Index that *Asopa and Chaudhary (2025)* report should be read with some caution. It shows both rising together, not that UPI's growth caused greater financial inclusion. Too many other changes in India's financial system were happening at the same time to separate out the effect of any one factor.

Access and usage also play out differently across groups. Education, income, gender, financial literacy, digital literacy, trust and connectivity all affect whether people are willing and able to use digital financial services. This is where the finding that PMJDY account ownership wasn't a statistically significant predictor of UPI usage in one rural study becomes especially relevant. A bank account gives people the opportunity to participate, but it doesn't automatically hand them the knowledge, confidence or willingness to actually use digital services. Digitalisation might reduce geographical barriers, but existing inequalities can persist wherever people have unequal access to devices, information, skills or financial decision-making power.

Outcomes make the picture even more complicated. *Agarwal et al. (2024)* find that greater adoption of digital payments after demonetisation was associated with higher consumer spending, which is useful evidence that digital finance can shape household behaviour beyond just the payment itself. But higher spending can't simply be read as an improvement in financial well-being. Existing research does find positive relationships between financial inclusion, digital financial literacy and financial well-being, yet there's still relatively little evidence on whether India's recent digital expansion has led to lasting gains in household savings, financial resilience or broader economic welfare.

There's also a real limitation in leaning too heavily on account numbers, transaction volumes and connectivity figures to judge financial inclusion. These measures show how far the system has spread, but they say much less about who is actually benefiting from it. A household might have a bank

account and use UPI regularly while still holding very little in savings or relying on informal credit. Likewise, owning a smartphone doesn't mean someone has the financial skills to make sound decisions with it. What people are actually able to do with the services available to them matters just as much as how many people have access to those services in the first place.

India has made considerable progress in bringing people into the formal financial system. The issue now is less about access on its own and more about what happens after access is granted. People need to be able to use financial services safely, regularly and with enough understanding for those services to actually be useful to them. Financial literacy, digital skills, trust and consumer protection all play a part here. The main gap sits between having access, being able to use that access effectively, and actually gaining lasting financial benefit from it. Future assessments of digital financial inclusion in India need to pay closer attention to this gap, rather than relying only on measures of infrastructure and transaction growth.

CHALLENGES AFFECTING THE USE OF DIGITAL FINANCIAL SERVICES

India's expanding financial and digital infrastructure has made financial services more accessible, but several problems continue to affect how people actually use them. One of the clearest is the gap between having access and actually using financial services. PMJDY has brought a large number of households into formal banking, yet the evidence of inactive or infrequently used accounts shows that opening an account is really just the beginning. UPI shows a similar gap. Simply having access to digital payment services does not mean that people use them regularly or feel confident using them.

Financial and digital literacy remain major barriers. A bank account, smartphone and internet connection might all be there, but people can still lack the knowledge or confidence to actually use digital financial services. This tends to matter most for rural populations, women, and people with lower incomes or less education. Concerns about fraud, privacy and cybersecurity add another layer of difficulty. Some users steer clear of digital services simply because they're unsure how safe they are, or don't know what to do if something goes wrong.

Gender and rural–urban differences also keep shaping participation. PMJDY has increased women's presence in formal banking, but gaps in access to devices, digital skills, information and financial decision-making still affect how much women are actually able to use these services. Rural areas have benefited from better connectivity too, but gaps in infrastructure, digital capability and access to local support haven't gone away.

POLICY IMPLICATIONS

India has already built much of the infrastructure needed for digital financial inclusion. The challenge now is making sure people can actually use these services and get something real out of them. The continued growth of PMJDY, UPI and digital connectivity give the country a strong base to work from, but access alone can't be the final measure of progress.

Active use of bank accounts deserves far more attention. PMJDY has pushed account ownership up significantly, but the presence of inactive or rarely used accounts shows exactly why account numbers alone can be misleading. Alongside counting accounts, policy evaluation should be looking at whether people are actually making regular transactions, saving through formal channels and using formal credit.

Financial and digital literacy need more practical attention too. Just telling people that digital services exist probably isn't enough. They need to know how to use UPI and mobile banking, protect themselves from digital fraud, and make basic financial decisions with confidence. These efforts should focus particularly on rural populations, women and people with lower education and income levels, who often face greater difficulties even when the infrastructure itself is already in place.

Trust and consumer protection are another area that can't be overlooked. Fear of fraud, privacy concerns and doubts about digital security can all discourage people from using these services in the first place. Awareness programmes should walk people through common forms of digital fraud and how to protect themselves against them. At the same time, grievance-redressal systems need to be easy to reach and quick to respond when things go wrong.

The gender dimension also needs attention. Getting more women to own bank accounts is a positive step, but it doesn't necessarily mean women have equal control over, or use of, financial services. Access to smartphones, connectivity, information and financial decision-making all shape how much they can actually participate. Policy assessment should look at how women actually use digital financial services, rather than leaning only on the number of accounts registered in their names.

The continued role of Business Correspondents and other local intermediaries is a reminder that digital finance doesn't have to mean removing human support altogether. For first-time users, or people still getting comfortable with digital services, local assistance can make a real difference. Strengthening these networks could be especially useful in rural and underserved areas.

Finally, how financial inclusion gets measured needs to change. Account numbers, transaction volumes and connectivity figures show how widely the system has spread. But they can't tell us whether households are saving more, coping better with financial shocks, or actually experiencing better financial well-being. Future assessments should combine access and usage measures with household-level indicators like savings, financial resilience, consumption and well-being.

The policy focus now needs to shift from simply providing access to making that access useful. Financial services need to be available, yes, but people also need to be able to use them safely, regularly and productively.

CONCLUSION

India has made substantial progress in expanding access to formal financial services. PMJDY, UPI, digital banking and wider connectivity have brought banking and digital payments within reach of a much larger share of the population, and the sheer scale of this expansion shows that India has built a strong foundation for digital financial inclusion.

But the evidence discussed in this article also shows that access is only one part of the story. A bank account, smartphone or UPI facility doesn't automatically translate into regular use or better financial well-being. Financial and digital literacy, income, education, gender, connectivity and trust all continue to shape how people actually use digital financial services. And there's still limited evidence on whether this growth in digital finance has produced lasting improvements in household savings, financial resilience and financial security.

So, the focus of financial inclusion needs to move beyond simply bringing people into the formal financial system. The next question is what people are actually able to do with the services they've gained access to. Future assessments should pay more attention to actual usage, financial capability, differences across social groups and the outcomes households experience, rather than relying mainly on account numbers and transaction volumes.

Ultimately, India's digital financial progress should be judged not just by how many people can access financial services, but by whether that access genuinely helps them participate more effectively in the financial system and improves their financial well-being over time.

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--Chapter--

Digital Financial Inclusion in Assam: Barriers, Opportunities and Behavioural Perspectives

Ananya Banik[1], Aatreya Das[2]

ABSTRACT

Digital financial services have become an increasingly important mechanism for extending financial inclusion by enabling individuals to access banking and payment services through digital channels. Assam has witnessed substantial development of digital-payment infrastructure alongside continuing efforts to expand financial literacy and last-mile financial access. Against this background, the present study examines the status of digital financial inclusion in Assam, identifies the major barriers affecting its effective expansion, and examines the behavioural factors influencing the adoption and use of digital financial services. The study adopts a descriptive research design based entirely on secondary data obtained from the Reserve Bank of India (RBI), State Level Bankers' Committee (SLBC), Assam, National Payments Corporation of India (NPCI), Government of Assam and relevant academic literature. The findings indicate that Assam has developed a substantial digital-financial ecosystem. NPCI data show that Assam recorded 203.78 million UPI transactions valued at ₹21,464.88 crore in August 2025. At the same time, RBI survey evidence reports digital-payment awareness of 75.8% among respondents in Assam. The study identifies infrastructure and connectivity constraints, technical problems in last-mile delivery, digital and financial literacy gaps, cybersecurity concerns and continued cash-based habits as important barriers. Existing Indian literature further indicates that perceived usefulness, convenience, ease of use, trust, perceived security and digital confidence encourage digital-financial adoption, whereas perceived risk and lack of confidence may inhibit usage. The study concludes that the next stage of digital financial inclusion in Assam should move beyond the expansion of digital infrastructure towards safe, informed, confident and sustained digital-financial usage.

Keywords: Digital Financial Inclusion; Digital Payments; Assam; UPI; Financial Literacy; Digital Financial Literacy

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INTRODUCTION

Financial inclusion has traditionally focused on ensuring that individuals and households have access to formal financial services such as bank accounts, savings, credit, insurance and pension facilities *(Varghese & Viswanathan, 2018).* The rapid development of information and communication technologies has expanded this concept by enabling financial services to be delivered through digital channels. Mobile banking, internet banking, UPI, Aadhaar Enabled Payment System (AEPS), debit cards and Business Correspondent (BC) networks have consequently become important components of the contemporary financial-inclusion ecosystem *(Murthy, 2025; Srivastava & Kanoujiya, 2026).* Digital financial inclusion offers several potential advantages. Digital transactions can reduce the time and cost associated with physical banking, facilitate remote payments and transfers, and enable individuals to access financial services without frequent visits to bank *branches (Agbeve et al., 2025; Fernandez, 2026).* However, the existence of digital infrastructure does not necessarily imply effective financial inclusion. Individuals must also possess the knowledge, technological capability and confidence required to use digital financial services. Trust and perceptions regarding security are equally important because digital transactions involve technological platforms and the electronic transfer of money *(Hussain & Gupta, 2025).*

This distinction is particularly relevant in Assam. The state has experienced increasing digitalisation of its banking and payment ecosystem, supported by banks, government agencies, BC networks and digital-payment infrastructure. The State Level Bankers' Committee (SLBC), Assam has reported substantial progress in the expansion and deepening of digital payments and has declared Assam a 100% digitized state at the institutional level. At the same time, SLBC records continue to identify issues relating to financial literacy, last-mile delivery, cyber fraud and other operational challenges.

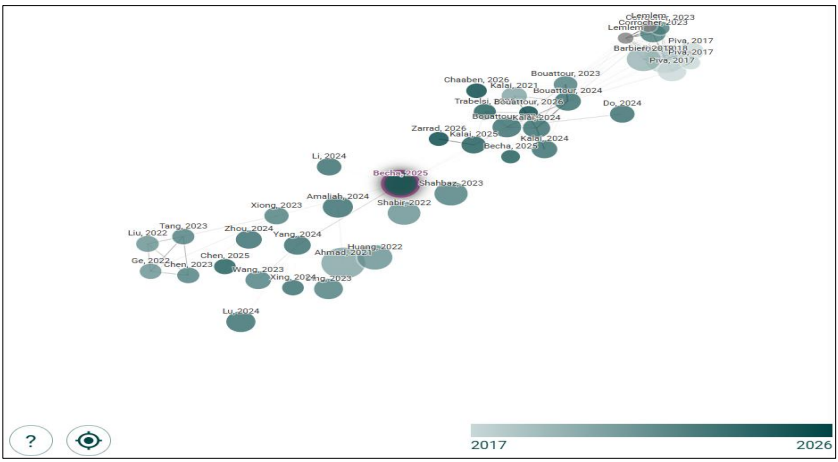
Digital-payment activity in the state also demonstrates the growing importance of digital channels. According to NPCI's state-wise UPI statistics, Assam recorded 203.78 million UPI transactions in August 2025, with a transaction value of ₹21,464.88 crore. Assam accounted for 1.02% of the reported UPI transaction volume and 0.86% of transaction value in the state-wise statistics. However, aggregate transaction activity alone cannot establish that all sections of the population are effectively included in the digital financial system. A high volume of transactions does not indicate the number of unique users, their frequency of usage or their ability to independently undertake digital financial transactions. Similarly, awareness of digital payments does not necessarily imply competent or sustained usage. The Reserve Bank of India's consumer survey provides useful evidence in this regard. Digital-payment awareness among respondents in Assam was reported at 75.8%, compared with 77.2% for India as a whole. The difference between awareness, access and actual usage highlights the importance of examining digital financial inclusion as a multidimensional *process (Azeez et al., 2024; Hussain & Gupta, 2025).*

Against this background, the present study examines digital financial inclusion in Assam through three dimensions: its current status, the barriers that constrain effective inclusion, and the behavioural factors influencing adoption and use. Rather than conducting a primary survey, the study synthesises official state-level evidence with findings from existing academic research.

REVIEW OF LITERATURE

The literature on digital financial inclusion indicates that access to financial services is increasingly intertwined with technological access and users' behavioural *characteristics (Azeez et al., 2024; Hussain & Gupta, 2025).* The existing research can broadly be organised around financial access, digital capability, socio-economic characteristics, trust and perceived risk, and continued usage.

Figure 1: Chronological and thematic development of Digital Financial Inclusion (2017-2026)



Source: Connected Papers (2026)

Research on rural India indicates that digital financial inclusion depends partly on the availability of digital devices and connectivity *(Saxena & Goyal, 2022; Zinal Vani & Kumari, 2025)*. This suggests that conventional financial access cannot automatically be converted into digital financial participation. Digital inclusion consequently requires an appropriate technological environment alongside formal banking access *(Kasiisii et al., 2023; Vani & Sathyanarayana, 2025)*.

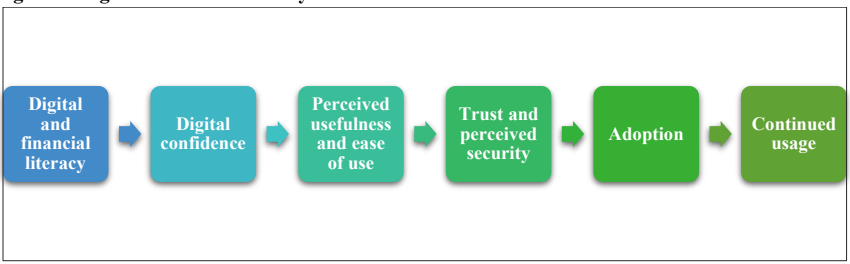
Socio-economic characteristics also influence digital-payment adoption. A recent study of rural UPI adoption in Aligarh found that age, gender, education, occupation and income were associated with adoption behaviour *(Shahid Raza et al., 2025)*. The findings suggest that exposure to technology and socio-economic circumstances can shape individuals' ability and willingness to use digital-payment systems.

Financial and digital literacy constitute another important dimension. Financial literacy provides individuals with the knowledge required to understand financial products, while digital financial literacy extends this capability to digital platforms and transactions *(Koskelainen et al., 2023)*. Users need to understand not only how to initiate transactions but also how to protect authentication credentials, identify fraudulent requests and respond to failed or unauthorised transactions.

Trust and perceived risk have also received considerable attention. Research on digital financial services in India suggests that trust between users and financial-service providers can facilitate adoption, while inadequate documentation, limited smartphone proficiency and weaknesses in digital infrastructure can constrain usage *(Yadav & Kalluru, 2024)*. Studies of low-income UPI users similarly indicate that performance expectancy, effort expectancy and facilitating conditions can encourage adoption, while perceived risk can act as an inhibitor.

The importance of behavioural factors extends beyond initial adoption. Research on rural digital-wallet users indicates that trust, incentives, satisfaction, facilitating conditions, performance expectancy, effort expectancy and habit can influence continuation intention *(Lakshmanan & Shanmugavel, 2025)*. This demonstrates that digital financial inclusion should not be viewed as a one-time transition from cash to digital payment. Sustained usage is equally important. The literature therefore suggests a broad behavioural pathway which has been showcased in figure 2.

Figure 2. Digital Financial Pathway



Source: Author's creation

Conversely, perceived risk, fear of fraud, technological anxiety, inadequate infrastructure and established cash-based habits can interrupt this process.

Although the literature provides considerable evidence on digital-financial adoption in India, there remains scope for a state-level synthesis focused specifically on Assam. Much of the existing empirical literature relies on primary surveys of particular populations or locations. The present study contributes by bringing together Assam-specific official evidence with findings from the wider Indian literature to examine digital financial inclusion as a combination of infrastructure, usage and behavioural capability.

OBJECTIVES OF THE STUDY

The study is guided by the following objectives:

1. To examine the status and growth of digital financial inclusion in Assam.
2. To identify the major barriers to digital financial inclusion in Assam based on available secondary evidence.
3. To examine the behavioural factors influencing the adoption and use of digital financial services in Assam.

RESEARCH METHODOLOGY

The study adopts a descriptive research design and is based entirely on secondary data. The approach is appropriate because the study seeks to assess the broader digital-financial inclusion environment in Assam rather than estimate the behaviour of a particular sample of respondents. Secondary information has been obtained from authoritative sources, principally the Reserve Bank of India, State Level Bankers' Committee, Assam, National Payments Corporation of India and Government of Assam, supplemented by peer-reviewed academic literature. The SLBC Assam maintains quarterly reports and agendas covering financial inclusion, digitisation, financial literacy, digital-payment expansion and related banking issues.

The study considers digital financial inclusion through three broad dimensions:

- **Access** - availability of banking and digital-payment infrastructure;
- **Usage** - evidence of actual digital-payment activity; and
- **Capability and quality** - awareness, financial literacy, security and behavioural conditions affecting effective usage.

State-level UPI statistics are used to demonstrate digital-payment activity. RBI survey evidence is used to assess digital-payment awareness. SLBC reports are examined to identify institutional and operational barriers and financial-literacy initiatives. Published academic studies are reviewed to identify behavioural factors associated with digital-financial adoption.

The analysis is descriptive and interpretative. No primary survey has been conducted and no respondent-level data have been created or estimated. Consequently, behavioural factors are presented as factors identified in the existing literature and interpreted for their relevance to Assam; they are not presented as statistically estimated determinants based on an Assam-specific primary survey.

STATUS OF DIGITAL FINANCIAL INCLUSION IN ASSAM

1. **Development of the Digital-Payment Ecosystem:** Assam has witnessed considerable development of its digital-financial ecosystem. SLBC Assam reports that the state has been declared a 100% digitized state because member banks have achieved complete digitisation across every district. This represents significant institutional progress in the creation of digital financial infrastructure. However, institutional digitisation and individual-level digital inclusion should be distinguished. The former relates to the digitisation of eligible banking services and accounts, whereas the latter requires individuals to possess the capability and willingness to use digital services effectively. This distinction is supported by the SLBC's continuing review of digital-payment expansion and financial inclusion. The September 2025 SLBC agenda, for example, recorded that 13 districts had reached full coverage while the remaining districts were reported at 99.98% coverage in the relevant digitisation programme. It also documented continuing work relating to unbanked villages and banking outlets.
2. **UPI Usage in Assam:** The strongest directly measurable indicator of digital-payment usage available for the state is UPI activity.

Table 1 UPI Transactions in Assam, August 2025

Indicator	Assam
UPI transaction volume	203.78 million
UPI transaction value	₹21,464.88 crore
Share of reported UPI volume	1.02%
Share of reported UPI value	0.86%

Source: NPCI, State-wise UPI Product Statistics, August 2025.

The figures demonstrate that UPI has become a substantial component of Assam's digital-payment ecosystem. The recorded volume of 203.78 million transactions indicates extensive transaction activity during the month. Nevertheless, transaction volume should be interpreted cautiously. The figure represents transactions rather than unique users. A single individual may conduct multiple transactions, and therefore the number cannot be interpreted as the number of people using UPI. The data nevertheless provide clear evidence that digital-payment infrastructure in Assam is being used for substantial economic activity.

3. **Digital-Payment Awareness:** Awareness represents another important dimension of digital financial inclusion. The RBI's consumer survey reported digital-payment awareness of 75.8% among respondents in Assam, compared with 77.2% for India as a whole.

Table 2. Digital-Payment Awareness

Area	Awareness (%)
Assam	**75.8**
All India	**77.2**

Source: Reserve Bank of India consumer survey on digital payments.

The figure indicates that awareness of digital payments is relatively widespread among the surveyed population. However, awareness should not be treated as equivalent to adoption or effective usage. A person may know about UPI or mobile banking without actually using these services or without

possessing sufficient knowledge to use them safely. The distinction is important for Assam because it suggests that the policy challenge is gradually moving beyond simply introducing people to digital payments towards improving their ability and confidence to use them.

4. **Financial Literacy Initiatives:** The continued implementation of financial-literacy programmes demonstrates institutional recognition of the capability dimension of financial inclusion. According to SLBC Assam, there were 32 Financial Literacy Centres during the relevant reporting period, and 5,831 financial-literacy camps had been conducted up to December 2025. These camps reached 112,893 beneficiaries during the same period.

Table 3. Financial Literacy Initiatives in Assam

Indicator	Status
Financial Literacy Centres	32
Financial Literacy Camps up to Dec. 2025	5,831
Beneficiaries up to Dec. 2025	1,12,893
Centre for Financial Literacy locations at block level	82

Source: SLBC Assam, December 2025 quarter.

The scale of these initiatives indicates that financial literacy remains an important policy component even as digital-payment infrastructure expands. For digital financial inclusion, such programmes can increasingly incorporate practical digital skills, cybersecurity awareness and safe-payment practices. Collectively, the evidence supports three cautious conclusions. First, Assam has developed a substantial institutional foundation for digital financial services. Second, the state records significant actual digital-payment activity through UPI. Third, the continued emphasis on financial literacy and the existence of unresolved operational issues indicate that infrastructure expansion alone does not eliminate barriers to meaningful digital financial inclusion. Therefore, Assam's digital-financial development should be understood as a transition from availability towards effective and sustained usage.

MAJOR BARRIERS TO DIGITAL FINANCIAL INCLUSION IN ASSAM

1. **Infrastructure and Connectivity:** Digital financial services depend on reliable technological infrastructure. Network interruptions, authentication failures and other technical problems can prevent users from completing transactions even when they possess bank accounts and digital-payment applications *(Han, 2024).* SLBC Assam's reports continue to review issues associated with digital delivery channels, banking outlets and last-mile infrastructure. The December 2024 SLBC material specifically includes review of BC operations, hurdles and inactive BCs as part of its financial-inclusion agenda. These problems are particularly relevant in locations where users have limited alternatives to assisted banking channels.
2. **Last-Mile Service Delivery:** Business Correspondents and other assisted channels remain important in extending banking services beyond conventional branches. However, inactive BCs and operational problems can reduce the effectiveness of these channels *(Dhar & Sarkar, 2016; Shah & Mandavia, 2025; Shylaja & Shivaprasad, 2021).* The December 2024 SLBC agenda specifically identifies hurdles/issues and inactive BCs for review. This indicates that the effectiveness of financial inclusion depends not only on establishing a digital platform but also on maintaining functioning delivery mechanisms at the local level.
3. **Digital and Financial Literacy:** Awareness and capability remain important barriers. The RBI's Assam awareness figure of 75.8% indicates that a significant proportion of surveyed respondents were aware of digital payments, but awareness does not necessarily demonstrate the ability to perform transactions independently or safely. The continued scale of financial-literacy activities in

Assam further indicates the importance assigned to this issue. More than simply explaining the existence of digital services, financial-literacy programmes need to build practical skills related to transaction procedures, authentication, fraud identification and grievance redressal.

4. **Cybersecurity and Fraud:** Security represents both a technological and behavioural barrier to digital financial inclusion *(Modwel, 2025).* The SLBC Assam agenda includes banking-related cyber fraud, phishing and money-mule accounts among the issues requiring institutional attention. The RBI has also repeatedly emphasised the need for public awareness regarding safe digital payments, including protection of PINs, OTPs and passwords and caution against malicious links, SIM-related fraud and spurious applications. The relevance of cybersecurity extends beyond the immediate financial loss caused by fraud *(Janisar, 2024).* A negative experience can reduce trust in digital financial services and discourage future usage.
5. **Cash-Based Habits and Behavioural Inertia:** Digital financial inclusion also involves a behavioural transition. Users accustomed to cash may continue to rely on familiar payment methods even when digital alternatives are available *(Dr Ranjana Sharma, 2024; Nair, 2026).* The broader Indian literature identifies habit, perceived risk and lack of confidence among factors that can influence digital-payment adoption and continued use *(Dadlani- & Gadve, 2026).* Therefore, increasing digital infrastructure must be accompanied by efforts to demonstrate the convenience and usefulness of digital services while reducing users' perceived risks.

BEHAVIOURAL FACTORS INFLUENCING ADOPTION AND USE

1. **Perceived Usefulness:** Individuals are more likely to adopt digital financial services when they believe that these services provide meaningful advantages, such as speed, convenience, lower transaction costs or reduced need to visit physical bank branches. Research on UPI adoption in India indicates that performance expectancy is positively associated with digital-payment adoption *(Shahid Raza et al., 2025).* Similar findings from rural contexts suggest that perceived benefits are important in determining whether digital services become part of routine financial behaviour. For Assam, the implication is that digital financial services are more likely to become sustainable when users experience clear practical benefits rather than merely being encouraged to use them.
2. **Ease of Use and Digital Confidence:** Ease of use is particularly relevant for first-time or less digitally experienced users. A complicated interface can create uncertainty and discourage independent usage *(Opaluch & Tsao, 1993).* Digital confidence is therefore an important intermediate factor. Users must feel capable of entering payment information, authenticating transactions, checking transaction status and resolving problems. This reinforces the importance of practical training. Financial literacy programmes can help users move from simply knowing that digital services exist towards confidently using them.
3. **Trust:** Trust is central to digital financial behaviour because users must rely on banks, payment platforms and technological systems to execute transactions correctly. Indian research on digital financial services identifies trust as an important component of adoption. Where users have doubts about the security or reliability of digital systems, they may prefer cash or assisted transactions *(Yadav & Kalluru, 2024).* For Assam, trust-building therefore needs to accompany digital infrastructure development.
4. **Perceived Security and Risk:** Perceived security and perceived risk represent two sides of the behavioural decision. Users who believe that digital payments are secure are more likely to use them, whereas users who fear fraud, privacy loss or monetary loss may avoid digital transactions *(Rawat et al., 2024).* The Indian literature on low-income consumers identifies perceived risk as a negative influence on UPI adoption. This suggests that cybersecurity awareness and effective grievance-redressal systems can contribute indirectly to digital inclusion by reducing uncertainty.

5. **Financial and Digital Financial Literacy:** Financial literacy helps individuals understand financial products and make informed decisions. Digital financial literacy extends this knowledge to technology-enabled financial services *(Braunstein & Welch, 2002).*
   In practical terms, digital financial literacy should enable users to:
   - make and receive digital payments;
   - protect PINs, OTPs and passwords;
   - recognise fraudulent messages and links;
   - verify payment recipients;
   - check transaction status;
   - report unauthorised transactions; and
   - use available grievance-redressal mechanisms.

   Thus, financial literacy should increasingly incorporate practical digital-financial skills.
6. **Habit and Continued Usage:** Initial adoption does not necessarily lead to sustained usage. Habit can influence whether users continue using digital financial services after their first experience. Research on rural digital-wallet usage identifies habit, trust, facilitating conditions and satisfaction among factors associated with continuation intention *(M & Mc, 2025).* This reinforces the argument that meaningful digital financial inclusion involves repeated and confident use rather than one-time adoption.
7. **Socio-economic Characteristics*:*** Age, gender, education, income and occupation may also influence digital-financial adoption. Research conducted in rural India has identified several of these characteristics as associated with UPI adoption *(Shankhpal, 2025).* These characteristics should not be interpreted as inherent limitations of particular groups. Rather, they may reflect differences in access to smartphones, internet connectivity, education, income, employment and opportunities to acquire digital experience. Consequently, digital-financial inclusion policies should be sensitive to differences in users' circumstances.

OPPORTUNITIES AND POLICY IMPLICATIONS

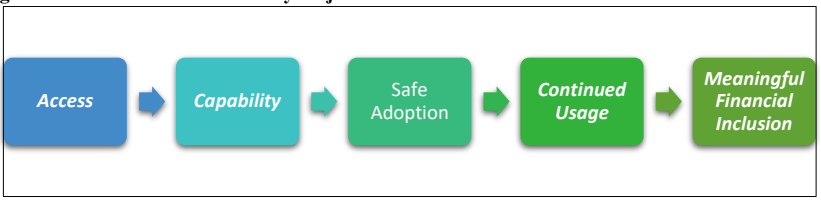
The evidence indicates that Assam has an opportunity to move from digital-financial availability towards meaningful digital-financial participation. This requires a shift in emphasis from infrastructure alone towards the quality and sustainability of usage.

1. **Strengthening Digital Infrastructure:** Reliable connectivity and authentication systems remain fundamental. Continued improvement in network reliability and digital infrastructure can reduce transaction failures and increase user confidence.
2. **Expanding Practical Digital Financial Literacy:** Financial-literacy programmes should increasingly incorporate practical digital skills. Training should cover UPI, mobile banking, AEPS, authentication, fraud prevention and grievance redressal. The existing network of Financial Literacy Centres and thousands of financial-literacy camps provides an institutional base for such interventions.
3. **Building Trust and Cybersecurity Awareness:** Digital-financial inclusion policies should integrate cybersecurity awareness with financial education. Users should understand common fraud mechanisms and know what steps to take when an unauthorised transaction occurs. RBI's continued emphasis on multilingual public-awareness campaigns demonstrates the importance of making digital-safety information accessible to users.
4. **Strengthening Last-Mile Delivery:** BCs and other assisted channels remain important for users who may not yet possess the capability or confidence to undertake all transactions independently. Improving the functioning of BC networks can therefore complement smartphone-based digital finance.

5. **Designing User-Centred Digital Services:** Digital financial services should be easy to understand and operate. User-friendly interfaces, clear transaction confirmations and accessible grievance-redressal systems can reduce uncertainty and improve confidence.
6. **Encouraging Sustained Usage:** Policy should distinguish between adoption and continued usage. Incentives may encourage initial experimentation, but long-term adoption depends more fundamentally on usefulness, convenience, trust, security and ease of use.

The overall policy objective should therefore be as showcased in figure 3.

Figure 3. Financial Inclusion Policy Objective



Source: Author's creation

CONCLUSION

Digital financial inclusion in Assam has progressed considerably alongside the expansion of digital-payment infrastructure and institutional digitisation. The evidence examined in this study demonstrates substantial digital-payment activity, with Assam recording 203.78 million UPI transactions valued at ₹21,464.88 crore in August 2025 *(NPCI, State-wise UPI Product Statistics, 2025).* The state has also developed institutional mechanisms for financial literacy, with 5,831 financial-literacy camps conducted up to December 2025 *(SLBC Assam, 2025).*

However, the findings indicate that digital financial inclusion should not be reduced to infrastructure or transaction volume. Digital-payment awareness in Assam stood at 75.8% in the RBI survey, demonstrating considerable awareness but also highlighting the importance of distinguishing awareness from actual and effective usage.

The major barriers identified in the available evidence include infrastructure and connectivity constraints, last-mile delivery challenges, digital and financial literacy gaps, cybersecurity risks and behavioural dependence on established payment practices. The literature further indicates that perceived usefulness, ease of use, trust, perceived security, digital confidence and financial literacy can encourage adoption, whereas perceived risk and lack of confidence can inhibit it.

The study therefore concludes that Assam has established a strong foundation for digital financial inclusion, but the next stage should focus on meaningful usage rather than access alone. Digital financial inclusion becomes more substantive when users can access services reliably, understand how they operate, trust the system, protect themselves against fraud and use digital financial services confidently and repeatedly.

Accordingly, future policy should integrate infrastructure development with digital financial literacy, cybersecurity awareness, effective last-mile delivery and user-centred service design. The transition that Assam now needs to consolidate is not simply from physical banking to digital banking, but from digital availability to safe, informed and sustained digital financial participation.

LIMITATIONS AND SCOPE FOR FUTURE RESEARCH

The study is based entirely on secondary data and published literature. It therefore does not estimate the behavioural determinants of digital-financial adoption using an Assam-specific primary survey. Aggregate UPI transaction figures also cannot identify unique users or establish the frequency or quality of individual usage. Future studies may undertake primary surveys across different population groups in Assam to examine the relationships among digital literacy, trust, perceived security, socio-economic characteristics and actual digital-financial behaviour. Such research would complement the state-level evidence presented in the present study.

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--Chapter--

Financial Technology for Rural Transformation: Bridging the Financial Inclusion Divide

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A Study on Fintech in Financial Inclusion in Assam

Saurav Brahma[1]

ABSTRACT

Financial inclusion is a crucial element of inclusive economic growth because it allows people, families, and small enterprises to use affordable and effective financial services. In Assam, financial inclusion remains a concern due to geographical limitations, remote rural settlements, inadequate facilities, financial illiteracy, socio-economic disparities. Financial Technology (FinTech) has become an important tool in making formal financial services more accessible, especially for rural and ignored populations of the state. Thereby, the paper examines the importance of FinTech in financial inclusion in Assam and explore aspects such as digital banking, mobile banking, Unified Payments Interface, digital wallets, Aadhaar-enabled payment systems, internet banking, electronic fund transfers, and credit and insurance solutions provided by the said technology. The study is mainly based on secondary data collected from the Reserve Bank of India, Government reports, reports from financial institutions and related academic studies. The findings of this study reveal that the users have started to avail the financial services with more ease, affordability and speed after the introduction of FinTech. Digital payments and mobile financial services have played a major role in making people part of the formal financial system. However, there are some problems that hinder the proper functioning of FinTech, like poor internet connectivity, lack of digital infrastructure, insufficient digital and financial knowledge, cybersecurity issues, etc. The findings of this study show that FinTech can significantly reduce financial exclusion in Assam if it is supported by improved digital infrastructure, better cybersecurity systems, financial and digital literacy programs, vernacular digital services, consumer protection legal framework, and effective institutional coordination. Thus, the introduction of these measures will ensure that technological innovation will be able to reduce financial exclusion as well as promote socio-economic progress within Assam.

Keywords: Financial inclusion, FinTech, Government, cybersecurity, digital financial services

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INTRODUCTION

Financial inclusion has become a significant factor in sustainable economic development by seeking to ensure that all classes of society have access to effective, low-cost, and reliable financial services. These

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services include savings accounts, payments, loans, insurance, pension plans, and a variety of other traditional financial services. The significance of the accessibility of financial services lies in the ability of families to deal with financial risks, acquire financial resources, invest in education and productive activities, as well as respond to shocks. According to the World Bank, financial inclusion can enhance poverty alleviation and expand economic opportunities (*World Bank, 2022*).

The rapid development of Financial Technologies (FinTech) has completely changed the way financial services are provided and used. FinTech can be defined as the use of innovative new technologies in the financial sector. Examples of FinTech tools are mobile banking, digital payments, internet banking, digital wallets, biometric payment systems, artificial intelligence, blockchain, and online lending platforms. According to *Gomber et al. (2017)*, FinTech can be regarded as a revolution in the world of finance that integrates technological innovations with the existing financial services. Similarly, *Sahi et al.,* (*2021*) elaborately show that with the application of digital technologies in finances it becomes possible to expand the accessibility of financial services and thus the population who previously been deprived of appropriate financial service get financial services.

The rapid growth of FinTech in India can be attributed to government initiatives aimed at achieving digital financial inclusion. In this regard, initiatives like Pradhan Mantri Jan-Dhan Yojana (PMJDY) biometrics payment system, mobile banking, and Unified Payments Interface (UPI) are vital in making formal financial services available to users. Also, RBI has incorporated digital financial inclusion in its initiatives (*Reserve Bank of India [RBI], 2024*). In practical terms, the digital public infrastructure in India allows banks and FinTech companies to reach out to customers through low-cost and accessible digital channels.

Assam presents a valuable regional perspective on FinTech and financial inclusion. The state has a massive rural population, scattered settlements, and geographical barriers in several places, which may pose difficulties for conventional banking. Nevertheless, digital financial services may help overcome some of these geographical barriers by enabling users to transact through mobile phones and other digital devices without actually moving.

FINANCIAL INCLUSION

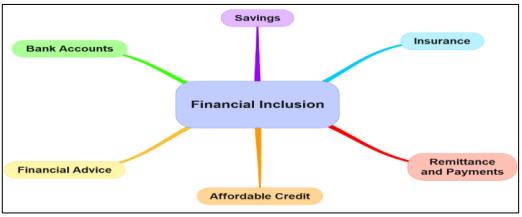
The term financial inclusion highlights the phenomenon of providing individuals and enterprises, especially the poor strata of the population and underprivileged groups in the society, with available and cheap access to basic financial services (Banking). Such services include bank accounts, savings accounts, loans, insurances, and payment systems. Financial inclusion is believed to be one of the most important aspects of helping to decrease inequality in economy *(World Bank, 2022).*

In India, financial inclusion was actively covered by different projects, like the Pradhan Mantri Jan-Dhan Yojana (PMJDY), payment systems based on the use of Aadhaar number, mobile banking, direct benefits transfers, and the Unified Payments Interface. These initiatives contributed to the improvement of financial services accessibility. Reserve Bank of India pointed out that financial inclusion should apply not only for opening an account at a bank, but for the use of available financial products as well *(RBI, 2024).*

Financial inclusion is especially important for rural areas and economically vulnerable people. Where traditional banking systems cannot work due to geographical distances, bad infrastructure, or high transaction costs, digital technology will give a way for financial services to be provided in an alternative way. FinTech has made this process stronger thanks to mobile payments, digital wallets, internet banking, digital lending and insurance technology, and biometric transactions. Gomber et al. in their research say that technology implementation significantly changed the structure and functions of financial services.

In Assam, financial inclusion is particularly relevant because of the importance of the rural population, geographical dispersion of its settlements, and the difficult landscape in some of its regions. FinTech technologies can overcome some physical aspects of banking and give access through mobile

phones and other digital means. But there are some obstacles that could affect the efficiency of using these services: bad internet connection, low level of digital literacy, problems related to cyber threats, lack of education, and difficulty in providing access to devices that help conduct financial transactions. Thus, the increase in financial literacy and tech education in Assam is one of the most important plans for financial inclusion improvement.



Source*: Kumar, 2025*

Figure: 1

ELEMENTS OF FINANCIAL INCLUSION

When defining financial inclusion, it is important to note that this is not simply the creation of possibilities for individuals to hold a bank account but is rather a multidimensional concept that includes the availability, accessibility, affordability, usage, quality, and security of a variety of financial products and services. Various researchers and institutions have described these dimensions while studying the efficiency of systems of finance for the underserved groups of the population *(World Bank, 2022; Demirgüç-Kunt et al., 2022)*. The meaning of accessibility lies in the opportunity for people to access and obtain financial services through banks, agents, ATMs, and other channels. The distance people live from financial institutions can have an exclusionary effect, especially when we speak about individuals living in remote locations *(World Bank, 2022)*. Financial inclusion implies that a variety of financial services is available for different disadvantaged groups of population. These services are represented by cash savings, loans, insurance, retirement plans as well as money transfer and payment services, and their existence allows the households to manage finances in a more efficient way *(Demirgüç-Kunt et al., 2022)*.

Affordability denotes the availability of financial services at affordable prices. High transaction costs, costs of maintaining accounts and interest rates can prevent low-income families from access to formal financial services. Affordable digital payments and low-cost banking services can significantly enhance financial inclusion *(World Bank, 2022)*. Having a bank account does not mean financial inclusion is successful. People need to be able to utilize their accounts actively, aside from using other financial products for saving, payment, withdrawal, transfer or credit. Regular use shows real participation in formal financial system *(Demirgüç-Kunt et al., 2022)*. The importance of digital access is increasing in the context of modern financial inclusion. Mobile banking, UPI, internet banking, digital wallets, Aadhaar-supported payment systems and other fintech platforms can promote financial access even beyond traditional banking infrastructure. Digital technologies can also assist rural and dispersed populations in having more chances to access necessary financial services wherever better connectivity is available *(Ozili, 2018)*.

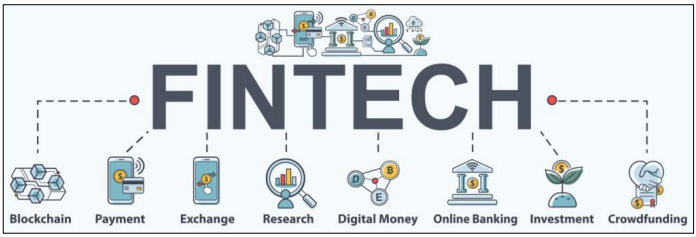
FINANCIAL TECHNOLOGY (FINTECH)

FinTech, the abbreviation for financial technology, refers to the application of modern-day digital technology to create, enhance and deliver financial services *(Gad et al., 2022)*. This merger of finance and technology leads to a plethora of innovations such as online banking, digital payments, cloud

computing, AI, machine learning, blockchain technology, big data analytics, biometric authentication, digital wallets, online lending, and automated financial advisory services *(Kou & Lu, 2025)*. It has revolutionized the traditional financial system by making financial transactions quicker, more convenient, more easily available, more transparent, and cheaper than ever before. Unlike traditional financial services that relied heavily on physical banks and face-to-face interaction, FinTech enables customers to access financial products using their smartphones, computers, digital platforms, and other devices *(Gomber et al., 2017)*.

The emergence of FinTech is attributed to the growing trend of telecommunications, information technology, internet, smartphone usage, cloud computing and information security. Another contributing factor to the rise of FinTech is the fact that big data is now being widely used by financial institutions and FinTech companies for creating tools for customer identification, assessment of their credit history, fraud detection, risk management, and financial personalization. Blockchain technology introduced ways of recording and verifying digital transactions. In addition, biometric identification helped provide clients with access to digital finance, as it simplified the process for those facing difficulties with traditional identification.

There are several ways in which FinTech can facilitate financial access. To begin with, digital payment systems provide affordable and fast domestic payment options that decrease reliance on cash (*OECD, 2020)*. Furthermore, mobile banking allows users to access bank accounts and perform transactions without having to go to bank branches often. Digital lending platforms can provide loans to people and small businesses with restricted access to common lending options. Tech-supported insurance platforms increase consumer awareness and access to insurance products. Furthermore, digital platforms for savings and investment motivate people to engage in the formal finance arena. Finally, digital finance contributes to direct payments of state benefits to citizens, thus enhancing the efficiency and openness of budgetary expenditures *(Demirgüç-Kunt et al., 2022)*.



Source: Authors compilation, 2026 (Created through AI for Representative purposes only)

In India, FinTech is rapidly developing due to improved digital infrastructure, rising smartphone usage, digital identity systems, and supportive government measures. Initiatives like the Pradhan Mantri Jan-Dhan Yojana (PMJDY) have tried to integrate previously unbanked people into the formal banking system. Establishment of Aadhaar-based services, Direct Benefit Transfer (DBT), mobile banking, internet banking, and Unified Payments Interface (UPI) is said to have developed India's digital finance environment. UPI, in particular, has provided real-time payment systems, making it an essential part of India's payment system. Reserve Bank of India also pursues goals such as financial inclusion and consumer protection, and stresses the importance of conductive payment infrastructure *(RBI, 2024)*.

The connection between FinTech and financial inclusion is broader than merely access to financial services. It includes additional aspects such as quality, affordability, frequency, and usability of financial products. Merely having a bank account does not mean being financially included if a client has not been using the financial service simply due to various obstacles. It is necessary for the financial services to be

affordable, reliable, clear, safe, and applicable to different social and economic groups for an effective level of financial inclusion to be achieved through FinTech *(Lusardi & Mitchell, 2014).*

FinTech is quite relevant for Assam, considering its topographical diversity coupled with a vast rural population, scattered settlements, and differences in access to formal financial infrastructural facilities *(Das & Das, 2020)*. In some cases, distance from banks and financial institutions make the regular access of financial services challenging. Digital banking, mobile payments, Aadhaar-enabled services, and technology-based financial platforms are capable of overcoming this distance issue. FinTech can offer ease of access to payment, savings, credit, insurance, and remittance services to rural households, agricultural workers, small traders, self-employed people, and small enterprises. It may make it easier to give government subsidies and social welfare benefits to qualified beneficiaries.

However, there are still some hurdles on the way of FinTech in Assam. Digital infrastructure and internet connectivity are critical determinants of access to online financial services, as far as remote areas are concerned. The accessibility of mobile banking apps and digital payment systems can be hindered by lack of digital literacy. It is likely to become a problem for an individual to use an application successfully if he does not understand how mobile banking works.

FINTECH IN CONTEXT OF ASSAM

FinTech is very useful in terms of promoting financial accessibility and thus improving the availability and affordability of such services. Services such as mobile banking, e-wallets, UPI, online banking, biometric payments, or Internet-based financial services have enabled previously underserved consumers to gain access to the financial world. Thus, FinTech facilitates overcoming geographic, economic, and infrastructural barriers to getting access to finances in particular areas *(Gomber et al. 2017; Ozili 2018).*

FinTech also contributes to the growth of digital payments. In India, the emergence of UPI, different types of mobile payments, or Aadhaar-based payments has also improved the digital financial landscape in general. Both technologies have the potential to decrease transaction costs, accelerate and increase the visibility of transactions. The emergence of digital payments has enabled small entrepreneurs and rural companies to take part more actively in the formal financial economy *(Reserve Bank of India [RBI], 2024).* The advancement of saving and investing is another significant contribution of FinTech. Digital banking services make it possible for clients to open and control their accounts, check their financial balances, transfer funds, and perform several savings-related activities. Having easier access to formal saving means allows more families to abandon informal saving techniques and gain better financial management abilities which enable them to deal with financial emergencies. FinTech services promote gaining access to investment products and relevant information as long as a customer has enough financial literacy to make responsible investment choices. Moreover, FinTech has played a vital role in strengthening money transfer services. Workers abroad and their families can transfer funds much faster and easier with the help of online services. In the same way, FinTech has made a significant contribution to the development of online insurance services due to the simplification of buying insurance policies, paying premiums, processing claims, and communicating with clients which provide more opportunities for the public to get access to financial risk management services. Another important aspect of FinTech is in enhancing the distribution of government welfare benefits

FinTech has the exceptional capacity in Assam to help overcome geographical limitations imposed on financial inclusion. The diverse settlements in rural areas of the state, cumbersome terrains of many regions, and varied accessibility to conventional banks require alternative methods to ensure financial access for the population. It is due to its emerging platforms, such as mobile banking, digital payments, Aadhaar-enabled services, etc., that FinTech can assist in making formal financial services available for rural population, farmers, small traders, women, self-employed individuals, and small business.

RESULTS AND DISCUSSION

With the globalisation of the market and the expansion of the financial sector, more and more segments of society are becoming involved in cashless transactions, which is driving growth and expanding the reach of fintech and financial inclusion. The government has also been making efforts to achieve significant progress in financial inclusion in recent years. The results over the past many years have been inconsistent. While more people have access to bank accounts, those accounts aren't being used as intended. The country's economy is suffering due to the rural population's lack of knowledge and understanding of personal finance; many people also lack access to formal loans and other associated services. The following are a few of the most important causes of the unbanked population:

1. One of the key causes for the low level of financial inclusion is the low level of financial knowledge among the rural people.
2. A lower financial inclusion index is being caused in part by the fact that some states or regions of the country have slightly lower bank penetration.
3. One reason for the unbanked population, particularly in rural areas, is a lack of trust when it comes to using technology or with documents.
4. Another obstacle to sustaining a high level of financial inclusion is a lack of awareness of cyber danger.

Because of these and other factors, Financial Inclusion has fallen short of its objectives thus far. Nonetheless, the Financial Inclusion Index's first criterion—access—may be satisfied by the many government initiatives and schemes that help young people become financially included. However, when considering the sustainability of financial inclusion in the long run, the second criteria, "Usages of Bank Account," becomes crucial. Unfortunately, people's reluctance to open bank accounts is a major factor in the insufficiency of Financial Inclusion. A decline in bank account usage might have a negative impact on the national economy. The way we see the contemporary economy and financial sector is being transformed by technology-enabled services, which do more than just make it easier for consumers to create and utilise bank accounts. Potential for growth: The expansion of the financial industry was made possible by advances in technology and innovative ideas. Saleh and Abd Majid released a report in the year 2022.Even though Bill Gates once said something like, "banking is necessary, banks are not," the banking sector has grown into its own business and is currently confronting enormous change *(PWC, 2014)*. The impact of technology progress on the growth and development of national economic processes, particularly in the financial sector, is well recognised. There has been a tremendous shift in the financial services business over the past few decades, brought about in part by the expansion of the financial sector and in part by the development of information technology. Financial technology's ability to aid economically disadvantaged groups and people is driving its rising popularity in both developed and developing countries. The American Financial Institutions (2016) states that some examples of fintech services that have contributed to economic growth include remittances, crowdsourcing, electronic wallets, and mobile money transfers. The expansion of the financial technology phenomenon has far-reaching consequences for both consumers and the economy at large, *claims Ozili (2018)*. Some academics have found that low-income people are using fintech firms to more effectively cover their day-to-day expenses. The broad usage of fintech has had a significant impact on borrowing, spending, investing, and saving. Fintech has altered consumer behaviour and payment methods, as pointed out by both Demerguc-kunt and Klapper. Some research suggests that people are more likely to start saving when given more flexible payment options. We claim to be financially inclusive when all individuals are able to fulfilll their financial demands through the provision of reasonable, sustainably sourced, and environmentally friendly products and services. People who do not currently have bank accounts are also able to have equal access to these services *(World Bank Report, 2018).*

The IT sector is far more helpful in encouraging the growth of new fintech companies than data collected from the financial services sector. Furthermore, research shows that the significance of expertise in the financial sector either grows or shrinks as fintech firms expand and seek investment *(Clark, GL, 2021)*. Since fintech facilitates the provision of financial services to those without access to conventional banking, it plays a crucial role in the promotion of financial inclusion. But there are a lot of obstacles for fintech to overcome, and one of them is the digital divide, which impacts things like access, influence, and resources. Fintech service use as it relates to habit, performance expectation, conductive settings, and behavioural intensity. It is *Odei-Appiah s. Wiredu (2022)* that provides the source.

The importance of fintech in expanding access to financial services will only increase during the 2019 COVID pandemic. Customers at the time reaped the benefits of electronic cash transfers and payment settlements, which prompted widespread use of digital payment systems and other financial technology services. The potential for technological advancements to lower the cost and increase accessibility of financial services is growing in significance. The dilemma of how to utilise mobile phones before the pandemic and the emergence of financial technology during the tough COVID-19 time have brought attention to potential technology-based solutions that might speed up the three pillars of the Financial Inclusion Index: access, usages, and accessibility. The following portion of the chapter delves into the understanding and usage of Fintech services in the payment industry, including apps based on UPI, mobile banking, ATM, loans, insutech, and more. Because the survey was conducted during the COVID-19 pandemic, it asked participants to rate their level of fintech usage both before and after the epidemic. Given the significance of comprehending the aspects that promote the last mile adoption of financial technology services, this chapter will provide crucial information concerning technology adoption, fintech applications, and the variables impacting the utilisation of fintech.

CHALLENGES OF FINTECH

It can be inferred from the rapid advancement of Fintech that it has given rise to numerous opportunities regarding financial inclusion in the state of Assam. However, there are many factors that prevent its effective use and adoption. The geographical specifics of the region, numerous rural citizens, differences in infrastructure and socio-economic conditions complicate the process of rolling out the digital financial services.

Inadequate digital infrastructure and internet connection are serious challenges hindering the successful implementation of digital banking services. Some areas of Assam remain without a reliable internet and mobile connection. The lack of such connectivity will lead to ineffective usage of the mobile banking services and applications. The situation can worsen due to some natural disasters like floods that disrupt communication and physical financial infrastructure.

Another key obstacle is low literacy in finance and digital technology. It is not enough to have access to a digital platform in order to achieve financial inclusion; users also need to be able to utilize the platform to make sound financial decisions. People with very little understanding of smartphones, banking apps, digital payments, interest rates, savings products, or credit conditions may be hesitant about using FinTech products and services. Ignorance can also lead to higher chances of being a victim of fraud and becoming involved with the wrong financial products. Thus, financial literacy is a key prerequisite for successful financial inclusion.

The digital gap is also a serious issue. Different levels of income, education, age, gender, geographic location, smartphone ownership, and access to the Internet affect the ability of people to engage in FinTech. For example, those with low incomes may struggle to buy a smartphone or have required data coverage. The elderly as well as the people with limited digital experience may also find FinTech apps difficult to use. Thus, the fact that FinTech is being developed does not mean that financial inclusion will necessarily occur.

Cybersecurity and online financial fraud have posed a major threat in recent years. Users can be victims of such crimes as phishing, identity fraud, unauthorized operations, fake instructions for payments, harmful software, and social engineering. Unawareness of cyber threats can leave novice users defenseless. Thus, it is imperative to improve authentication, data protection, knowledge of the cybersecurity basics, and complaint mechanisms.

SUGGESTIONS

In light of exploring FinTech and the topic of financial inclusion in Assam, it is now time to suggest some possible methods that will make sure that digital finance could serve the rural populace and the marginalized and low-income groups of Assam.

1. Establishment of functional mobile communication, broadband service, electricity supply, and service points would be critical for people's successful operation of the existing services such as mobile banking, UPI and eWallets.
2. It is crucial to pay more attention to digital and financial literacy programs. This work should be conducted by banks, educational institutions, NGOs, Panchayati Raj institutions, and local authorities.
3. It is relevant to use affordable, simple, and convenient FinTech services. Financial programs must have user-friendly design and be available in all local languages spoken in Assam.
4. Reducing unnecessary transaction costs will further motivate poor households go digital.
5. Enhanced cybersecurity and consumer protection is necessary. All banks and FinTech companies should have good security features to provide authentication, transaction monitoring, fraud monitoring, data protection, privacy, etc.
6. Utilisation of FinTech in providing fair access to formal credit for farmers, micro-entrepreneurs, self-employed individuals, and small businesses.
7. Authorities in Assam should support FinTech progress while taking care about rules and regulations of innovations.

CONCLUSION

The demonstrates how important the role of FinTech is in providing financial services to the rural sector, people with low-income, and other groups, which face difficulties in obtaining financial services from traditional financial institutions. The advent of FinTech has changed the traditional way of delivering financial services using tools such as mobile banking, UPI, digital wallets, Aadhaar payment system, internet banking, different types of lending and insurance technology, etc. In normal, such innovations have made the process of financial services easier, faster and less expensive as the need for a physical banking infrastructure has reduced. Therefore, FinTech has become an important means for financial inclusion. The importance of FinTech is particularly noticeable in Assam as the geographical variability, remote settlements, high rural population density, and limitations of the conventional banking system can hinder access to finance. Digital financial services may help overcome some of these limitations because they give people an opportunity to perform payments, send money, save, get loans, receive government support, and use various other financial services remotely. Thus, FinTech can also assist agricultural workers, small traders, self-employed individuals, women, rural families, as well as micro and small business entities to become economically active. Nevertheless, research shows that the growth in FinTech activities does not perform the function of providing full financial inclusion. Low level of digital connection, poor digital and financial awareness among people, lack of access to smartphones, cybersecurity issues, digital fraud, privacy problems, problems with language, the lack of trust, and unequal access of vulnerable groups to digital financial services related problems still influence the effective use of digital financial technologies. Based on this, for the improvement of FinTech-driven financial inclusivity in Assam, there needs to be the collaboration of policymakers, banking, FinTech

organizations, monitoring bodies, and communities. Infrastructure investment in rural areas, affordable connectivity, digitalization and financial literacy campaigns, as well as those related to cybersecurity and personal data safety are of importance. That excludes the necessity of taking into consideration the requirements of women, elderly population, agricultural workers, and the poor population. Thus, one may think about the fact that there are good perspectives regarding the use of FinTech in Assam, although in the long run it will depend on whether technology will be combined with affordable prices, accessibility, safety, as well as public awareness.

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--Chapter--

Financial Technology for Rural Transformation: Bridging the Financial Inclusion Divide

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Digital Financial Literacy among College Students: A Study of Awareness, Usage and Challenges with Special Reference to Rupahi College

Amio Bora[1]

ABSTRACT

The expansion of digital financial technologies has transformed the way youth access and use financial services. College students are active users of digital payment platforms, including UPI, mobile banking, digital wallets, and internet banking. However, frequent use of these services does not necessarily indicate adequate knowledge of financial security, privacy, fraud prevention, and responsible practices. Against this background, the present study examines digital financial literacy among students of Rupahi College, Nagaon, Assam, focusing on awareness, usage patterns, purposes, and challenges associated with digital financial services. The study adopts a descriptive design based on primary data collected from 100 students through a structured questionnaire. The data are analysed using frequency and percentage methods. The findings indicate a high level of awareness of digital financial services, with UPI emerging as the most recognised and widely used platform. Money transfer, mobile/DTH recharge, and online shopping are the major purposes of digital financial transactions. However, the overall level of digital financial literacy is predominantly moderate; indicating that regular use of digital financial services is not necessarily accompanied by comprehensive financial and security knowledge. The study further identifies cyber security and digital fraud risks, privacy concerns, transaction failures, poor internet connectivity, and inadequate knowledge as major challenges. It recommends digital financial education through workshops, awareness programmes, cyber security training, and collaboration with financial institutions. Strengthening digital financial literacy can enable students to use digital financial services more safely, effectively, and responsibly.

Keywords: Digital Financial Literacy, College Students, Digital Financial Services, UPI, Mobile Banking, Cyber security.

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INTRODUCTION

The increasing integration of digital technology into financial activities has fundamentally altered the manner in which individual access, utilise, and manage financial services. The expansion of mobile banking, Unified Payments Interface (UPI), electronic wallets, internet banking, and other digital payment

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mechanisms has enhanced the speed, convenience, and accessibility of financial transactions. Consequently, digital financial services have become an important component of everyday economic activities, particularly among younger populations who are generally more familiar with smartphones and internet-based technologies. However, technological familiarity alone may not ensure the ability to make informed, secure, and financially responsible decisions in a digital environment.

Digital financial literacy has therefore emerged as an important component of contemporary financial capability. It encompasses the knowledge, skills, awareness, and confidence required to access and use digital financial products and services appropriately. It also involves the ability to recognise financial risks, protect personal and financial information, identify fraudulent activities, understand transaction procedures, and evaluate digital financial alternatives before making decisions. In this context, digital financial literacy extends beyond conventional financial knowledge by incorporating technological competence and awareness of the risks associated with digitally mediated financial transactions.

College students constitute an important segment of digital financial service users. Their increasing dependence on digital platforms for education, communication, shopping, entertainment, and financial transactions has created greater exposure to digital payment systems. Students commonly use UPI applications, mobile banking, electronic wallets, debit cards, and online payment facilities for transferring money, purchasing goods and services, paying bills, and meeting other routine financial requirements. Nevertheless, high levels of digital engagement should not automatically be interpreted as evidence of adequate digital financial literacy. Students may possess the technical ability to operate financial applications while having insufficient knowledge regarding cybersecurity, financial fraud, privacy protection, investment products, transaction risks, and responsible financial management.

The existing literature provides evidence of this distinction between digital financial usage and digital financial capability. *Kumar (2025)* reported that although college-going students were frequent users of UPI, e-wallets, and digital banking services, gaps remained in their understanding of investment opportunities, fraud prevention, cyber security, and safe digital practices. Similarly, *Rahim, Ali*, and *Adnan (2022)* examined students' financial literacy from a digital perspective and highlighted limitations in digital financial knowledge and awareness of associated risks. *S. D. and Kumar (2024)* further examined students' knowledge of digital financial services, emphasising the importance of adequate awareness for their effective utilisation. *Jacob (2024)* also demonstrated the relevance of financial literacy to the financial behaviour of college students. More recently, Aban et al. (2026) examined the relationship between digital financial literacy, electronic-wallet usage, and spending behaviour among college students, while *Dewmini, Wijekumara, and Sugathadasa (2023)* investigated the relationship between digital financial literacy and financial behaviour among university undergraduates.

Despite the growing body of literature, considerable scope remains for institution-specific and context-based studies, particularly in educational institutions located in semi-urban and rural areas of Assam. The digital financial experiences of students may differ according to their socio-economic background, academic discipline, digital exposure, family environment, and access to financial information. Moreover, the rapid expansion of digital payments creates new challenges relating to cyber fraud, data privacy, transaction errors, online scams, and inadequate understanding of digital financial products. Examining these dimensions at the institutional level can therefore provide a more contextual understanding of students' digital financial capabilities.

Against this backdrop, the present study examines digital financial literacy among college students with special reference to Rupahi College, Nagaon, Assam. The study focuses on three broad dimensions—awareness, usage, and challenges associated with digital financial services. It seeks to assess students' awareness of digital financial products and services, examine their patterns of digital financial usage, and identify the major difficulties and risks encountered while conducting digital financial transactions. The study also gives attention to cybersecurity awareness, fraud prevention, privacy protection, and students' ability to use digital financial services responsibly.

The significance of the study lies in its attempt to examine whether regular exposure to digital financial technologies is accompanied by adequate knowledge and responsible financial practices. The findings may provide useful insights for educational institutions, financial service providers, policymakers, and other stakeholders in designing targeted programmes for improving digital financial literacy among young adults. Strengthening such capabilities can contribute not only to safer use of digital financial services but also to more informed financial decision-making and responsible participation in the increasingly digitalised financial system.

REVIEW OF LITERATURE

Kumar, D. (2025) examined digital financial literacy among college-going students, focusing on awareness, usage, challenges, and cyber security. The study found frequent use of UPI, e-wallets, and digital banking, but limited knowledge of investment, fraud prevention, and safe digital practices. It emphasized practical financial education and awareness programmes to improve responsible digital financial behaviour.

Bhatt (2023) examined digital financial awareness among college students and highlighted the importance of students' knowledge and understanding of digital financial services. The study emphasized improving financial awareness to promote informed and effective use of digital financial technologies among young users.

Rahim, N., Ali, N., & Adnan, M. F. (2022) examined digital financial literacy among 184 university students in Selangor, Malaysia. The study found high financial knowledge and transaction experience but limited digital financial knowledge and awareness of digital financial risks, emphasizing the need to integrate digital financial literacy into student financial education.

Jacob, M. S. (2024) examined financial literacy among 400 college students and found moderate overall literacy, with significant differences across academic disciplines. The study also reported a positive relationship between financial literacy and responsible financial behaviour, emphasizing financial education and digital tools for improving students' financial capabilities.

S, D., & Kumar, N. S. (2024) examined digital financial literacy and knowledge of digital financial services among college students. The study highlighted the importance of students' awareness and understanding of digital financial services for their effective and informed use, emphasizing the need for stronger digital financial education among young users.

Aban et al. (2026) examined digital financial literacy and electronic-wallet usage among college students, focusing on their spending habits. The study highlighted the relationship between students' digital financial knowledge, e-wallet usage, and financial spending behaviour.

Dewmini et al. (2023) investigated digital financial literacy and financial behaviour among management undergraduates in Sri Lankan state universities. The study emphasized the importance of digital financial knowledge and skills in shaping responsible financial behaviour among university students.

OBJECTIVES OF THE STUDY

1. To assess the level of digital financial literacy among students of Rupahi College.
2. To examine students' awareness of digital financial services, including UPI, mobile banking, digital wallets, and internet banking.
3. To analyse the usage patterns and purposes of digital financial services among the students.
4. To identify the major challenges and risks faced by students, particularly regarding cyber security, digital fraud, privacy, and transaction-related issues.

RESEARCH METHODOLOGY

1. **Research Design**: The present study adopts a descriptive research design to assess the level of digital financial literacy among college students. The study focuses on students' awareness, usage patterns, cyber security knowledge, and challenges associated with digital financial services.
2. **Study Area**: The study is conducted among students of Rupahi College, Nagaon, Assam.
3. **Target Population:** Undergraduate and postgraduate students of Rupahi College.
4. **Sample Size:** The study includes 100 students from different academic disciplines.
5. **Sampling Technique:** Convenience sampling is used based on the accessibility and willingness of students to participate in the survey.
6. **Data Collection Tools**: A structured questionnaire containing closed-ended and Likert-scale questions is used to collect primary data. The questionnaire covers demographic characteristics, awareness and usage of digital financial services, cyber security awareness, and challenges faced by students. Secondary information is obtained from RBI reports, academic journals, research publications, books, and relevant institutional reports.
7. **Data Analysis:** The collected responses are systematically tabulated and analysed using frequency, percentage, and descriptive statistical methods. The findings are presented through tables, bar charts, and pie charts to identify major patterns in students' awareness, usage, and challenges related to digital financial services. Where appropriate, the findings are compared with previous empirical studies to establish consistency and identify differences.

DATA ANALYSIS AND INTERPRETATION

The primary data collected from 100 students of Rupahi College were systematically classified, tabulated, and analysed using frequency and percentage methods. The analysis focuses on the three major dimensions of the study: awareness, usage, and challenges related to digital financial services.

Table 1: Gender-wise Distribution of Respondents

Gender	Frequency	Percentage
Male	54	54%
Female	46	46%
Total	**100**	**100%**

Source: Primary data, 2026

Interpretation: The estimated distribution indicates that male students constitute 54% of the respondents, while female students account for 46%. The sample therefore provides a relatively balanced representation of both genders.

Table 2: Level of Digital Financial Literacy among Students

Level of Digital Financial Literacy	Frequency	Percentage
Low	18	18%
Moderate	57	57%
High	25	25%
Total	**100**	**100%**

Source: Primary data,2026

Interpretation: The table indicates that the majority of students (57%) possess a moderate level of digital financial literacy, while 25% demonstrate a high level of literacy. About 18% of the respondents fall under the low-literacy category. The findings suggest that although most students are familiar with digital financial services, a considerable proportion require further improvement in areas such as cyber security,

fraud prevention, privacy protection, and responsible use of digital financial services. Overall, the estimated results indicate a moderate level of digital financial literacy among students of Rupahi College.

Table 3: Awareness of Digital Financial Services

Digital Financial Service	Aware		Not Aware	
	Frequency	Percentage (%)	Frequency	Percentage (%)
UPI	98	98%	2	2%
Mobile Banking	91	91%	9	9%
Digital Wallets	76	76%	24	24%
Internet Banking	82	82%	18	18%
Overall	—	86.75%	—	13.25%

Source: Primary data, 2026

Interpretation: The table shows that students have a high level of awareness of digital financial services. UPI has the highest awareness, with 98% of respondents familiar with the service, followed by mobile banking (91%) and internet banking (82%). Awareness of digital wallets is comparatively lower at 76%. Overall, the estimated average awareness level is 86.75%, indicating that most students are familiar with major digital financial services. However, a small proportion of students remain unaware of these facilities, particularly digital wallets and internet banking, suggesting a need for continued digital financial awareness initiatives.

Table 4: Usage Patterns of Digital Financial Services

Digital Financial Service	Regularly	Occasionally	Never	Total
UPI	72 (72%)	26 (26%)	2 (2%)	100
Mobile Banking	51 (51%)	36 (36%)	13 (13%)	100
Digital Wallets	24 (24%)	38 (38%)	38 (38%)	100
Internet Banking	21 (21%)	43 (43%)	36 (36%)	100
Online Payment Services	67 (67%)	30 (30%)	3 (3%)	100

Source: Primary data, 2026

Interpretation: The findings show that UPI is the most widely used digital financial service, with 72% of students using it regularly. Online payment services are also highly popular (67%). Mobile banking has moderate usage, while digital wallets and internet banking have comparatively lower regular usage. Overall, students prefer simple, convenient, and transaction-oriented digital financial services for their routine financial activities.

Table 5: Purposes of Using Digital Financial Services

Purpose	Frequency	Percentage
Money Transfer	74	74%
Mobile/DTH Recharge	69	69%
Online Shopping	61	61%
Bill Payment	43	43%
Educational Expenses	35	35%
Other Purposes	12	12%

Source: Primary data, 2026

Interpretation: The table indicates that money transfer is the most common purpose of using digital financial services among students, reported by 74% of respondents. Mobile/DTH recharge follows closely at 69%, while 61% use digital services for online shopping. Bill payment accounts for 43%, whereas 35% use them for educational expenses. Only 12% reported other purposes. Overall, the findings suggest that

students primarily use digital financial services for routine payments, communication-related expenses, and online consumption, rather than for broader financial activities.

Table 6: Major Challenges Faced by Students

Challenge	Frequency	Percentage
Cyber security/Fraud Risk	58	58%
Privacy Concerns	47	47%
Transaction Failure	42	42%
Poor Internet Connectivity	39	39%
Lack of Knowledge	31	31%
Technical Problems	28	28%
Fear of Financial Loss	25	25%

Source: Primary data, 2026

Interpretation: Cyber security and fraud risk emerge as the most prominent estimated challenges, reported by 58% of students. Privacy concerns and transaction failures are also significant. These findings suggest that improving digital financial literacy should include not only knowledge of digital services but also practical cyber security education.

FINDINGS OF THE STUDY

The study reveals that students of Rupahi College have a relatively high level of awareness and active engagement with digital financial services, although certain gaps remain in their overall digital financial literacy. The gender distribution of the respondents is relatively balanced, with males constituting 54% and females 46% of the sample. Regarding the overall level of digital financial literacy, 57% of the students are estimated to possess a moderate level, 25% a high level, and 18% a low level. This indicates that while most students are familiar with digital financial activities, there is considerable scope for improving their knowledge and skills.

The findings further indicate that UPI is the most widely recognised digital financial service, with 98% of students being aware of it, followed by mobile banking at 91% and internet banking at 82%. Digital wallets have comparatively lower awareness at 76%. In terms of actual usage, UPI is again the most frequently used service, with 72% of students using it regularly, followed by online payment services at 67% and mobile banking at 51%. Digital wallets and internet banking show relatively lower regular usage.

With regard to the purposes of digital financial transactions, money transfer is the most common purpose, reported by 74% of respondents, followed by mobile/DTH recharge (69%) and online shopping (61%). Bill payments and educational expenses account for 43% and 35%, respectively. This indicates that students primarily use digital financial services for routine transactions and consumption-related activities rather than broader financial management.

The study also identifies several challenges associated with digital financial services. Cybersecurity and fraud risks are the most prominent concerns, reported by 58% of respondents, followed by privacy concerns (47%) and transaction failures (42%). Poor internet connectivity, lack of adequate knowledge, and technical difficulties are additional concerns. Overall, the findings suggest a gap between frequent use of digital financial services and comprehensive digital financial literacy, highlighting the need for practical education on cyber security, fraud prevention, privacy protection, and responsible digital financial behaviour among college students.

RECOMMENDATIONS

Based on the findings of the study, it is recommended that Rupahi College organise regular digital financial literacy programmes, workshops, and awareness campaigns for students. These programmes should cover UPI, mobile banking, digital wallets, internet banking, and responsible use of digital financial services. Particular attention should be given to cyber security and digital fraud prevention, including phishing, fake links, OTP scams, unauthorised transactions, and password protection. Students should also be informed about appropriate procedures for reporting cyber fraud and resolving failed or unauthorised transactions. Practical sessions on privacy protection and safe handling of personal and financial information should be conducted to reduce security risks. Digital financial education may also be integrated into relevant academic and co-curricular activities, with emphasis on budgeting, saving, responsible spending, and basic investment awareness. The college can collaborate with banks and financial institutions to provide practical demonstrations and updated information on emerging digital financial services and risks. Since students primarily use UPI and online payment services, greater awareness should be created regarding other digital banking facilities and broader financial management. Regular awareness campaigns can help students adapt to changing technologies and emerging cyber threats. Overall, the focus should shift from mere digital financial usage to informed, secure, and responsible financial behaviour.

CONCLUSION

The present study examined the digital financial literacy among college students with special reference to Rupahi College, Nagaon, Assam, with particular emphasis on their awareness, usage patterns, and challenges associated with digital financial services. The findings indicate that digital financial services have become an important part of students' routine financial activities. Most students are familiar with UPI, mobile banking, internet banking, digital wallets, and online payment services, demonstrating the growing influence of digitalisation on the financial behaviour of young people.

The estimated findings reveal that UPI is the most widely recognised and frequently used digital financial service, followed by online payment services and mobile banking. Students primarily use digital financial platforms for money transfers, mobile/DTH recharges, online shopping, bill payments, and educational expenses. This demonstrates that digital financial technologies provide students with greater convenience, speed, and accessibility in managing their routine transactions. However, their usage remains largely concentrated on basic payment-related activities rather than broader financial management, savings, investment, and financial planning.

Despite relatively high awareness and usage, the study identifies a moderate overall level of digital financial literacy among the respondents. A significant proportion of students continue to face challenges related to cyber security, digital fraud, privacy, transaction failures, internet connectivity, and inadequate knowledge. In particular, security-related concerns indicate that technological familiarity does not necessarily ensure comprehensive knowledge of digital financial risks. Therefore, there is a need to bridge the gap between digital financial access, usage, and informed financial capability.

The study concludes that improving digital financial literacy requires more than encouraging students to adopt digital payment technologies. Educational institutions should provide practical knowledge relating to cyber security, fraud prevention, privacy protection, responsible spending, financial planning, and safe use of digital financial services. Regular awareness programmes and collaboration with financial institutions can further strengthen students' capabilities. Ultimately, enhanced digital financial literacy can enable college students to make safer, more informed, responsible, and financially sound decisions in an increasingly digital financial environment.

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6

Financial Technology for Rural Transformation: Bridging the Financial Inclusion Divide

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--Chapter--

Digital Financial Literacy and Digital Payment Adoption

Nibedita Das[1]

ABSTRACT

Digital financial literacy has become progressively important with the rapid expansion of digital financial services and payment technologies in India. It refers to the knowledge and skills required to use digital financial services safely, effectively, and prudently. This chapter examines digital financial literacy and digital payment adoption, with particular importance on rural youth in Assam. It discusses the meaning and importance of digital financial literacy, crucial digital financial knowledge and skills and the importance of cybersecurity and safe digital transactions. The chapter also describes major digital payment methods and examines factors affecting their adoption among rural youth, including insufficient infrastructure, poor internet connectivity, digital illiteracy, lack of trust and security concerns. Further, it emphasizes the opportunities and benefits of digital payments in promoting financial inclusion, convenience, accessibility, entrepreneurship and livelihood opportunities. The role of FinTech and major government initiatives, including Digital India, Pradhan Mantri Jan-Dhan Yojana, UPI and BHIM, Pradhan Mantri Gramin Digital Saksharta Abhiyan, and Aadhaar-enabled Direct Benefit Transfer is also discussed. Finally, the chapter provides suggestions and policy implications for promoting safe, effective and sustainable digital payment adoption among rural youth in Assam. Strengthening digital financial knowledge, improving digital infrastructure, enhancing security awareness and providing localized training can help rural youth to participate more effectively in the digital financial ecosystem.

Keywords: FinTech, Financial literacy, Online payment, Financial ecosystem, Rural youth, Assam

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INTRODUCTION

The rapid development of digital technology has significantly transformed the payment landscape in India. Digitalisation has expanded the reach of payment services and made digital transactions easier and faster for individuals and businesses. In recent years, digital payments have become increasingly important in everyday financial transactions, with technological advancements and platforms such as the Unified Payments Interface (UPI) contributing to their wider adoption. However, the availability of

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digital payment facilities alone is not sufficient for effective adoption. Individuals also require adequate financial knowledge and awareness to use digital payment services safely and effectively *(RBI, 2024).*

Digital financial literacy refers to the knowledge, skills and competencies required to make informed financial decisions and use digitally delivered financial products and services safely and effectively. It enables individuals to understand and use digital payment platforms, manage digital financial transactions and protect their personal and financial information. It also helps individuals identify and respond to potential risks associated with digital financial services. Therefore, digital financial literacy is an important foundation for the safe and effective adoption of digital payments *(Alliance for Financial Inclusion, 2021).* Digital financial literacy has particular relevance in the context of rural communities. It can support individuals in understanding and using digital financial services and in developing greater confidence in digital transactions. In this context, rural youth can be considered an important group for promoting awareness and responsible use of digital financial services. Their participation can contribute to the wider use of digital financial services and support the development of a more digitally connected financial environment.

In India, the growth of digital payment systems has been supported by technological development and various government initiatives. One of the major developments in this area is the Unified Payments Interface (UPI), which is a system that enables multiple bank accounts to be accessed through a single mobile application, while providing seamless fund routing and merchant payments. NPCI conducted the pilot launch of UPI with 21 member banks on 11 April 2016 *(Digital India, n.d.).* Government initiatives such as the Pradhan Mantri Jan-Dhan Yojana (PMJDY), launched in 2014, have also promoted financial inclusion and access to banking services *(PIB, 2014).*

Digital payment adoption can provide several benefits to users by making transactions faster, more convenient and accessible. Digital payments can also support financial inclusion by reducing cost and geographical barriers to financial services. At the same time, challenges such as poor internet connectivity and cybersecurity risks can affect the safe and effective use of digital payment services. Therefore, both the benefits and challenges associated with digital payments need to be considered when examining their adoption *(RBI, 2024).*

In this context, the present chapter discusses digital financial literacy and digital payment adoption with particular relevance to rural youth in Assam. It focuses on major digital payment methods, factors affecting adoption, opportunities and benefits, the role of FinTech and government initiatives, and measures that can promote safe, effective and sustainable digital payment adoption among rural youth.

DIGITAL FINANCIAL LITERACY

Digital Financial literacy is the knowledge which is required to use Digital money tools safely without making faults. It involves necessary knowledge and skills needed to execute financial transactions on Digital platforms. According to the Alliance for Financial Inclusion (AFI), digital financial literacy refers to acquiring the knowledge, skills, confidence and competencies needed to safely use digitally delivered financial products and services and make informed financial decisions. Digital financial literacy can also help individuals understand digital financial services and manage the associated risks effectively *(Alliance for Financial Inclusion, 2021).* Therefore, individuals need to be digitally literate to use these services effectively, securely and efficiently. Digital financial literacy can be beneficial for all, some of its benefits are listed below:

1. **Access to Financial Services:** Digital financial literacy helps individuals understand and use digitally delivered financial products and services safely and effectively *(Alliance for Financial Inclusion, 2021)*.
2. **Fraud Prevention:** Digital Financial Literacy protects against digital frauds and financial crimes. As the digital financial services grows, the cybercrimes and financial frauds are also increases. In

2023, India saw a significant rise in phishing attacks and SIM swap frauds, targeting users of digital banking and payment platforms *(Sethi & Singh,2024).*

3. **Better Decision-Making:** Digital Financial Literacy also helps in making better decisions because when individuals have proper financial knowledge and skills they can compare decisions about investments and savings. Understanding digital financial products helps individuals to choose options which are suitable for their needs and financial goals *(Sethi & Singh,2024).*
4. **Financial Inclusion:** Digital Financial Literacy plays an important role in enhancing financial inclusion mainly in rural areas and undeserved areas because they are lacks access to traditional banking services. So digital financial services provide an avenue for these individuals to engage with the financial system. In India initiatives like Pradhan Mantri Jan Dhan Yojana (PMJDY) have opened over 450 million bank accounts and most of these accessible via digital platforms *(Sethi & Singh,2024).*

DIGITAL FINANCIAL KNOWLEDGE AND SKILLS

Digital financial knowledge is important for using digital financial services safely and effectively. It includes the knowledge, skills, confidence and competencies needed to use digitally delivered financial products and services and make informed financial decisions *(AFI, 2021).* It helps to avoid digital scams and securing personal and account information. Digital financial skills may be of different types, which are given below:

1. **Digital payments:** Setting up Unified Payments Interface (UPI), QR code scanning and peer-to-peer transfers securely.
2. **Online Budgeting:** Using digital apps to monitor daily spending and automate savings.
3. **Critical Detection:** Evaluating digital lending apps and online investment products.
4. **Security:** Enabling two-factor authentication system and avoid using public Wi-Fi for banking services.

CYBER SECURITY AND SAFE DIGITAL TRANSACTIONS

For safe digital transactions, most essential thing is active cyber security habits to protect individual funds and data from financial frauds. Cyber security is a practice of protecting computers, digital devices, servers, networks and data from digital attacks and unauthorised access. Proper cyber security habits prevent costly data breaches and can identify theft. Such important tips are listed below:

1. **Never share OTP or PIN:** Banks and payment apps never ask for OTP, UPI PIN or passwords. So do not share these things with anyone *(Ritesh Kumar, 2025).*
2. **Verify Before Pay:** Always check receiver's name and amount entered because once sent, digital payments are non-reversible *(Ritesh Kumar, 2025).*
3. **Do Not Click Unknown Links:** Avoid clicking on suspicious links received through SMS, email or WhatsApp claiming rewards or refunds *(Ritesh Kumar, 2025).*
4. **Use Only Official Apps:** Download payment apps from Google Play Store, Apple App Store and avoid third-party or unknown apps *(Ritesh Kumar, 2025).*
5. **Enable App lock and Phone Security:** Use screen lock and enable app lock for payment apps *(Ritesh Kumar, 2025).*
6. **Careful With QR Codes:** Scan QR code only for making payments, not for receiving money. To receive money, share your UPI ID *(Ritesh Kumar,2025).*
7. **Regularly Check Bank Statements:** Frequently monitor your transaction history and immediately report if you see any unknown transaction *(Ritesh Kumar, 2025).*

DIGITAL PAYMENT ADOPTION

Digital payment adoption refers to the use and acceptance of electronic methods for making financial transactions. The increasing availability of digital payment services has provided individuals with different options for making payments through cards, digital wallets, bank transfers and other electronic channels. Understanding the major digital payment methods is important for examining how individuals choose and use digital payment services.

1. **Major Digital Payment Methods:** Digital payment methods provide variety of features to suit different necessities from quick mobile transactions to secure international payments. Individuals can choose their digital payment method depends on their preferences, security needs and transaction fees *(Salesforce, n.d.)*. There are eight major widely used payment method:
   - **Debit and Credit Cards:** Credit and debit cards are the most common digital payment method because customers trust them for their security, fraud protection, global acceptance and fast transaction processing. Customers simply enter their card details at checkout and the information is sent through a payment gateway. After that the issuing bank verifies the transaction and funds are immediately approved or declined based on available balance and security checks *(Salesforce, n.d.)*.
   - **Digital Wallets:** It is also a widely used payment method. Digital wallets like PayPal, Apple Pay and Google pay allow customers to store payment details securely. Customers only need to link their debit and credit card or bank accounts with digital wallets then they can pay only by choosing their digital wallet and the funds are immediately transferred without manually entering the card details *(Salesforce, n.d.)*.
   - **Bank Transfers:** It is a direct account-to-account funds transfer method which is generally used for high value purchases or B2B e-commerce payments. In this digital payment method, customer needs to manually transfer their funds to the business account *(Salesforce, n.d.)*.
   - **Buy Now, Pay Later (BNPL) Services:** BNPL providers allow customers to split the purchase amount in smaller instalments. It is often interest free and it makes larger purchases more accessible which can increase the average order value *(Salesforce, n.d.)*.
   - **Crypto currency:** Crypto currency like Bitcoin provides an alternative option to traditional financial system with lower fees and no reliance on banks. Customers transfer crypto currency from their digital wallet to the crypto wallet. But this financial technology is still new so it is in the early stages of adoption *(Salesforce, n.d.)*.
   - **Prepaid cards:** Prepaid cards are like debit cards but they aren't link with bank accounts. Customers need to load funds in their prepaid card then they can use for making payments. Once the card balance is depleted, they need to reload funds to the card for continue using it *(Salesforce, n.d.)*.
   - **Mobile Payment System:** Digital Payment Apps make it easier to send and receive money instantly, customers only need to link their bank account or card to a mobile Payment app. At checkout, they can either scan a QR code or can send money through the app to complete their transaction instantly *(Salesforce,n.d.)*. The digital payments have managed to abstract the technology and process-related complexity such that the first-time users or under-serviced classes can learn these without much help.
   - **Autopay System:** This System allows to charge customers automatically on a set schedule. It is ideal for subscriptions, memberships and utility payments. Customers only need to enter their payment details once then the System automatically processes payment at the scheduled intervals *(Salesforce, n.d.)*.
2. **Adoption among Rural Youth:** India's rural landscape is currently undergoing a profound economic transformation, fuelled in large part by the rapid spread of digital payment technologies.

With over 65% of the population residing in rural areas—many of whom have historically been excluded from formal financial services. The urgency of extending digital infrastructure to these communities is clear. Rural youth, typically defined as those aged 15 to 35 living in non-urban settings, represent a pivotal demographic in this shift. Their natural adaptability to technology and their role as future economic drivers positions them as both the primary beneficiaries and the leading catalysts of a more inclusive digital economy. However, evidence suggests that digital payment adoption among rural youth still lags significantly behind their urban peers, held back by a complex web of structural, behavioural, and policy-related obstacles. The expansion of digital payment platforms in India has been remarkable by any standard. Launched in 2016 by the National Payments Corporation of India (NPCI), the Unified Payments Interface (UPI) revolutionized money transfers by enabling instant, secure, and affordable transactions across various banking institutions *(More et al.,2026)*. Between April 2017 and December 2020, UPI transaction volumes surged from 17.9 million to over 2.23 billion, with half of all new users originating from Tier 3–6 cities—a clear sign of penetration into previously underserved semi-urban and rural markets. Currently valued at US$3 trillion, India's digital payments market is projected to surpass US$10 trillion by 2026, with Tier 3–6 locations accounting for 60–70% of new mobile payment customers over the last two years *(More et al.,2026)*. While these aggregate figures point toward a structural democratization of finance, they often mask critical disparities regarding which segments of the rural population are actually participating. The persistent challenges to financial inclusion in rural India are deeply embedded in broader developmental gaps. According to the NABARD All India Rural Financial Inclusion Survey (2021–22), rural households still struggle with significant deficits in financial literacy, limited access to digital transaction methods, and a lack of trust in formal institutions *(More et al.,2026)*. While the TRAI Telecom Services Performance Indicators report for early 2022 noted a national broadband subscriber base of 788.30 million, rural tele-density and reliable data connectivity continue to lag far behind urban standards. The gender dimension of this digital divide is equally pronounced. Analysis at the SAARC level confirms that lower educational attainment, unemployment, and rural residency remain the primary drivers of reduced digital financial inclusion, contributing to a persistent gender gap across the region. In the Indian context, however, evidence suggests that fintech adoption can reduce this gender gap in financial access by 23% and increase formal credit access by 31% among previously unbanked populations. These figures highlight the immense transformative potential of digital interventions, provided that the specific barriers facing rural youth are systematically addressed *(More et al.,2026)*.

3. **Factors Affecting Adoption:** Although much has been accomplished since the advent of digital payments in India, adoption is still steady and slow. Digital payments are becoming more popular as technology advances, but acceptance is stymied by problems including cybercrime, a lack of infrastructure, ignorance, adoption in tier 3 and tier 4 cities, transaction costs, connectivity challenges, etc. Other significant obstacles to the expansion of digital payments include the relatively higher Infrastructure costs, the low financial literacy of small business owners, the large propensity of Households to save money in cash, and the disorganized monetary incentives *(Trivedi & Sanchiher,2023)*.
    - **Lack of Infrastructure:** Infrastructure for digital payments is still missing in some areas. So, this implies that those residents would not have access to digital payment choices, or that those options might be scarce or unreliable. Rural areas often lack of the basic infrastructure to support digital literacy and for this reason people face difficulty to learn about and use digital technologies *(Trivedi & Sanchiher,2023).*

- **Poor Internet Connectivity:** India is a big country with a diverse population and not everyone there has access to the Internet. The inability of many rural communities to access the internet makes it challenging for residents to use digital payment services because Digital payments rely heavily on internet connectivity *(Trivedi & Sanchiher,2023)*.
- **Digital Illiteracy:** More information and awareness about digital payments are required because some individuals might not understand how to use digital payment platforms or may not be aware of the advantages of doing so. Only 14.7% of India's population in computer literate and 20% of population use internet, according to NSO 2020 survey. According to a 2018 estimate by the "Digital Empowerment Foundation", around 90% of Indians are digitally illiterate. The inability to use and benefit from information and communications technology services due to access or lack of skills is known as digital poverty, a relatively recent notion *(Trivedi & Sanchiher,2023)*.
- **Trust:** Another aspect that has a big impact on whether or not digital payments are used is trust. Due to security worries and frauds, many people are still hesitating to use digital payments. In India, there have been instances of digital payment frauds. To increase user confidence, the government and digital payment service providers must solve these security issues *(Trivedi & Sanchiher,2023)*.
- **Security Reasons:** Unauthorised payment connections, fraudulent UPI handles, and screen monitoring by fraudsters are a few of the potential concerns associated with UPI. Mobile payments are susceptible to fraud, including unauthorized purchases and false returns. Both businesses and consumers may suffer financial losses as a result of this. So, utilizing trustworthy payment processors and routinely keeping an eye out for suspicious activities are crucial for reducing this risk *(Trivedi & Sanchiher,2023)*.
- **Cyber Frauds:** As per a report (Lyra, 2021), 52% of people in India does not know how to protect themselves against cyber fraud and cyber-crime. The reasons for frauds in online payments are due to insufficient investment in security technology and lack of awareness of people with respect to cyber frauds and cyber-crimes. Because of this people become victim of these frauds and it reduces trust in digital mode of payments. While the banking and fintech sectors are attempting to regulate this but hackers and cybercriminals are also improving their methods. In such an environment, technological utilization combined with more knowledge and tougher legislation can aid in avoiding the dangers of security issues *(Trivedi & Sanchiher,2023)*.

OPPORTUNITIES AND BENEFITS OF DIGITAL PAYMENT

Digital payments ensure convenience and efficiency in making transactions. Users of digital payments no longer need to be burdened by having to bring physical cash with them at all times and waste valuable time queueing for counter services to manage bills.

1. **Security:** In terms of security, keeping or carrying large amount of cash or cheques makes individuals vulnerable to misplacing them or becoming victims to theft. Digital payments reduce these risks thanks to the controls that technology enables. Trusted digital payments adopt security measures, such as identity verification of customers and access control *(Brunei Darussalam Central Bank [BDCB], n.d.)*.
2. **Easy Tracking and Financial Planning:** Digital payments can also assist to facilitate record keeping and better financial planning, i.e. budgeting, active savings through direct debit instructions, etc. *(BDCB, n.d.)*.

3. **Instant Payments:** Digital payments help in moving money in seconds with the help of Unified Payments Interface (UPI) or digital wallets.
4. **Reduce Physical Burden:** Digital payments eliminate the need to carry exact change, heavy cash or visit bank branches to pay utility bills.
5. **Financial Inclusion:** It helps by bringing banking services to rural or underserved areas and it allows people to manage their accounts via smartphone.
6. **Employment opportunities:** Digital payment system supports rural youth interested in self-employment and small entrepreneurship because they can sell their products/services on Digital marketplaces.
7. **Convenience:** Digital payments can also increase the profitability of the entrepreneurs by making financial transactions with customers, suppliers and government because it's more convenient, safer and cheaper.

ROLE OF FINTECH IN ENHANCING FINANCIAL SERVICE DELIVERY

FinTech or Financial Technology plays an important role in strengthening quality and safety of digital financial services.

1. FinTech makes digital payment services more convenient, accessible and secure.
2. FinTech improves financial services because only mobile banking applications have made it possible for the individuals of remote or underserved areas to access banking services without any physical branches.
3. It reduces entrepreneurs operating costs and improves customer satisfaction by making financial transactions faster and less costly than traditional banking processes.

ROLE OF GOVERNMENT INITIATIVES IN PROMOTING DIGITAL FINNACIAL SERVICES

The government takes various initiatives and launches schemes to promote digital financial literacy and digital payment adoption among rural communities.

1. **Digital India:** This initiative launched by the Government of India on July 1, 2015 to transform the country into digitally empowered society and knowledge economy. Main three pillars of this program are: Digital infrastructure as a utility to every citizen, digital governance and services on demand and the digital empowerment of citizens *(Viji,2026)*.
2. **Pradhan Mantri Jan Dhan Yojana (PMJDY):** Pradhan Mantri Jan-Dhan Yojana (PMJDY) is National Mission for Financial Inclusion to ensure access to financial services, namely, a basic savings & deposit accounts, remittance, credit, insurance, pension in an affordable manner. Under the scheme, a basic savings bank deposit (BSBD) account can be opened in any bank branch or Business Correspondent (Bank Mitra) outlet, by persons not having any other account *(Department of Financial Services [DFS], n.d.)*.
3. **Unified Payments Interface (UPI) and Bharat Interface for Money (BHIM):** UPI is India's most used digital payment system, developed by National Payments Corporation of India (NPCI) that enables millions of real-time transactions everyday across banks, apps and merchants. The BHIM app is a UPI-based digital payment application developed to make instant bank-to-bank transfers simple and accessible and it also available in 15+ Indian languages, making the app accessible to a diverse user base across the country *(Bajaj Finance, 2026)*.
4. **Pradhan Mantri Gramin Digital Saksharta Abhiyan (PMGDISHA):** This is initiated under Digital India programme would cover 6 crore households in rural areas to make them digitally literate. This is one of largest digital literacy programmes in the world. The scheme targeted 6 crore

households, with one person from each household. As a result, 6.39 crore households were trained *(Viji,2024)*.

5. **Aadhaar-enabled services and Direct Benefit Transfer (DBT):** Aadhaar-enabled Direct Benefit Transfer (DBT) helps deliver subsidies, pensions, scholarships and welfare benefits directly to beneficiaries' bank accounts. It promotes transparency, reduces leakages, ensures targeted delivery and strengthens efficient governance across welfare schemes in India *(UIDAI,2026)*.

Government'a FinTech initiatives are particularly relevant to rural youth because they can support their participation in digital financial services and help to develop the knowledge and skills required for safe and effective digital payment use. Rural youth are an important group for expanding digital financial usage because they are generally more familiar with smartphones and digital technologies. Digital payments are already widely used among rural youth's but infrastructure, connectivity, security and awareness issues remain.

SUGGESTIONS AND POLICY IMPLICATIONS

Following measures can help to promote safe, effective and sustainable digital payment adoption among rural youth in Assam.

1. **Localized Training Programs:** Conducting digital financial literacy programs in colleges, educational institutions and youth organisations in local languages like Assamese, Bengali and local dialects will help them in digital payment adoption.
2. **Improved Digital Infrastructure:** Poor digital infrastructure is a major problem in rural areas. Although rural youth use digital payment services, they often face problems such as poor internet connectivity and transaction failures.
3. **Security Enhancement:** Strengthen awareness of digital security concerns, including fraud prevention and trust-building measures. The government should also take stricter action against digital scams.
4. **Provide Incentives:** Encourage digital payment adoption among youth by providing incentives such as cashback and discounts.

CONCLUSION

Digital financial literacy is an important foundation for the safe and effective adoption of digital payment services. The chapter highlights that users need adequate knowledge and skills to conduct digital transactions, protect financial information, and identify potential fraud. Digital payments provide rural youth with greater convenience, accessibility, faster transactions, and opportunities to participate in formal financial services.

However, challenges such as poor digital infrastructure, unreliable internet connectivity, limited digital literacy, lack of trust, and cybersecurity concerns continue to affect adoption among rural communities. Government initiatives and FinTech services have contributed significantly to expanding digital financial services through programmes such as Digital India, PMJDY, UPI, PMGDISHA, and Aadhaar-enabled DBT.

For rural youth in Assam, localized digital financial literacy programmes, improved connectivity, security awareness, and appropriate incentives can encourage safer and wider adoption. Training through educational institutions and youth organisations can further improve their knowledge and confidence. Overall, strengthening digital financial literacy along with secure and accessible digital infrastructure can support financial inclusion, entrepreneurship, and rural economic development in Assam.

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Financial Technology for Rural Transformation: Bridging the Financial Inclusion Divide

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Gender, Education, and Marital Status as Determinants of Financial Literacy and Investment Behaviour in Semi-Urban Assam

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ABSTRACT

This study examines socioeconomic determinants of financial literacy and investment decisions among households in Lanka Town, a semi-urban area in Assam, India. Using primary data gathered from 70 respondents through structured questionnaires, the data were used to look at what people know about money, how they behave with money and their attitudes toward money. The research used methods like the Mann-Whitney U test, ANOVA and correlation tests. These showed that higher levels of education, graduation and post-graduation are linked to a better understanding of things like inflation and how risk and return relate to each other. People in the study mostly chose ways to invest, like putting money in the post office or in banks. Few people chose modern options like mutual funds or stocks, which is less than 10%. This shows that people are not very familiar with financial services. The study also found that there is a link between how much money a person earns and their age. These results show that differences in education and whether someone is married or not affect how much people know about money. People also tend to prefer ways of investing and are not using modern financial products. This makes it hard for people to use financial services. To fix this, schools and colleges should include financial education. Programs should be made to help groups of people with the issues they face. Also, places like post offices and banks, which people trust, can be used to introduce digital financial services. These steps are important for making sure everyone in Assam and similar areas in North East India can use technology.

Keywords: *Financial Literacy, Socioeconomic Determinants, FinTech, Digital Financial Inclusion, Investment Behaviour, Assam, Semi-Urban Households*

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INTRODUCTION

Every day, every individual makes important financial decisions that are crucial for financial well-being. Financial planning is a roadmap that guides you through expenses and maximises earning opportunities, making it possible to reach your life goals — and all of these decisions are made based on it. A good financial plan will not only improve savings and lower costs, but it will make you wealthier, plan for retirement, educate your children and save more on tax. It is an important factor in individual and economic development. It is a process that goes on continuously and enables individuals to spend their hard-earned money judiciously, build an emergency fund and retirement corpus, and manage their finances properly. To have a successful financial plan, it is important that an individual has financial knowledge, financial awareness and habits. Financial literacy has been a term since 1992, when it was first used in a report commissioned by the NatWest Bank for the National Foundation for Educational Research (NFER) *(Noctor, Stoney, and Stradling, 1992)*. Financial literacy is a term that describes knowledge about a wide range of financial terms and concepts, such as budgeting, saving, investing, debt management, and financial planning. This includes the ability to make informed and effective decisions with our finances. Multiple factors can impact gender differences in financial decision-making, such as education, work history, cultural norms, and exposure to financial resources.

Traditionally, men have dominated household financial decision-making, with socio-cultural norms positioning men as the primary breadwinners and financial managers. But with the participation of women in the workforce and a rise in educational standards, these are being challenged *(Bahl, 2023)*. More equal gender norms in the household positively impact the efficiency of household financial management, as they lead to higher financial market participation, equity holdings and asset diversification, according to *Guiso and Zaccaria (2020)*, implying a cost for patriarchal norms in economic terms. Financial education is not only a personal good thing to have, but a national need for India's growth and stability in the future. Better financial literacy helps people engage more deeply in the formal financial sector, avail financial services such as loans and insurance, and access pension products that help keep them better-equipped to enjoy life *(Kumar et al., 2023)*. The country is on the fast track of digitisation, and financial literacy is essential to ensure safe usage of digital financial services and to safeguard against fraud.

This study is conducted in a semi-urban region, Lanka Town, which is a transitional economic zone between the traditional rural economy and the financial economy of the cities in Assam. Assam's distinctive cultural setting, such as matrilineal practices in certain communities, may result in gender-specific differences in financial behaviour which can have varying impacts on women's involvement in financial decision-making processes relative to other regions of India. While financial literacy has been extensively studied in urban centres, the present study observes that there is a lack of studies about financial literacy in small towns such as Lanka Town, which has also become a prominent part of the economic landscape in India. As India moves towards digital finance, it is essential to understand the adaptability of women in Lanka Town when making use of online banking and investment platforms, with a view to creating financial education initiatives that are inclusive.

REVIEW OF LITERATURE

1. Global Evidence on Gender and Financial Literacy

Lusardi & Mitchell (2014) found that women consistently scored lower than men on financial literacy tests across 15 countries, attributing this to differences in confidence, math skills, and financial socialisation. *The OECD (2020)* revealed that globally, only 30 per cent of women could answer basic financial questions compared to 35 per cent of men.

Barber & Odean (2001) linked gender gaps to risk aversion, showing that men trade more aggressively but often underperform. *Fonseca et al. (2012)* found that women's lower self-assessed

financial knowledge (even when objectively competent) discourages active financial decision-making. *Wagner et al. (2022)* found that females in joint households were significantly less likely to engage in financial behaviours compared to males, suggesting that women may not be well-prepared for financial decision-making in single or joint households.

2. Indian Context

Bapat (2020) noted that financial literacy among urban Indian women was 22% higher than that of rural women, which could be attributed to their education and participation in the workforce. *Kumar & Sharma (2021)* reported that only 19% of rural women are allowed to make decisions independently of their husbands regarding investment in banks, and banking as a whole is a place where women's empowerment is limited.

Bahl (2023) examined the financial decision-making abilities of urban working women in India and Singapore, and determined that there was a positive relationship between education and gender parity in financial decision-making. There was a higher level of financial agency among the working women than among homemakers, reflecting the influence of work on women's financial agency.

Maurya (2022) revealed that working women have a different purpose and need for investment, and there are very few women who make investment decisions without the involvement of their husbands. According to *Banerjee et al. (2021)*, only 19 per cent of Indian women have complete control over the decision-making process of the household finances, while 27 per cent of the men have the same. But women who are more financially savvy are 37-38 per cent more likely than men to be part of financial decision-making. Increased participation among women in investment is positively related to their level of education and income *(Kansal & Singh, 2013)*, but most Indian women do not have adequate financial resources, especially in rural areas. *Shashwat Parmar (2023)* pointed out that gender inequality and societal norms remain to be a constraint on women's financial literacy and inclusion.

3. North East India

Das (2019) found that the financial literacy level of women in Guwahati, Assam, was moderate (42 per cent), whereas in rural areas, it was found to be 28 per cent. *Baruah* (*2021*) revealed that the financial awareness of tea garden workers in Assam was very low; 85% of the workers depended on the men of the family for decision-making. But women in the Guwahati region are seen to be more active in financial literacy than in rural areas *(Bora, 2023).*

The work of *Sushma V and Vinay Joshi C (2023*) from Bengaluru Rural District, India, revealed key differences between men and women in financial knowledge, financial behaviour and financial decision-making, highlighting the importance of gender-sensitive financial education initiatives.

4. FinTech and Financial Inclusion

As *Sholevar and Harris (2020***)** defined financial literacy as the awareness and knowledge of exploiting the available financial services from essential financial needs to potential financial inclusion, an effective programme should consider the needs and availability of financial options in every context. They argued that this concept is characterised by the demand and supply sides; awareness and need are related to the demand side, while the supply side encompasses the availability of financial services. The study highlights the importance of FinTech in the quest for financial inclusion, especially in recent studies. Digital products for women are more than social goods; they represent great market opportunities. But for it to realise its potential, financial services need to be built to align with women's digital fluency, agency and aspirations *(Women's World Banking, 2024).* Women's experience with digital financial services is not only harder and more emotional but also shaped by strong social and psychological factors; as well as developing women's financial skills, it is also vital to build women's confidence *(Mishra et al., 2024).*

Research in Assam, which was done by *Kedia and Banik (2024*), shows that women who start their businesses invest their money in many different things. They like to put their money in funds, shares and things like gold or property, and they like these options equally. 26.7 Percent of women entrepreneurs choose each of these options. On the other hand, a smaller number of women prefer to play it safe and put their money in bank accounts or government securities. About 3.3 per cent of women entrepreneurs choose to put their money in the bank, and about 6.7 per cent choose government securities. This means that women entrepreneurs like to have a mix of old ways of investing their money. They do not just pick one type of investment; they like to balance their portfolio with a bit of everything, including modern investments and traditional things they can touch. Women entrepreneurs in Assam do not just choose investments or investments that might make their money grow a lot; they choose a little bit of both.

5. Research Gap

Some cultural norms in Assam are different from the rest of the country (such as a matrilineal system of inheritance in some communities) and may have an impact on financial behaviour. Research on the gender gap in financial knowledge and investment behaviour tends to be conducted in metropolitan areas or cities. The socio-economic and cultural dynamics in small towns like Lanka Town, Assam, are likely to vary, and there is limited research on these areas. Although some works have considered the gender gap in financial knowledge, few works have looked into how the financial gender gap manifests in real investment choices in a joint or patriarchal decision-making environment. Research has been directed toward traditional financial literacy, yet in recent years, as digital banking and online investments have emerged, gender gaps could grow or evolve. Financial literacy programs may not be gender sensitive or adapted to rural/semi-urban populations. The gap in research has been identified in this research, which aims to fill the gap in the study area by examining financial attitude, financial knowledge and financial behaviour across the population.

6. Objectives

1. To examine the relationship among investment avenues, employment status, financial behaviour and marital status of the sample respondents.
2. To analyse the investment decision and selected indicators of financial literacy in the study.
3. To examine the association between financial literacy and investment decisions by employment status, marital status, and selected socioeconomic indicators.

7. Hypotheses

$H_0$1: There is no significant difference in investment objectives between married and unmarried respondents.

$H_0$2: There is no significant difference in financial behaviour between married and unmarried respondents.

$H_0$3: There is no significant difference in mean ranks as far as their marital status is concerned.

$H_0$4**:** There is no significant relationship between age and annual income of the sample respondents.

CONCEPTUAL FRAMEWORK

The conceptual framework for this research situates the problem statement within a multi-dimensional structure, focusing on the interplay between gender, socioeconomic factors, financial literacy, psychological influences, and investment behaviour.

Independent Variables:

- Gender (Male/Female)
- Socioeconomic Factors: Income level, Education level, Employment status, Marital status

Dependent Variables:

- Financial Literacy Level: Financial Knowledge, Financial Attitude, Financial Behaviour
- Investment Behaviour: Investment Profile, Frequency of investment decisions, Elements of investment decision

Theoretical Foundation:

- **Gender Theory:** Examines how societal norms shape financial roles
- **Household Decision-Making Models:** Unitary vs. Collective models of financial control
- **Behavioural Finance Theories:** How cognitive biases affect investment choices differently across genders

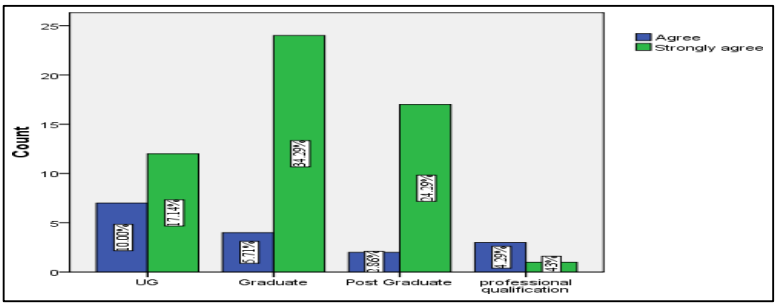
METHODOLOGY

1. **Study Area:** Assam's unique cultural context, including matrilineal traditions in some communities prompted to conduct the study in the state of Assam. In Assam, the Lanka town has been chosen as the area of study, as a semi-urban area, the area represents a transitional economic space between rural traditions and urban financial systems. A notable research gap concerning financial literacy in small towns like Lanka Town has also been observed.
2. **Sample Design:** A total of 70 respondents were surveyed, with one adult respondent selected from each household. A purposive sampling method was used to capture a broad spectrum of experiences and backgrounds, with special attention to gender balance and socioeconomic diversity. The data was collected in the month of April of 2025. The key variables collected includes Financial Literacy, Investment Profile, Elements of Investment Decision, Risk Preferences, Socio-economic Factors
3. **Data Collection:** Primary data were collected through structured questionnaires covering demographic Information (age, gender, education, occupation, income), Financial Literacy (knowledge, behaviour, attitude), Investment Behaviour (types of investments, decision-makers), and Risk Preferences.
4. **Analytical Techniques:** The collected data was analysed using Mann-Whitney U test, ANOVA, Post-hoc Test (Tukey HSD), Pearson correlation, Test of Normality, and Descriptive Statistics through SPSS and MS Excel.

RESULTS AND DISCUSSIONS

1. Financial Knowledge

Figure 1: Educational Attainment and Understanding of Inflation

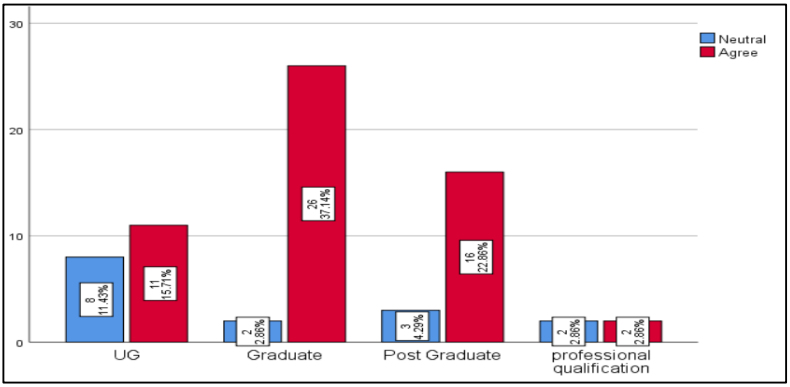


Source: Author's calculation based on field survey, April, 2025

Interpretation: The findings reveal a strong positive correlation between educational attainment and financial knowledge. For the statement "The cost of living increases due to high inflation," graduates

were found to be comparatively higher in strong agreement (34.29%) followed by postgraduates (24.29%) and undergraduates (17.14%). This indicates that respondents who are graduates and above have strongly agreed with the statement.

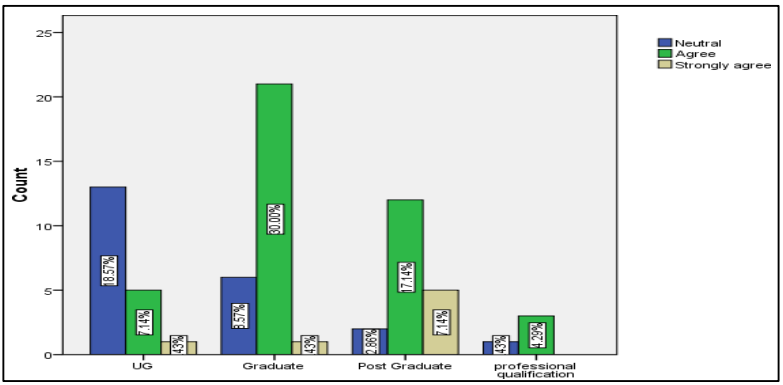
Figure 2: Educational Attainment and Risk-Return Understanding



Source: Author's calculation based on field survey, April, 2025

Interpretation: For the statement "An investment with high return is likely to have higher than average risk," graduates were found comparatively higher in agreement (37.14%), followed by postgraduates (22.86%) and undergraduates (15.71%). This demonstrates that respondents with higher education have a more nuanced understanding of risk-return relationships.

Figure 3: Educational Attainment and Basic Financial Knowledge

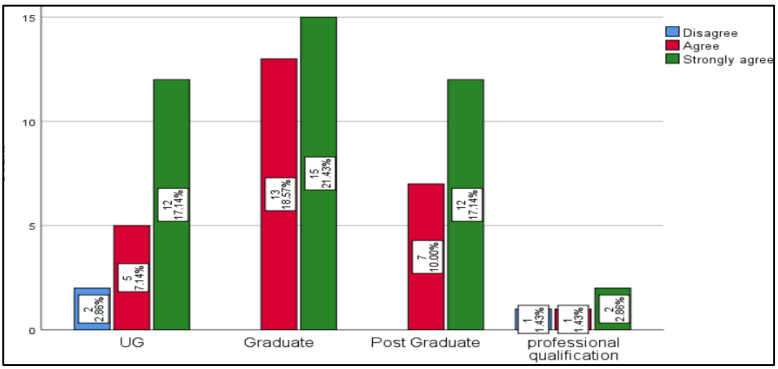


Source: Author's calculation based on field survey, April, 2025

Interpretation: However, the majority of undergraduate respondents neutrally responded (18.57%) to the statement that simple interest is charged on the principal amount by considering the daily rate and the number of days, with only 7.14% agreeing and 4.3% strongly agreeing. This shows limited confidence in basic financial concepts even among educated respondents.

2. Financial Behaviour

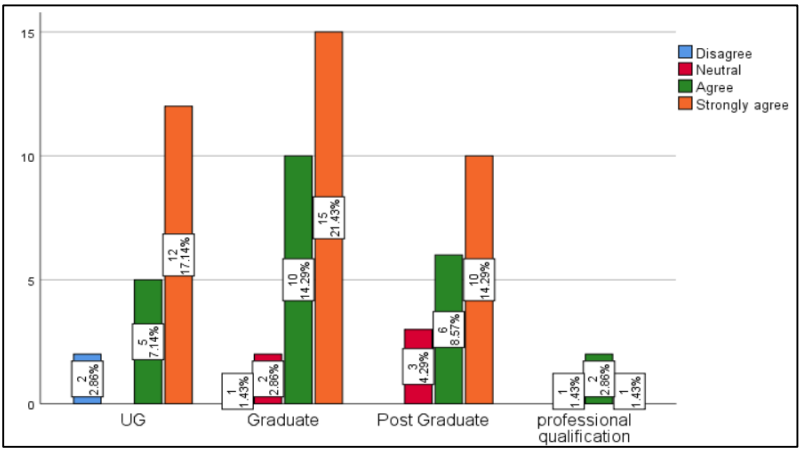
Figure 4: Educational Attainment and Emergency Savings



Source: Author's calculation based on field survey, April, 2025

Interpretation: Graduates were found to be comparatively higher in strong agreement (21.43%) with setting aside money for future emergencies, followed by postgraduates (17.14%) and undergraduates (17.14%). This indicates that individuals with a graduate degree are most likely to consistently set aside money for future emergencies compared to those with other educational backgrounds.

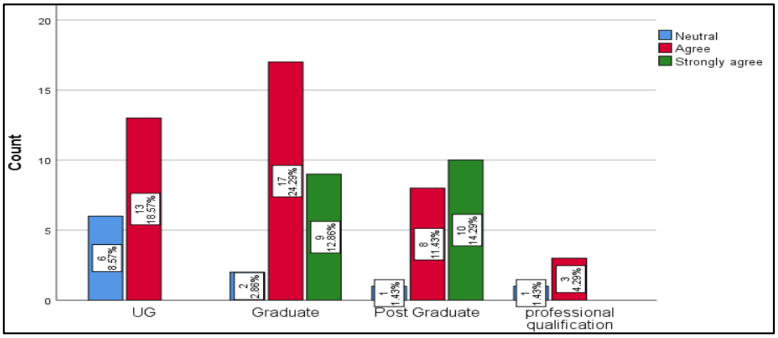
Figure 5: Educational Attainment and Long-term Planning



Source: Author's calculation based on field survey, April, 2025

Interpretation: For keeping money for special purposes like children's marriage or education, graduates were found comparatively higher in strong agreement (21.43%), followed by undergraduates (17.14%) and postgraduates (14.29%). This pattern indicates that individuals with a graduate degree tend to prioritise financial planning for significant life events.

Figure 6: Educational Attainment and Tax Compliance

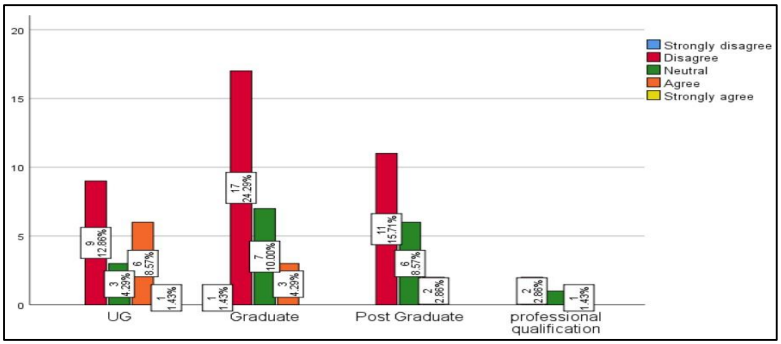


Source: Author's calculation based on field survey, April, 2025

Interpretation: Graduates were found comparatively higher in agreement (24.29%) with filing tax returns on time, followed by undergraduates (17.14%), while postgraduates were higher in strong agreement (14.29%). This shows that respondents with a graduate degree are most likely to agree that they file their tax returns or pay income tax on time.

3. Financial Attitude

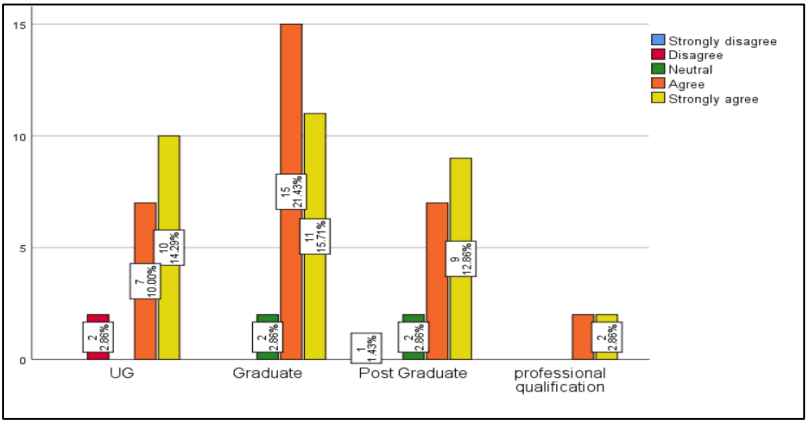
Figure 7: Educational Attainment and Spending vs. Saving Preference



Source: Author's calculation based on field survey, April, 2025

Interpretation: For the statement "Spending money gives men more satisfaction than saving it for the long term," graduates were found comparatively higher in disagreement (24.29%), followed by postgraduates (15.71%) and undergraduates (12.86%). This indicates that most respondents do not find more satisfaction in spending money compared to saving it for the long term, suggesting a general preference for saving over spending.

Figure 8: Educational Attainment and Women's Financial Education

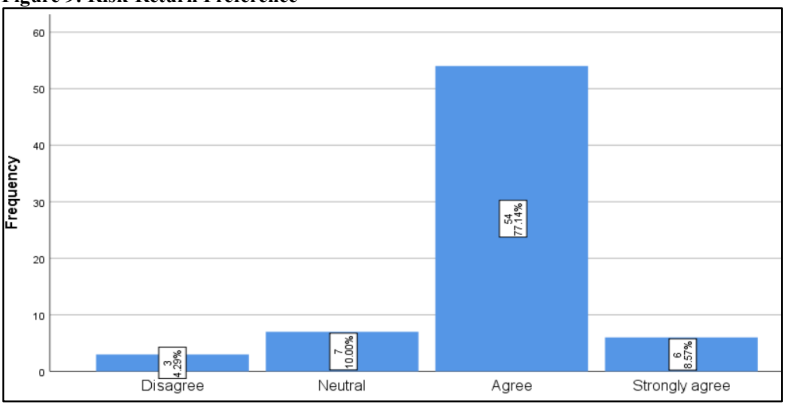


Source: Author's calculation based on field survey, April, 2025

Interpretation: For the statement "I believe more information is needed for women pertaining to money management and investing," graduates were found comparatively higher in agreement (21.43%), followed by undergraduates (14.29%) and postgraduates (12.86%). The highest number of responses was in the "strongly agree" category, indicating a strong consensus about the need for more financial information for women.

4. Investment Preferences

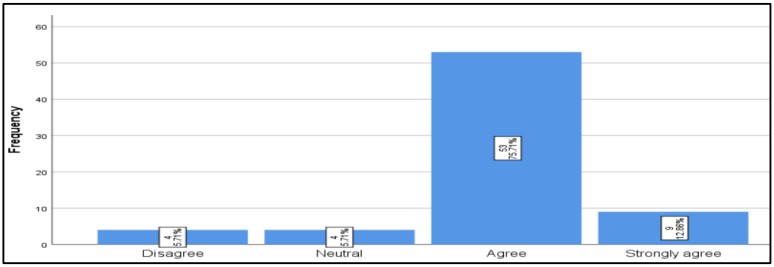
Figure 9: Risk-Return Preference



Source: Author's calculation based on field survey, April, 2025

Interpretation: The majority of respondents agreed (77.1%) that there is some risk associated with high return. Only 4.29% disagreed. Similarly, 62.86% agreed that there is low risk associated with low return, while 24.29% strongly agreed. However, 50% disagreed that there is high risk associated with high return, and 51.43% strongly disagreed with "potentially high return regardless of the potential loss." This indicates that most respondents are risk-averse as far as return is concerned.

Figure 10: Investment Goals



Source: Author's calculation based on field survey, April, 2025

Interpretation: The majority of respondents agreed (75.71%) that they have clear short-term and long-term financial goals that guide their investment decisions, with 12.86% strongly agreeing. Similarly, 77.14% agreed that diversifying investments reduces risk and improves returns, with 4.29% strongly agreeing. Additionally, 60% strongly agreed, and 38.57% agreed that age and stage of life significantly influence investment decisions.

5. Relationship between investment avenues and marital status of sample respondents

Table 1: Descriptive Statistics of Investment Avenues

Statistics	AVE: Bank deposits	AVE: Post office savings schemes	AVE; Precious metals	AVE; Insurance/ pension plans	AVE: Mutual funds	AVE: Shares/bonds /Debentures	AVE: Real Estate
Mean	3.81	3.96	3.21	3.63	2.77	1.79	3.76
Mode	4	4	3	4	2	1	4
Std. Deviation	0.98	0.81	0.80	0.85	0.95	1.06	0.94
Minimum	2	2	1	1	1	1	1
Maximum	5	5	5	5	5	5	5

Source: Field Survey, April 2025

Interpretation: Table 1 indicates that out of the 70 respondents, the majority are leaning most towards post office savings, followed by bank deposits and real estate. This suggests that these individuals have first priority for post office services, second priority for bank deposits, and third priority for real estate. Thus, they are essentially the conventional investors. Nevertheless, we have observed a lack of consensus regarding mutual funds, stocks, and bonds. This suggests that a very small number of individuals are leaning towards mutual funds, shares, and bonds. Moreover, female participants showed a notably lower involvement with contemporary financial products such as mutual funds and shares/bonds in comparison to male participants.

Table 2: Tests of Normality of investment avenues

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Investment avenue	.105	70	.053	.971	70	.100
a. Lilliefors Significance Correction						

Source: Field Survey, April 2025

Interpretation: The data for the variable "Investment Avenue" were assessed for normality using two common tests: the Kolmogorov-Smirnov and the Shapiro-Wilk tests. For a sample size of 70, the Kolmogorov-Smirnov test yielded a statistic of 0.105 with significance (p-value) of 0.053, while the Shapiro-Wilk test showed a statistic of 0.971 with a significance of 0.100. Typically, a p-value above 0.05 suggests that the data do not significantly deviate from a normal distribution. However, the Kolmogorov-Smirnov result (0.053) is very close to the conventional threshold, indicating a borderline case for normality, especially since the Shapiro-Wilk test is considered more reliable for samples of this size, and it clearly does not reject normality (p = 0.100). Ho: All group means are equal. H1: All group means are not equal

Table 3: The one-way ANOVA between employment categories and investment avenues

Investment avenue					
	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.229	3	.410	3.109	.032
Within Groups	8.698	66	.132		
Total	9.928	69			

Source: Author's calculation based on field survey, April 2025

Interpretation: Even with the non-significant post-hoc findings, the overall ANOVA for "Investment Avenue" showed significance (p = 0.032), suggesting that not all group means are the same. The overall variance (9.928) was divided into between-groups (1.229, df = 3) and within-groups (8.698, df = 66), featuring mean squares of 0.410 and 0.132, respectively. This important finding endorses the application of parametric tests such as ANOVA, even when normality is only approximate.

Table 4: Post-hoc Test (Tukey HSD) Between Employment Categories and Investment Avenues

Investment avenue			
Tukey HSD			
Employment status	N	Subset for alpha = 0.05	
		1	2
part time	2	2.8750	
Full time	50	3.1050	3.1050
Retired	8	3.1719	3.1719
currently unemployed	10		3.4625
Sig.		.541	.378

Source: Author's calculation based on field survey, April 2025

Interpretation: The Tukey HSD test put four employment statuses into two groups that're similar. These are the groups: Subset 1, which has part-time and full-time and retired people and Subset 2, which has time and retired and unemployed people. The test showed that the differences between these groups are not significant. The numbers are 0.541 and 0.378, which are both more than 0.05. This means that when we look at each pair of employment groups, we do not see any differences. So even though the overall ANOVA test might show some differences between the groups, the Tukey HSD test does not find any significant differences between the employment groups, like the part-time and full-time and retired and unemployed groups at the 0.05 level.

6. Relationship Between Marital Status and Investment Objectives

Table 5: Descriptive Statistics of Investment Objectives

Statistics	Saving income tax	Children's education/ marriage	Secured Income	Regular Income	Capital growth
Mean	2.24	4.04	3.83	3.57	3.90
Mode	3	5	4	4	4
Std. Deviation	0.999	1.013	0.884	0.957	1.024
Minimum	1	1	1	1	1
Maximum	5	5	5	5	5

Source: Author's calculation based on field survey, April 2025

Interpretation: Table 5 shows that among the 70 respondents, there is a strong inclination towards children's education/marriage capital growth, followed by capital growth and secure retirement. This suggests that individuals who are prioritized first for children's education, second for capital growth, and third for a secure retirement. They are essentially the conventional investors. Nevertheless, we have observed a lack of consensus on mutual funds, stocks, and bonds. It suggests that a small number of individuals are inclined to save income tax and earn regular income. We first transform the statement to an average and then assess normality; since the statements are not normally distributed, researchers must resort to non-parametric tests such as the Shapiro-Wilk test and Kolmogorov-Smirnov. This portion is an objective segment where researchers aim to understand what the primary objective is behind household investments in Lanka town.

Table 6: Test of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Objectives	.197	70	.000	.941	70	.002
a. Lilliefors Significance Correction						

Source: Author's calculation based on field survey, April 2025

Interpretation: The normality assessments for the "objectives" variable consist of the Kolmogorov-Smirnov (K-S) test, applying the Lilliefors significance correction, alongside the Shapiro-Wilk test. The K-S statistic is 0.197, with a sample size (df) of 70 and a significance (p-value) of 0.000; conversely, the Shapiro-Wilk statistic is 0.941 with the identical sample size and a significance of 0.002. The two p-values are significantly below the usual cutoff of 0.05, suggesting robust evidence against the null hypothesis of normality. The Lilliefors correction plays a crucial role here as it modifies the K-S test by accounting for the estimation of mean and variance from the sample instead of using known values, enhancing the test's suitability for real-world data where population parameters are unknown. The findings from both examinations indicate that the data for "objectives" does not exhibit a normal distribution; therefore, non-parametric statistical techniques might be more suitable for additional analysis of this variable.

H_0: There is no significant difference in investment objectives between married and unmarried respondents.

H_1: There is a significant difference in investment objectives between married and unmarried respondents.

The Mann-Whitney U test was conducted to examine whether investment objectives differed by marital

status.

Table 7: Mean ranks of investment objectives between married and unmarried sample respondents.

Ranks				
	Marital status	N	Mean Rank	Sum of Ranks
Investment objectives	Married	42	38.38	1612.00
	unmarried	28	31.18	873.00
	Total	70		

Source: Author's calculation based on field survey, April 2025

Table 8: Results of the Mann-Whitney U test of investment objectives between married and unmarried sample respondents

	Investment objectives
Mann-Whitney U	467.000
Wilcoxon W	873.000
Z	-1.468
Asymp. Sig. (2-tailed)	.142
a. Grouping Variable: Marital status	

Source: Author's calculation based on field survey, April 2025

Interpretation: Five statements on a Likert scale (1 = strongly disagree to 5 = strongly agree) were utilised to assess investment goals. Due to the non-normal distribution of the investment objective scores, the Mann-Whitney U test was utilised in place of an independent t-test to compare groups based on marital status. The test yielded significant results ($p < 0.05$), suggesting a disparity between married and unmarried participants. Married participants exhibited a higher average rank, indicating stronger consensus and implying they possess relatively superior investment goals compared to unmarried participants.

7. Relationship Between Financial Behaviour and marital status of sample respondents

Finance is crucial for all, and investing is a vital means for creating wealth. Single and married individuals pursue financial independence and future security, yet their financial planning requirements vary greatly. Singles enjoy greater autonomy in making independent investment choices, whereas married individuals frequently encounter difficulties in aligning their finances with their partners. Current research indicates that gender and marital status both have a substantial impact on investment behaviour. To investigate this, the researcher analysed the financial behaviour dataset for normality and determined it was non-normal. Consequently, a Mann-Whitney U test was performed to evaluate variations in financial behaviour based on marital status, with the subsequent hypotheses examined.

H_0: There is no significant difference in financial behaviour between married and unmarried respondents.

H_1: There is no significant difference in financial behaviour between married and unmarried respondents.

Table 9: Mean Ranks of financial behaviour between married and unmarried sample respondents

	Marital status	N	Mean Rank	Sum of Ranks
Financial behaviour	Married	42	39.44	1656.50
	Unmarried	28	29.59	828.50
	Total	70		

Source: Author's calculation based on field survey, April 2025

Table 10: Results of the Mann-Whitney U test of financial behaviour between married and unmarried sample respondents

Test Statistics[a]	
	Financial behaviour
Mann-Whitney U	422.500
Wilcoxon W	828.500
Z	-2.007
Asymp. Sig. (2-tailed)	.045
a. Grouping Variable: Marital status	

Source: Author's calculation based on field survey, April 2025

Interpretation: A total of twelve Likert-scale statements (1 = strongly disagree to 5 = strongly agree) were employed to assess financial behaviour scores. Due to the lack of normal distribution in the scores, the Mann-Whitney U test was utilised instead of an independent t-test to compare groups based on marital status. The test showed significance ($p < 0.05$), suggesting a difference in financial behaviour between married and single respondents. Married participants exhibited a higher mean rank, indicating greater consensus and implying they generally demonstrate better financial habits than their unmarried counterparts.

Table 11: Relationship among the number of dependents, age and annual income of the sample respondents

Correlations				
		Number of Dependents	Age	Annual Income
Number of Dependents	Pearson Correlation	1	-.140	.208
	Sig. (2-tailed)		.250	.086
	N	69	69	69
Age	Pearson Correlation	-.140	1	.256*
	Sig. (2-tailed)	.250		.033
	N	69	70	70
Annual income	Pearson Correlation	.208	.256*	1
	Sig. (2-tailed)	.086	.033	
	N	69	70	70
*. Correlation is significant at the 0.05 level (2-tailed).				

Source: Author's calculation based on field survey, April 2025

Interpretation: Table 11 shows Pearson correlation coefficients among three variables: Number of Dependents, Age, and Annual Income, based on a sample of about 70 individuals. The correlation between Number of Dependents and Age is negative and weak (−0.140), but it's not statistically significant (p = 0.250), so there's little evidence of a relationship. The correlation between Number of Dependents and Annual Income is slightly positive (0.208) but also not statistically significant (p = 0.086), so any apparent link is not strong enough to generalise. The correlation between Age and Annual Income is positive and moderate (0.256) and is statistically significant (p = 0.033), indicating that, on average, older individuals in this sample tend to have higher incomes. That's why only Age and Annual Income show a meaningful and statistically significant relationship in this data. This means that people with more dependents are not clearly older or younger, nor do they clearly have higher or lower incomes.

Table 12 Tests of Normality of Investment Strategy

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	df	Sig.
Investment Strategy	.183	70	.000	.942	70	.003
a. Lilliefors Significance Correction						

Source: Author's calculation based on field survey, April 2025

Interpretation: Five statements were used to calculate mean investment strategy scores. Normality testing revealed a non-normal distribution (Kolmogorov-Smirnov p = 0.000; Shapiro-Wilk p = 0.003), both below 0.05, leading to rejection of the normality assumption and necessitating non-parametric tests for comparing investment strategy by marital status.

Table 13 Mean Ranks of Investment Strategy between married and unmarried sample responses

Ranks				
	Marital status	N	Mean Rank	Sum of Ranks
Investment Strategy	Married	42	29.07	1221.00
	Unmarried	28	45.14	1264.00
	Total	70		

Source: Author's calculation based on field survey, April 2025

Interpretation: The table provides a summary of ranks for investment strategies based on marital status. There are 70 participants in total, with 42 being married and 28 being unmarried. For each group, the mean rank is calculated: married participants have a mean rank of 29.07, and they are considered to have a better or higher position. Unmarried participants have a higher mean rank of 45.14are considered to have the worse or lower position if lower numbers mean better. On average, unmarried individuals are ranked higher than married individuals regarding investment strategies.

Table 4.14

Results of the Mann-Whitney U test of Investment strategy between married and unmarried sample respondents

Investment Strategy	
Mann-Whitney U	318.000
Wilcoxon W	1221.000
Z	-3.325
Asymp. Sig. (2-tailed)	.001
a. Grouping Variable: Marital status	

Source: Author's calculation based on field survey, April 2025

Interpretation: The analysis compared investment strategy rankings between married and unmarried individuals among a total of 70 participants. The Mann-Whitney U test results include a U value of 318.000, a Wilcoxon W matching the married group's sum of ranks (1221.000), a Z-score of - 3.325, and a highly significant p-value (.001). It indicates a statistically significant difference in rankings between the two groups. Assuming that lower ranks represent better performance, these results suggest that, on average, married individuals are ranked higher (better) in their investment strategies compared to unmarried individuals.

FINDINGS

The analysis of primary data collected from 70 respondents in Lanka Town, Assam, reveals several key findings. First, educational attainment is positively correlated with financial knowledge. For the statement 'The cost of living increases due to high inflation,' graduates (34.29%) and postgraduates (24.29%) showed higher levels of strong agreement compared to undergraduates (17.14%). Similarly, for the risk-return relationship, graduates (37.14%) and postgraduates (22.86%) demonstrated stronger agreement compared to undergraduates (15.71%). However, a notable portion of respondents across educational backgrounds showed limited confidence in basic financial concepts, with the majority of undergraduates (18.57%) responding neutrally to the statement on simple interest. Second, in terms of financial behaviour, graduates were more likely to set aside money for future emergencies (21.43% strongly agreed) and plan for special purposes like children's education or marriage (21.43% strongly agreed) compared to other educational groups. Graduates also showed higher compliance with tax filing (24.29% agreed). Third, regarding financial attitudes, most respondents preferred saving over spending, with graduates showing the highest disagreement (24.29%) with the statement that spending gives more satisfaction than saving. A strong consensus emerged on the need for more financial information for women, with the highest number of responses in the 'strongly agree' category. Fourth, investment preferences remain overwhelmingly traditional. Post office savings schemes (mean = 3.96) and bank deposits (mean = 3.81) were the most preferred investment avenues, while mutual funds (mean = 2.77) and shares/bonds (mean = 1.79) showed low adoption rates, indicating limited exposure to modern financial products. Fifth, marital status significantly influences financial behaviour and investment objectives. Married respondents exhibited higher mean ranks in financial behaviour (39.44) compared to unmarried respondents (29.59), with the difference being statistically significant ($p = 0.045$). Similarly, married respondents showed higher mean ranks in investment objectives (38.38) compared to unmarried respondents (31.18), though this difference was not statistically significant ($p = 0.142$). Sixth, a positive correlation was found between age and annual income ($r = 0.256$, $p = 0.033$), indicating that older respondents in the sample tend to have higher incomes. However, the number of dependents showed no significant relationship with age or income. Finally, ANOVA results revealed that employment status does not significantly differentiate investment preferences ($F = 3.109$, $p = 0.032$), with post-hoc tests confirming no significant pairwise differences between employment groups.

In nutshell, the findings highlight the influence of education, marital status, and demographic

factors on financial knowledge, attitudes, and investment behaviours in semi-urban Assam. Married and more educated individuals generally exhibited stronger financial planning and risk management practices, while investment preferences remained predominantly conservative.

CONCLUSION

The findings reveal a complex interplay of factors influencing financial decision-making, with notable disparities linked to income, employment status, marital status, and education. While higher-income groups generally benefit from greater financial knowledge and access to services, lower-income groups face persistent barriers. Importantly, the research highlights how education significantly enhances financial acumen and risk awareness, and how marital status, more so than employment, impacts proactive investment behaviour. The study also points to a prevailing preference for traditional, conservative investment options, reflecting risk-averse attitudes across the population. Ultimately, these insights call for targeted policies that promote financial education, support digital inclusion, and strengthen household financial resilience to drive broader economic growth.

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8

--Chapter--

Financial Technology for Rural Transformation: Bridging the Financial Inclusion Divide

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FinTech Adoption Behaviour in Rural Assam: An Integrated Technology Acceptance Framework for Inclusive Rural Transformation

Neha Rani Das[1]

ABSTRACT

Financial technology (FinTech) has transformed the delivery of financial services by reducing geographical and transactional barriers; making them faster, cheaper and open to everyone, thus, expanding the potential reach of formal financial system. However, access to digital financial infrastructure does not automatically leads to meaningful or sustained usage, particularly in rural and socio-economically diverse settings. This chapter examines FinTech adoption behaviour in rural Assam through a structured narrative synthesis of technology-acceptance literature, recent evidence on digital financial inclusion in India, and the institutional context of rural financial service delivery. The chapter integrates the Technology Acceptance Model (TAM), Unified Theory of Acceptance and Use of Technology (UTAUT), Theory of Planned Behavior (TPB), and Technology Readiness Index (TRI), while incorporating trust, perceived risk and human-mediated financial services as contextual mechanisms. The framework distinguishes between financial access, technology acceptance, adoption intention, actual usage, sustained usage and financial inclusion outcomes. The synthesis suggests that perceived usefulness and ease of use primarily shape the cognitive evaluation of FinTech for users, while social influence, perceived behavioural control and technology readiness contribute to users' willingness and confidence to engage with digital financial services. Facilitating conditions, including connectivity, device access, local support and digital literacy, influence the conversion of intention into actual use. In rural Assam, these relationships are further shaped by trust, perceived risk, language accessibility, gendered access to digital devices and the availability of Business Correspondents and Bank Sakhis. The chapter consequently proposes a contextualised "phygital" technology-acceptance framework in which digital platforms and human intermediaries jointly facilitate financial inclusion. The framework provides implications for financial institutions, FinTech providers and policymakers seeking to move beyond account ownership towards meaningful, secure and sustained digital financial participation in rural Assam.

Keywords: FinTech adoption, Technology acceptance, Digital financial inclusion, Rural Assam, Technology acceptance model, UTAUT, Bank Sakhi, Phygital, Rural transformation.

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INTRODUCTION

Financial inclusion has increasingly moved beyond the provision of traditional banking infrastructure towards ensuring that individuals and households can meaningfully access, use and benefit from appropriate financial services. The Reserve Bank of India's Financial Inclusion Index (FI-Index) explicitly captures this multidimensionality through three broad dimensions—access, usage and quality—The latest FI-Index increased from 64.2 in March 2024 to 67.0 in March 2025, with improvement across all three dimensions and the stronger contribution coming from usage and quality *(Reserve Bank of India, 2025)*.

India's progress in financial access is also reflected in the expansion of the Pradhan Mantri Jan Dhan Yojana (PMJDY). The latest PMJDY state-wise statistics available as of 5 August 2026 report approximately 58.97 crore accounts nationally, with total deposits of ₹3,11,076.86 crore and. Of these accounts, 45.86 crore are classified as rural accounts *(Pradhan Mantri Jan Dhan Yojana, 2026)*. Assam accounted for approximately 2.60 crore PMJDY accounts, including 2.34 crore rural accounts, with deposits of approximately ₹7,491.41 crore and *(Pradhan Mantri Jan Dhan Yojana, 2026)*. These figures demonstrate substantial expansion of formal financial access; however, they should not automatically be interpreted as evidence of sustained digital financial usage.

The distinction between access and active usage becomes clearer in the latest World Bank Global Findex Database 2025. Based on data collected in 2024, 90% of both Indian men and women had an account, while 65% of Indian adults owned a mobile phone *(World Bank, 2025)*. At the same time, the Global Findex 2025 reports that 16% of Indian account owners did not have an active account, compared with an average of 4% among account owners in other low- and middle-income economies *(Klapper et al., 2025)*. This evidence is particularly relevant to the present study because it demonstrates that account ownership and meaningful financial usage represent different stages of financial inclusion.

Nevertheless, the expansion of digital financial infrastructure creates a distinction between availability and adoption. The distinction is important because the existence of a bank account does not necessarily imply active participation in the formal financial system. This distinction is particularly important in rural Assam. The state's geographically diverse terrain, dispersed settlements, agricultural and informal economic activities, linguistic diversity and exposure to periodic connectivity and infrastructure constraints create a distinctive context for technology-enabled financial inclusion. Rural users may encounter digital financial services through smartphones, merchants, Customer Service Points (CSPs), Business Correspondents (BCs), Bank Sakhis or government-linked financial channels. Consequently, FinTech adoption in this setting cannot be understood exclusively as a relationship between a user and a digital application.

Existing technology-acceptance models explain individual perceptions and behavioural intention reasonably well, while financial-inclusion literature emphasises infrastructure, institutional access and human intermediaries. However, these dimensions are rarely integrated into a single framework that explains the transition from FinTech intention to actual and sustained usage in rural Assam. In particular, the role of human intermediaries as a potential bridge between digitally enabled services and independent usage remains insufficiently incorporated into conventional technology-acceptance models.

Accordingly, the central problem addressed in this chapter is not simply the availability of FinTech infrastructure but the behavioural and contextual conditions under which rural individuals decide to adopt and continue using FinTech services. The chapter therefore conceptualises rural FinTech adoption as a multi-dimensional process driven by cognitive, behavioural, social, infrastructural and institutional factors. Technology acceptance theories provide useful explanations of individual adoption, but their explanatory power can be strengthened when contextual conditions such as digital literacy, trust, perceived risk, language accessibility and human-mediated financial services are incorporated.

The chapter has four objectives. First, it examines the major theoretical perspectives relevant to FinTech adoption. Second, it identifies the principal behavioural and contextual determinants of digital financial adoption in rural settings, with particular attention to Assam. Third, it develops an integrated

conceptual framework that connects individual technology acceptance with facilitating conditions, trust, risk and human intermediaries. Finally, it derives policy and managerial implications for advancing inclusive rural transformation.

FINTECH ADOPTION AND DIGITAL FINANCIAL INCLUSION

FinTech Adoption refers broadly to the integration and use of financial technology to the provision, delivery and transformation of financial services. Its scope extends beyond digital payments to include digital banking, lending, insurance, investment, remittances and other technology-enabled financial activities. In the context of rural development, the significance of FinTech lies not simply in technological innovation but in its capacity to reduce transaction costs, improve accessibility and connect financially underserved populations with formal financial institutions.

However, digital financial inclusion should be understood as a process rather than a single event. For the purpose of this chapter, six analytically distinct stages are proposed:



Source: Authors compilation

Stage	Concept
Access	The availability of a financial account, device, network or service point.
Awareness	Knowledge that the service exists and an understanding of its basic purpose.
Acceptance	Psychological willingness to consider the technology useful, understandable and appropriate
Adoption	Actual initiation of use
Sustained Use	Continued and repeated engagement with the technology
Financial Inclusion Outcomes	The extent to which usage improves access to payments, savings, credit, insurance, transfers, financial security or economic opportunities

Source: Authors compilation

This distinction is consistent with the multidimensional approach adopted by RBI, which separates access from usage and quality. It is also supported by the Global Findex evidence showing that India has achieved substantial account ownership while digital payment usage remains comparatively lower.

The distinction is particularly important for rural households. An individual may hold a bank account yet rely on family or local intermediaries for digital transactions, highlighting a gap between access and autonomy. Similarly, an individual may use UPI for small payments but avoid digital credit, insurance or investment services because of unfamiliarity or perceived risk. Consequently, FinTech adoption should not be treated as a homogeneous behavioural outcome.

Recent research on Indian rural households also reinforces the importance of trust, usefulness and perceived risk in FinTech adoption. A 2026 study applying TAM and UTAUT to Indian rural households reported that perceived trust, perceived usefulness and perceived risk were important factors in adoption. This provides further support for extending conventional technology-acceptance models beyond usefulness and ease of use.

THEORETICAL FOUNDATIONS OF FINTECH ADOPTION

1. Technology Acceptance Model

The Technology Acceptance Model (TAM), developed by *Davis (1989)*, explains technology acceptance primarily through perceived usefulness (PU) and perceived ease of use (PEOU). Perceived usefulness concerns the extent to which a person believes that using a technology will improve performance, while perceived ease of use concerns the degree to which the technology is perceived as requiring little effort.

For rural FinTech adoption, perceived usefulness may emerge from practical benefits such as reducing travel to bank branches, receiving payments quickly, facilitating merchant transactions or accessing government transfers. Perceived ease of use may depend upon interface simplicity, language, authentication procedures and the user's digital capability.

TAM is particularly valuable for the present chapter because rural adoption is unlikely to occur when users cannot identify a clear economic or practical benefit. However, TAM by itself does not fully explain the influence of community norms, infrastructure, behavioural control, technology readiness or financial risk.

2. Unified Theory of Acceptance and Use of Technology

UTAUT integrates elements from several earlier technology-adoption theories and identifies four major determinants: performance expectancy, effort expectancy, social influence and facilitating conditions *(Venkatesh et al., 2003).*

Performance expectancy overlaps substantially with TAM's perceived usefulness, while effort expectancy overlaps with perceived ease of use. Combining these constructs directly would introduce theoretical redundancy; hence, they are synthesized into unified dimensions of utility and effort. Perceived usefulness/performance expectancy is treated as a unified cognitive construct representing expected economic and functional benefits. Perceived ease of use/effort expectancy is treated as a unified construct representing the cognitive and operational effort required.

UTAUT's distinctive contribution is therefore retained through social influence and facilitating conditions. In rural Assam, social influence may arise from family members, community leaders, merchants, SHG members and local financial intermediaries. Facilitating conditions include smartphone access, connectivity, electricity, customer support and the availability of local assistance.

3. Theory of Planned Behavior

The Theory of Planned Behavior (TPB) proposes that behavioural intention is influenced by attitude, subjective norms and perceived behavioural control, with intention and perceived behavioural control contributing to actual behaviour *(Ajzen, 1991).*

The present framework does not reproduce all TPB constructs because there is considerable overlap between subjective norms and UTAUT's social influence. Instead, perceived behavioural control (PBC) is retained as a distinct contribution because it captures an important issue in rural digital finance: whether users believe that they can independently perform a digital financial transaction.

PBC is therefore closely connected with digital self-efficacy. A user may believe that UPI is useful but still avoid independent usage because of fear of entering the wrong PIN, selecting the wrong recipient or being unable to resolve a failed transaction.

4. Technology Readiness Index

The Technology Readiness Index (TRI) explains individuals' propensity to embrace new technologies. *Parasuraman (2000)* conceptualised technology readiness through four dimensions: optimism and innovativeness as drivers, and discomfort and insecurity as inhibitors. TRI 2.0 subsequently streamlined the original scale while retaining the broader concept of individual readiness to embrace technology *(Parasuraman & Colby, 2015).*

TRI is useful in the rural FinTech context because two individuals with similar access to smartphones and networks may respond differently to the same technology. One may experiment with digital services, while another may remain dependent on cash or intermediaries.

Importantly, technology readiness should not be treated as synonymous with perceived risk. Insecurity is a dimension of technology readiness, whereas perceived risk concerns anticipated negative consequences of using a service. Perceived risk is therefore incorporated separately in the present

framework. Research on electronic service adoption demonstrates that perceived risk can inhibit adoption and can be incorporated alongside technology-acceptance variables *(Featherman & Pavlou, 2003).*

CONTEXTUAL DETERMINANTS OF FINTECH ADOPTION IN RURAL ASSAM

1. Perceived Usefulness and Economic Utility

For rural users, FinTech adoption is likely to be strongly associated with visible economic utility. Digital payments can reduce the need for physical travel, facilitate immediate transfers and support transactions between households, merchants and service providers. The usefulness of digital finance is therefore likely to be evaluated through everyday economic experiences rather than abstract technological sophistication.

This suggests that FinTech providers should demonstrate concrete use cases rather than merely promote digital applications. Farmers, wage earners, micro-entrepreneurs and SHG members may respond more strongly to applications that solve immediate financial problems than to technology marketed primarily through technical features.

2. Ease of Use, Language and Digital Literacy

Ease of use becomes particularly important when users have limited prior experience with digital systems. Interface complexity, unfamiliar terminology, multiple authentication steps and unclear transaction notifications may increase cognitive burden.

Language is an important component of this problem. A multilingual environment requires more than literal translation; it requires user-centred design that reflects local vocabulary, comprehension levels and transaction practices. Voice assistance, icon-based navigation, clear confirmation messages and simplified error-resolution procedures may therefore strengthen perceived ease of use and behavioural control. The policy objective should consequently shift from merely making applications "available in local languages" to developing vernacular and low-literacy-oriented financial interfaces.

3. Social Influence and Community-Based Adoption

Technology adoption is socially embedded. UTAUT's social influence construct is particularly relevant in communities where technology-related decisions may be shaped by family members, merchants, SHGs, community leaders and local financial agents.

For a first-time user, observing a trusted community member successfully conducts a digital transaction can reduce uncertainty. Social learning can therefore reinforce both confidence and perceived usefulness.

This is especially relevant where digital financial literacy is uneven. Rather than treating digital literacy as an exclusively individual attribute, financial institutions can use community-based learning models in which users learn through demonstration and repeated assisted practice.

4. Perceived Behavioural Control and Digital Self-Efficacy

The ability to perform transactions independently represents a crucial transition from assisted to autonomous usage. A user who always requires another person to enter a PIN, select a recipient or interpret a transaction message has technically accessed digital finance but has not necessarily achieved autonomous digital inclusion.

PBC therefore occupies an important position between intention and actual usage. Training, repeated exposure and assisted practice can strengthen confidence. This also explains why the presence of a trusted intermediary may facilitate eventual independent use.

5. Facilitating Conditions and Infrastructure

Facilitating conditions determine whether positive intentions can become actual behaviour. Smartphones, network connectivity, electricity, merchant acceptance, service availability and customer support are therefore not merely background conditions.

RBI's digitalisation review highlights that India's payment transformation has involved technology, agents, institutions and policy interventions rather than technology alone. The rural context makes this interaction especially important because even a highly usable application cannot compensate for persistent connectivity or service-access constraints. Consequently, infrastructure should be incorporated directly into the adoption framework rather than treated merely as an external environmental issue.

6. Trust and Perceived Risk

Financial transactions involve a higher level of perceived consequence than many ordinary digital activities. Users are not merely concerned about whether an application works; they are concerned about whether their money will remain secure.

Perceived risk may include: financial loss; transaction failure; privacy and security concerns; uncertainty regarding refunds or failed transactions; fraud and phishing; inadequate grievance redressal. The importance of risk is supported by research integrating perceived risk into technology-acceptance models. Recent Indian rural-household research likewise identifies trust and perceived risk among important FinTech adoption factors.

Trust should therefore be treated separately from risk. Users may perceive a transaction as risky but nevertheless use it if they have strong trust in their bank, intermediary or payment system. Conversely, technically secure systems may remain underused if users lack institutional confidence.

THE PHYGITAL MECHANISM: HUMAN INTERMEDIARIES IN RURAL FINTECH ADOPTION

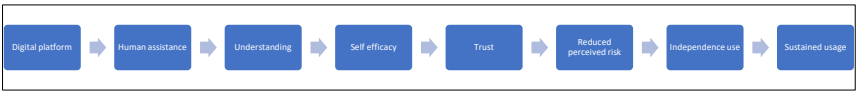
One of the most important contextual insights emerging from the rural financial inclusion literature is the continuing relevance of human intermediaries.

The Business Correspondent (BC) model was designed to extend banking services beyond conventional branches and has become an important technology-supported mechanism for reaching geographically dispersed populations. Research on the BC model highlights its role as an agent-based alternative to branch-centred banking.

The role of Bank Sakhis is particularly relevant to rural women. The Assam State Rural Livelihoods Mission officially maintains a financial-inclusion and BC Sakhi framework, including resources and policies concerning the deployment of BC Sakhis. Its current programme documents also emphasise digital transaction initiatives and the use of BCA/DigiPay Sakhi channels.

This suggests the usefulness of a phygital perspective: financial inclusion occurs through the interaction of physical human assistance and digital financial technology.

The mechanism can be represented as:



Source: Authors compilation

The intermediary therefore does not merely compensate for technological weakness. The intermediary can function as a behavioural bridge between technology and the user.

This proposition is especially relevant to rural Assam because the institutional ecosystem already includes BCs, CSPs and Bank Sakhis. Rather than replacing human agents, inclusive FinTech policy should leverage human mediation to transition rural users from assisted to autonomous digital participation.

GENDER AND INCLUSIVE FINTECH ADOPTION

The World Bank's India Global Findex evidence indicates that while account ownership has achieved considerable gender parity, digital-payment usage continues to display a gender gap. This distinction demonstrates why opening accounts is insufficient. Women may possess formal accounts but face barriers relating to device ownership, mobility, digital confidence, household decision-making and control over financial resources. Evidence from rural women's financial-inclusion programmes also demonstrates the potential role of women BC agents in bringing financial services closer to rural communities.

For Assam, the implication is that Bank Sakhi and women-led financial-intermediary models should not be understood simply as employment programmes. They can potentially operate as gender-sensitive technology-adoption mechanisms by reducing social distance, providing trusted assistance and increasing women's confidence in using financial technology.

DEVELOPMENT OF AN INTEGRATED CONCEPTUAL FRAMEWORK FOR FINTECH ADOPTION IN RURAL ASSAM

The preceding discussion supports an integrated framework consisting of five layers shown in the figure below:

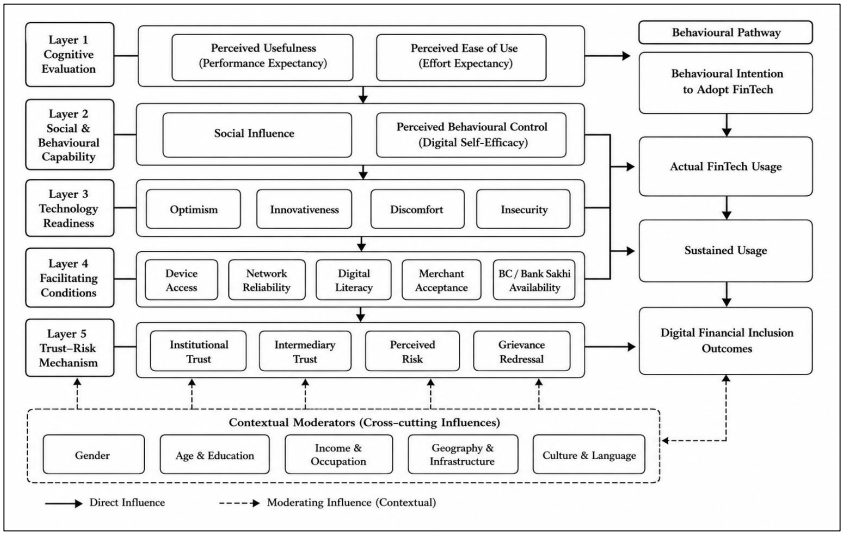


Fig: 1

Source: Author's conceptualisation based on Davis (1989), Ajzen (1991), Parasuraman (2000), Parasuraman and Colby (2015), and Venkatesh et al. (2003), contextualised for rural FinTech adoption in Assam

The proposed conceptual framework integrates complementary dimensions of all the five layers to explain FinTech adoption behaviour in rural Assam. The framework conceptualises adoption as a multi-dimensional socio-technical process in which individual perceptions interact with social, infrastructural and institutional conditions.

The first layer, Cognitive Evaluation, represents users' initial assessment of the functional value and usability of FinTech services. Perceived usefulness or performance expectancy reflects the extent to

which individuals believe that FinTech can provide tangible benefits, such as convenience, faster transactions, reduced travel and improved access to financial services. Perceived ease of use or effort expectancy captures the extent to which users perceive digital financial technologies as simple, understandable and manageable. These constructs are primarily derived from the Technology Acceptance Model *(Davis, 1989)* and UTAUT *(Venkatesh et al., 2003)*.

The second layer, Social and Behavioural Capability, incorporates social influence and perceived behavioural control. Social influence recognises that adoption decisions in rural communities can be shaped by family members, peers, merchants, self-help groups and other trusted community actors. Perceived behavioural control, derived from the Theory of Planned Behavior *(Ajzen, 1991)*, represents an individual's confidence in his or her ability to perform digital financial activities independently. This dimension is particularly relevant where users possess access to digital services but remain dependent on others for conducting transactions.

The third layer, Technology Readiness, captures users' predisposition towards adopting and experimenting with technology. Following *Parasuraman (2000)* and *Parasuraman and Colby (2015)*, technology readiness incorporates positive dimensions such as optimism and innovativeness and inhibiting dimensions such as discomfort and insecurity. The inclusion of this layer recognises that individuals exposed to similar technological environments may nevertheless demonstrate different levels of willingness to engage with FinTech services.

The fourth layer, Contextual Conditions or Facilitating Conditions, reflects the environmental factors required to convert positive attitudes and intentions into actual usage. These include access to smartphones and other devices, network reliability, electricity availability, merchant acceptance, digital literacy, language accessibility and the availability of Business Correspondents (BCs), Customer Service Points (CSPs) and Bank Sakhis. In the rural Assam context, these conditions are particularly important because technological intention cannot easily translate into actual behaviour when the necessary physical, digital or human infrastructure is unavailable.

The fifth layer, Trust–Risk Mechanism, addresses the distinctive nature of financial technology adoption. Unlike many non-financial digital services, FinTech involves direct exposure to monetary, privacy and security risks. Institutional trust, trust in intermediaries, perceived transaction security, perceived financial risk and confidence in grievance-redressal mechanisms may therefore influence users' willingness to adopt and continue using digital financial services. The framework treats trust and perceived risk as distinct but interconnected mechanisms, rather than equating risk with technology readiness.

These five layers move towards the behavioural pathway, beginning with behavioural intention and progressing to actual FinTech usage and subsequently to sustained usage. The framework deliberately distinguishes these stages because intention does not necessarily result in actual behaviour, and initial usage does not necessarily imply continued engagement. Facilitating conditions, trust, perceived risk and human assistance can influence the extent to which intention is translated into actual and sustained usage.

An important contextual feature of the framework is the role of human intermediaries, particularly BCs, CSPs and Bank Sakhis. Their inclusion reflects the possibility of a phygital model of rural financial inclusion, in which digital technologies operate alongside human assistance. Such intermediaries can reduce uncertainty, provide transaction support, improve digital confidence and facilitate the transition from assisted usage towards independent digital financial behaviour.

The final outcome of the framework is digital financial inclusion, understood not merely as ownership of a bank account or access to a digital payment facility, but as meaningful, effective and continued participation in formal financial services. Thus, the framework conceptualises FinTech adoption as a progression from cognitive evaluation and behavioural capability to intention, actual usage, sustained usage and ultimately broader financial inclusion outcomes.

This proposed framework is conceptual and does not claim empirical validation at this stage. Rather, it synthesises established technology-acceptance theories with contextual determinants relevant to rural FinTech adoption and provides a theoretically grounded set of relationships that can be tested through future primary research in rural Assam.

PROPOSED RESEARCH PROPOSITIONS

Based on the integrated framework, the following propositions are advanced:

[1] P1: (Core Acceptance Drivers): Perceived usefulness and perceived ease of use positively influence behavioural intention to adopt FinTech services in rural Assam.

[2] P2: (Social + Control Mechanism): Social influence and perceived behavioural control positively influence behavioural intention and independent FinTech usage.

[3] P3: (Readiness Effect): Technology readiness positively influences behavioural intention to adopt FinTech services.

[4] P4: (Contextual Conversion Mechanism): Facilitating conditions, trust and perceived risk are expected to influence the translation of behavioural intention into actual and sustained FinTech usage.

[5] P5: (Phygital Mediation Effect): Human intermediaries such as BCs, CSPs and Bank Sakhis are expected to mediate the relationship between behavioural intention and actual FinTech usage by increasing user confidence, improving understanding and reducing perceived risk

These propositions provide a basis for future survey-based studies using regression, structural equation modelling or other appropriate quantitative techniques.

POLICY AND MANAGERIAL IMPLICATIONS

1. **Move from access-oriented to usage-oriented financial inclusion:** The policy focus should progress from account opening towards active and meaningful use. RBI's FI-Index already provides a useful institutional foundation by distinguishing access, usage and quality. Financial inclusion programmes should therefore include indicators of transaction frequency, independent usage, product diversity, user confidence and grievance resolution.
2. **Develop vernacular and low-literacy-oriented interfaces:** FinTech providers should design for users rather than merely translate existing interfaces. Voice support, visual navigation, simplified transaction flows, clear error messages and culturally appropriate communication can reduce cognitive barriers.
3. **Strengthen Bank Sakhi and BC ecosystems:** The evidence on BC models and the institutional infrastructure maintained by ASRLM suggest that human intermediaries can remain relevant even in increasingly digital financial systems. Bank Sakhis should therefore be positioned as digital-financial facilitators who provide transaction assistance, financial literacy, fraud awareness and transition support towards independent usage.
4. **Improve infrastructure resilience:** Connectivity should be treated as a core component of financial infrastructure. Low-bandwidth applications and appropriate offline or near-offline payment mechanisms can be useful in areas with intermittent connectivity. NPCI introduced UPI Lite X specifically to enable offline transactions on compatible devices, demonstrating the technological possibility of designing for connectivity constraints. However, such technologies should be recommended only where they are operationally appropriate, compatible with users' devices and accompanied by adequate consumer awareness.
5. **Strengthen trust and grievance redressal:** Digital financial inclusion requires more than technical security. Users need to know what happens when a transaction fails, money is debited without confirmation or fraud occurs. Clear complaint procedures, rapid dispute resolution and understandable security communication can reduce perceived risk.

NPCI's UPI architecture itself includes mechanisms for transaction complaints, illustrating how grievance redressal can be incorporated into digital payment ecosystems.

6. **Address gendered digital access:** Women should be supported not only as beneficiaries but also as users, entrepreneurs and financial intermediaries. Training programmes should address personally controlled device access, digital confidence and independent transaction capability.
7. **Build a complete local digital ecosystem:** FinTech adoption cannot be achieved solely by distributing applications. The local ecosystem must include:

Device + Network + Bank Account + Payment Infrastructure + Merchant Acceptance + Human Support + Consumer Protection

The absence of any one component can reduce the value of the others.

CONCLUSION

FinTech has created significant opportunities for expanding financial inclusion; however, technology availability does not automatically produce meaningful financial participation. The central challenge for rural Assam is therefore not simply how to make digital financial services available, but how to enable individuals to understand, trust, adopt and repeatedly use them.

This chapter has developed an integrated framework combining TAM, UTAUT, TPB and TRI while extending the analysis through trust, perceived risk, facilitating conditions and human-mediated financial services. The integration is deliberately selective. TAM contributes the cognitive evaluation of usefulness and ease of use; UTAUT contributes social influence and facilitating conditions; TPB contributes perceived behavioural control; and TRI contributes individual technology readiness. Perceived risk and trust are treated separately because neither is conceptually interchangeable with technology readiness.

The resulting framework positions FinTech adoption as a progression from access and awareness to acceptance, adoption, sustained usage and financial inclusion outcomes. Within rural Assam, this progression is further shaped by infrastructure, digital literacy, language, gender, social influence and institutional confidence.

The chapter's central contextual contribution is the proposition that rural FinTech adoption may be better understood as a phygital process rather than a purely digital one. BCs, CSPs and Bank Sakhis can act as bridges between users and digital financial technologies by reducing uncertainty, increasing confidence and supporting the transition towards independent use. Assam's existing institutional architecture for BC Sakhi and financial inclusion provides a relevant foundation for such an approach.

The framework remains conceptual and requires empirical validation. Future research should test the proposed relationships using primary data from different rural contexts in Assam, while comparing groups by gender, age, education, occupation, digital literacy and type of FinTech service used. Such research can establish whether the proposed determinants operate similarly across UPI, AePS, mobile banking, digital credit, insurance and other services.

Ultimately, inclusive rural transformation requires a shift from viewing FinTech as a technological delivery mechanism to understanding it as a socio-technical financial ecosystem. When digital infrastructure, appropriate product design, human support, consumer protection and user capability develop together, FinTech has greater potential to contribute not only to financial access but also to sustained financial participation and broader rural economic transformation.

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--Chapter--

Financial Technology for Rural Transformation: Bridging the Financial Inclusion Divide

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FinTech Adoption and Business Sustainability of Rural Entrepreneurs in Assam: A Secondary Data Analysis

Melody Narzary[1]

ABSTRACT

FinTech (Financial Technology) can help create better access to financial services, make it easier to conduct digital transactions and assist in the management of business operations. For entrepreneurs who live in rural areas, there are many forms of digital financial services available, including mobile banking, UPI (Unified Payments Interface), QR Code payments, and online banking. While there are potential benefits to FinTech, these depend upon digital literacy, trust, connectivity, awareness, and reliable support systems. Using secondary data from published studies, this paper explores the adoption of FinTech by rural entrepreneurs in Assam and how FinTech may affect the sustainability of their businesses. The review of the literature shows that FinTech adoption has grown, however, demographic variations, misperceptions, trust issues, perceived utility, and practical constraints still influence how people use FinTech. Research in Northeast India indicates that there are numerous possibilities for expanding digital payment systems among merchants. However, the current literature does not provide clear evidence as to whether or not FinTech adoption directly contributes to the long-term sustainability of rural enterprises in Assam. Therefore, this paper concludes that digital financial services may contribute to the sustainability of businesses when combined with financial literacy, reliable digital infrastructure, consumer protection mechanisms, and access to appropriate financial services. This study provides a regional synthesis of prior research and identifies priorities for further enterprise-level research.

Keywords: FinTech adoption, Business sustainability, Rural entrepreneurship, Financial services, Digital payments

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INTRODUCTION

The role of rural entrepreneurs is essential for employment generation, income generation and local economic growth. The small businesses that operate in rural areas can take many forms including retail shops, agricultural businesses, handicraft/handloom units, food processing businesses, trading businesses,

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and service businesses. All of these types of businesses provide a means to utilize the natural resources available to them locally. In addition, they contribute to providing families with a living through supporting their households' livelihoods. Furthermore, they generate economic opportunities for residents living in communities with limited access to formal employment.

Rural entrepreneurs have many advantages but also face several disadvantages including; limited availability of formal credit, incomplete/missing financial records, lack of access to markets, higher than average costs for each transaction, and insufficient understanding of contemporary financial products. these barriers will impact their ability to operate effectively on a day-to-day basis, react to unplanned events and maintain business operations.

The development of financial technology (often called FinTech), provides an avenue to solve many of the issues that exist. FinTech is defined as the application of digital technology to provide or enhance financial products and/or services *(Xu et al., 2025)*. Some examples of FinTech in India are; UPI (Unified Payment Interface), QR code-based payments, Mobile Banking, Internet Banking, Digital Wallets and other Technology-Enabled Financial Services.

Digital payments can assist companies in receiving payment from their clients, as well as making transfers to suppliers. Entrepreneurially minded individuals can track cash flow through digital records of transactions. Additionally, access to formal financial services can provide more options for saving, borrowing, and managing financial risks. The Global Findex Database 2021 by the World Bank shows that there is growing international account ownership and use of digital payments; however, there continue to be disparities in accessing and utilizing these financial tools among various demographics (*Demirgüç-Kunt et al., 2022).*

Digital financial services provide an opportunity for entrepreneurs, but it is not a given that they will take advantage of it. Entrepreneurs must first know what digital financial services exist, learn how to utilize them properly, and trust the security of the service. There are many obstacles that could discourage entrepreneurs from using digital financial services such as poor internet connectivity, digital fraud, failed transactions, and a lack of available customer support *(Ghosh & Ghosh, 2026)*.

Rural entrepreneurial differences are best explained through technology adoption theories. *Davis*' *(1989)* model suggests that both how useful an individual believes a new technology will be and how easily they believe the technology will be used affects whether or not that individual accepts the use of the new technology. After *Davis, Venkatesh et al. (2003*) developed the Unified Theory of Acceptance and Use of Technology (UTAUT). The UTAUT model identifies four main components that affect technology acceptance; performance expectancy, effort expectancy, social influence, and facilitating conditions. All four of these components can help explain why certain rural entrepreneurs have adopted FinTech quicker than other rural entrepreneurs.

Assam's regional context is what makes the above-mentioned issues especially pertinent. *Das and Das* (2020) studied how bank customers in Hojai district perceived, adopted, and used FinTech services. They discovered links between demographic factors and FinTech usage, and they determined that misconceptions are barriers to FinTech adoption. In 2023, Das and Das studied FinTech adoption by prime household earners in Assam during the COVID-19 pandemic. Both of these studies have provided significant data on digital financial behaviour in Assam; however, neither study focused solely on rural entrepreneurs.

The Better Than Cash Alliance report of 2021 showed that there are significant opportunities for merchants to become digitized. Additionally, the alliance looked at how the digital payment system is being used through the use of data sets, meetings with organizations, and surveys of merchants located within Assam and Mizoram. The findings from this research show how important digital payments can be to trade within the region. However, they also demonstrate how important it will be to create an environment where merchants can easily transition to using digital payments.

Business sustainability is defined by a business's capacity to maintain its operational integrity for an extended period of time; while also being financially stable; having efficient resource management; and being capable of responding to fluctuations in the economy *(Rezaee, 2016)*. This is much broader than simply achieving profitability in the short-run. Businesses that are sustainable will have effective cash flow management; reliable customer transaction processing; cost controls; and the ability to react quickly when there are interruptions in their operations.

FinTech could help achieve these results through increasing transaction ease and record keeping of financial records. However, the extent to which it does so is dependent upon how the entrepreneurs utilize the digital services and if the benefits of using such services are greater than the potential negative consequences or costs.

Against this backdrop, the current study will compile the available research on FinTech adoption, digital payment methods, and entrepreneurship in rural areas (with an emphasis on Assam). In addition, it will explore the possible relationships between FinTech and sustainable business practices; identify areas where additional research is needed; and provide recommendations to policymakers, financial service providers, and entrepreneurs in rural areas.

OBJECTIVES OF THE STUDY

The primary goal of this study was to review previous studies on FinTech adoption, and what relationships may exist between FinTech adoption and the sustainability of businesses operated by rural entrepreneurs in Assam.

The specific objectives are:

1. To find the primary types of FinTech that apply to rural entrepreneurship.
2. To examine the variables that influence how individuals who utilize financial services and businesses (merchants) in Assam and Northeast India adopt FinTech.
3. To evaluate both the possible advantages and disadvantages of using FinTech within a rural business setting.
4. To examine the connection among FinTech implementation, access to financial services (inclusion), and long-term viability of businesses (sustainability) based on available literature.
5. To find areas where there are gaps in the current research, and suggest ways to increase responsible adoption of FinTech by rural entrepreneur.

REVIEW OF LITERATURE

1. Technology Acceptance Model

Davis (1989) introduced a model for the acceptance of information technology called the Technology Acceptance Model (TAM). This model identifies two main variables that influence an individual's decision to accept and use a given technology; perceived usefulness and perceived ease-of-use.

Perceived Usefulness: This represents the level of belief an individual holds regarding how well a technology can assist in performing a job-related function. Perceived Ease of Use: This is the level of belief an individual has as to how easy or difficult it would be to utilize a particular technology. Perceived usefulness can be seen in rural entrepreneurship through several aspects such as receiving customer payments in a timely manner, reducing the amount of time that is spent on processing cash and having access to transaction records. Perceived ease of use will vary depending on if an entrepreneur can understand how to operate the payment application, complete transactions with confidence and solve standard technical problems. The model implies that providing access to digital payment systems does not suffice. It is necessary for entrepreneurs to acknowledge the practicality of these systems and feel reasonably confident in using them.

2. Unified Theory of Acceptance and Use of Technology

The UTAUT was developed by *Venkatesh et al. (2003)*, which combined numerous models that address how people adopt technology. The framework focuses on performance expectations, effort expectations, social influences and supporting circumstances. All of these variables are helpful in understanding how rural businesses adopt technology.

Performance expectancy is defined by how well an entrepreneur believes that FinTech can enhance their company's daily functions. Effort expectancy is based upon the amount of time and effort an entrepreneur will need to spend learning to utilize FinTech in order to improve their company's overall operation. Social influence refers to the amount of support an entrepreneur receives from their customers, suppliers, family members, and peers when utilizing FinTech to benefit their business. Lastly, facilitating conditions are those which provide an entrepreneur with the resources needed to use FinTech effectively, such as internet access, compatible hardware/software, technical support, etc.

3. FinTech Adoption Among Bank Customers in Hojai, Assam

The study by *Das & Das (2020)* investigated customer views on FinTech services, how customers were adopting FinTech services, and what the barriers to FinTech service use were for bank customers in the Hojai district of Assam.

The study included responses from 215 people and found there was a strong correlation between people's demographic information and how they used technology-based financial services. The authors identified that younger generations (Millennials and Generation Z) had a greater level of knowledge of technology-based financial services, as well as a higher frequency of utilizing these services when compared to older generations. In addition, the authors identified misconceptions as a barrier to increasing the adoption of technology-based financial services.

The current study is unique in that it offers data collected in Assam as opposed to just using data collected at the national level, as well as at the international level. This research shows that digital financial habits vary among demographic populations and that awareness of digital finance is a critical factor.

In addition to the previous points made about the study's limitations, the sample group was composed of bank customers and not a group of only rural entrepreneur. Thus, we cannot determine how adopting FinTech affects business continuation, cash-flow management, and the viability of rural enterprise.

4. FinTech Adoption During COVID-19 in Assam

Das and Das (2023) studied how people used FinTech during the COVID-19 pandemic by using data collected on 1,066 primary wage earners in households that had bank accounts in Assam. They investigated what is related to technology adoption by using technology acceptance theories and examining how different aspects of technology affect its use. The authors' results show that there has been a growth in FinTech usage over the time frame they used. Also, the authors emphasize the significance of perceived usefulness, trust, social influence, perceived risk and government support. This study provides insight into the way in which external factors and an individual's perception can affect their use of digital financial products. Due to its geographical focus, this study is especially applicable to this paper.

Therefore, the study does not provide direct evidence of whether rural entrepreneurial businesses are sustainable. However, the study does provide some context about why individuals with primary income in their households may or may not use digital financial services to support their entrepreneurial activities.

5. Digital Payments and Merchant Adoption in Northeast India

The Better Than Cash Alliance, in partnership with India's Ministry of Electronics and Information Technology, released a report entitled "Catalyzing Responsible Digital Payments in the North East Region of India" (2021). The study of the regional digital payment ecosystem relied upon a total of ten different

data sets, nine reports, and interviews/consultations with representatives from twenty-five organizations. In addition to these sources, the results of the research were based on the responses to twelve types of merchant surveys/interviews conducted in both Assam and Mizoram. The report has provided a merchant digitisation opportunity that is about $18 billion (or ₹1.3 lakh crore) based on 1.5 million merchants within the region being able to adopt digital payments. This represents an estimated opportunity that the report has found; it does not represent the amount of money spent on digital transactions to date, nor does it measure the profit generated by rural merchants. The report also emphasized the involvement of women and rural merchants and suggested strategies to increase the number of merchants who accept credit cards. The evidence is good for us to use because it is about the regional payment system and its merchants. However, a digitisation opportunity as described above does not prove that by using digital payments you will be able to survive, make more money or stay in business for longer.

6. Financial Inclusion and Digital Payments

In their 2021 World Bank Global Findex Database, *Demirgüç-Kunt et al., (2022)* assessed financial account ownership, digital payments and financial resilience among countries. This report contains evidence of the international expansion of formal financial account access and digital payment service utilization. The report also documents variations in access and usage among different demographic and economic categories. Access to a formal financial service system (which includes sending/receiving money, saving/credit) makes it easier for rural entrepreneurs to manage their money. Digital payment systems can provide a way for entrepreneurs to track their business transactions electronically.

However, the ability to open an account and make purchases using electronic means does not equal business success. The Global Findex has provided evidence regarding financial inclusion at the community level; however, it does not provide evidence that shows how FinTech affects the long-term performance of rural enterprises in Assam.

7. FinTech Adoption and Business Sustainability Among SMEs

Kurniasari et al. (2025) studied the relationship between financial literacy, FinTech usage, access to financing, business performance and sustainability for Indonesian Small & Medium Sized Enterprises (SMEs). They used a serial mediation model to examine the relationship between each of these variables. In doing so, they have shown that it is important to consider both an individual's level of financial literacy and their access to funding as well as the adoption of technology in order to understand business results. FinTech can impact the way businesses are sustainable by providing various options for business owners to utilize resources, beyond simply using technology. Business owners will need to comprehend the service(s) that they are using, effectively manage their money and find appropriate financial products.

However, as this study was carried out in Indonesia and specifically targeted small-and-medium-sized enterprises (SMEs), it cannot automatically be inferred that the results will be applicable to rural entrepreneurs operating in Assam until more studies have been completed.

RESEARCH GAP

There are numerous existing research studies that provide relevant empirical data regarding the use of FinTech, technology acceptance, and digital financial inclusion. Both *Davis (1989) and Venkatesh et al. (2003)* have provided theories to help explain why individuals accept technology. Additionally, *Das and Das (2020)* analysed FinTech adoption among banking customers in Hojai, and *Das and Das (2023)* studied FinTech usage by household prime earners in Assam. Lastly, the Better Than Cash Alliance (2021) has provided regional evidence concerning the digital payments ecosystem and opportunities for merchants to become more digitally integrated in Northeast India. Three gaps emerge from the reviewed literature:

1. The studies conducted specifically for Assam have focused on bank customers and primary household earners, rather than only focusing on rural entrepreneurs.
2. A majority of the regional data on this topic relates to how people adopt, use and make digital payments. There needs to be more direct data related to the outcome of using these services for business purposes including; transaction efficiencies, managing cash flows, continuing operations during difficult times (such as pandemics) and maintaining long term viability.
3. Research on small-to-medium-sized enterprise (SME) development from an international perspective may not accurately represent the realities of operating a rural business in Assam. This includes factors such as access to digital technology, levels of financial literacy among rural entrepreneurs, and the presence of supporting organizations or resources for rural businesses.

RESEARCH METHODOLOGY

1. Research Design

The study utilizes secondary data as part of its descriptive and analytical research methodology. This includes the synthesis of existing published research, institutional reports, and theoretical literature on FinTech adoption, digital payments, financial inclusion, and business sustainability.

2. Sources of Data

The paper draws on the following sources:

- Peer-reviewed research on technology acceptance and FinTech adoption.
- Empirical studies conducted in Assam.
- Institutional reports on digital payments in Northeast India.
- World Bank publications on financial inclusion and digital payments.
- Published research examining FinTech and business sustainability among SMEs.

3. Selection and Analysis of Literature

The literature was organised into four broad themes:

- Theoretical explanations of technology acceptance.
- FinTech adoption and usage in Assam.
- Digital payment adoption among merchants in Northeast India.
- Financial inclusion, enterprise performance and business sustainability.

4. Method of Analysis

The study has conducted using a thematic comparison and descriptive synthesis method. It identifies similar themes among various studies, compares how each study focuses on those themes, and synthesizes the descriptions from each study into a unified description of the themes. The analysis separates reported results from likely mechanisms and potential connections that have yet to be examined. This separation is required because the finding that FinTech is being used does not necessarily imply that there has been an increase in the sustainability of businesses.

FINDINGS

The information presented here has been taken directly from existing research and institutional reports.

1. FinTech Adoption Differs Across Demographic Groups

Das and Das (2020) conducted a study involving 215 bank customers in the Hojai district of Assam. They found that there are significant relationships between demographic factors and the use of FinTech. Millennials and Generation Z were found to have a greater level of awareness and usage of FinTech compared to Generation X and baby boomers.

A study was conducted which showed that misconceptions were a hindrance to the use of technology-based financial services. The use of digital financial services is not expected to be identical for all users. Training programs and awareness-building initiatives will need to consider factors such as age, level of education, experience using mobile applications and self-assurance when making purchases online. However, the results presented here apply to bank customers, and cannot be assumed to represent trends in demographics for rural entrepreneurs.

2. FinTech Usage Expanded During the COVID-19 Period

Das and Das (2023) studied FinTech adoption of 1,066 household prime earners who had bank accounts in Assam. The authors found that there was an increased level of usage of FinTech services over the time frame that they studied. They also looked at the factors related to FinTech service adoption. The research studied how people accepted technology and other factors like confidence, believed use, social influences, perceived dangers, and help from the government.

External factors may cause people to utilize digital financial services, but trust and expected outcomes are still key components of adopting digital financial services. In the case of rural entrepreneurs, these factors will likely affect how they feel about being paid digitally, and whether they would choose to use mobile banking. While the increased use of digital financial services during the pandemic doesn't prove that businesses became more sustainable; it does demonstrate that many businesses utilized digital financial services to help manage their operations during the pandemic.

3. Northeast India Has a Significant Merchant Digitisation Opportunity

The Better Than Cash Alliance (2021) has estimated that there is a potential for US$18 billion (or INR 130,000 crores) if 1.5 million merchants in Northeast India are able to go digital. The report utilized data from several sources including institutional reports, consultations with stakeholders, and interviews with merchants within Assam and Mizoram. The expansion of merchant digitalization represents a substantial regional opportunity. Increased access to digital payments can make transacting more convenient for consumers and increase the use of legitimate digital financial services. However, the estimated opportunity does not represent revenue, profit or long-term sustainability that has already been generated. Rather, it should be viewed as an indication of what may be achieved, rather than a proven business result.

4. Financial Inclusion and Digital Payments Have Expanded Internationally

Demirgüç-Kunt et al., (2022) studied the increase in financial account holdings and digital payments in the Global Findex Database 2021. The report also noted ongoing disparities in access to and usage of financial services among various demographic groups.

Digital financial services are one component of a broader financial inclusion effort. The degree to which these services will be valuable to rural entrepreneurs depends on whether access to them results in actual use of the services and if they provide reliable and cost-effective services. While global evidence provides some insight into how these services are being used globally, it is not a substitute for data collected at the level of individual businesses in Assam.

5. Business Sustainability Requires More Than Digital Payment Adoption

A study by *Kurniasari et al. (2025)* was focused on examining the relationship between FinTech adoption, financial literacy, access to financial services, business performance and sustainability within Small and Medium Enterprises (SMEs) in Indonesia. This study demonstrates the value of looking at many related issues when studying how businesses are affected.

FinTech can help with sustainability by allowing for more efficient transaction processing, better management of money, and greater access to financial resources. It cannot replace financial education, proper business practices, consumer demand, or appropriate funding sources. The degree to which there

are correlations between the aforementioned variables for rural entrepreneurship in Assam must be studied directly.

DISCUSSION

The research reviewed indicates that adopting FinTech is a process that includes accessing, being aware of, having confidence in, and using FinTech practically rather than simply choosing to use an online app.

Studies in Assam shows that there are various factors such as demographic differences and misconceptions about FinTech that could influence whether people use FinTech or not (Das & Das, 2020). This finding emphasizes the importance of providing digital financial education to consumers along with user-friendly financial products/services. To allow rural entrepreneurs to successfully adopt FinTech, it may be necessary to provide them with hands-on experience in using payment systems, verifying transactions, and dealing with unsuccessful transactions.

Das and Das (2023) found that an individual's adoption can vary depending upon their situation and what they perceive as being the advantages of using a product. Entrepreneurs will likely find digital payment methods most beneficial when there are customer expectations for convenient payment options or when the need for remote transaction capabilities arises. Although, just because an entrepreneur has adopted digital payment methods during a specific period of time does not mean that those same methods will continue to provide benefits to the company over the long-term.

The Better Than Cash Alliance's 2021 report points out that there are regions where there is potential for merchants to become digitized. This emphasizes that it is necessary to build infrastructure and merchant acceptance networks. Entrepreneur's will require more than just access to digital payment apps; they'll also need customers that are able to use them, reliable internet connection and accessible support when issues arise.

FinTech's potential impact on business sustainability is understood in a larger sense through the concept of financial inclusion. The record of digital transactions can assist an entrepreneur in monitoring their receipts and payments. Access to formal financial services can allow entrepreneurs to save or obtain loans. However, the effectiveness of both mechanisms depends on how frequently they are used and how well the business is managed financially. Digital payment systems alone cannot provide assurance that a business will generate enough revenue to cover its expenses, manage its costs effectively, or continue to be profitable.

Ultimately, research into Small and Medium-Sized Enterprises (SMEs), such as that conducted by *Kurniasari et al. (2025)*, demonstrates that FinTech is a part of the "financial literacy and access to finance" equation. In essence, this finding is consistent with a wider perspective regarding how to achieve sustainable entrepreneurship through using digital tools to supplement the knowledge of how to operate a business, have access to appropriate financial products and use good management practices.

The general body of research has provided possible avenues through which FinTech could enhance the long-term viability of rural businesses. While the potential for this relationship exists, the extent to which it is relevant to rural entrepreneurial ventures in Assam is not well documented within the reviewed studies. Thus, the primary value of the current study lies in synthesizing existing documentation and highlighting the requirement for direct enterprise-level research.

RECOMMENDATIONS

Following suggestions have been put forwarded for the purpose of the study:

1. **Strengthen Digital Financial Literacy:** Banks, financial institutions, local development organizations, and entrepreneurial support agencies can provide practical training in using UPI, QR code-based payment systems, mobile banking, validating transactions, and maintaining security online.

2. **Improve Digital Infrastructure:** Public authorities and service providers should work together to provide better access to reliable internet and appropriate devices to ensure that people can make use of digital financial services effectively.
3. **Improve Awareness and Trust:** Financial institutions and FinTech companies can use simple language to explain their process for conducting transactions, how much they charge for these services, what they do with the data collected from customer transactions, and how customers can report issues with their services.
4. **Strengthen Customer Support and Fraud Protection:** Entrepreneurs should have access to help if payment failures occur, transactions are delayed, or there is suspected fraud. Businesses providing payment services should make their customer complaint process easy to find and offer clear instructions for reporting potential fraudulent behavior.
5. **Integrate FinTech with Financial Management Training:** Digital payment systems should be adopted by businesses that are also using standard financial practices such as basic bookkeeping, cash flow planning, tracking expenses, and being responsible with debt.
6. **Support Inclusive Merchant Digitisation:** Programs that support the adoption of digital payments should address the specific requirements of rural merchants, female entrepreneurs, small businesses, and individuals who have limited knowledge about how to use digital technology.
7. **Encourage Enterprise-Level Research:** Universities and research organizations can do studies with entrepreneurs in rural areas of Assam. These studies will look at the use of FinTech by some entrepreneurs and not by others. Also, if entrepreneurs agree to share their business records, these studies can also look at those records.

IMPLICATIONS OF THE STUDY

1. Theoretical Implications

The study demonstrates the relevance of the theories of technology acceptance (TAM and UTAUT) in understanding how people adopt FinTech. TAM and UTAUT provide a framework for examining the factors that influence individuals' perceptions of usefulness, ease of use, social influence, and facilitating conditions. In addition, the studies on the sustainability of SMEs suggest that when studying the adoption of FinTech, we must also consider the levels of financial literacy and access to finance among those who will be using it. These different perspectives can be used in future studies to create a rural entrepreneurship model specific to the region of Assam.

2. Practical Implications

For rural businesses, FinTech provides a convenient method of receiving payments, transferring money, and tracking transactions. The usefulness of FinTech will be determined by how well the services provided by FinTech companies work, how inexpensive they are, what types of digital skills the users have, and how much the business owners use digital records to manage their businesses. Banks and FinTech companies can use this research to help build trust with customers, educate them about their services and provide excellent customer service. This research is also helpful for policy makers as it shows that providing access to digital payments for merchants should be done in conjunction with improving the physical infrastructure of a country, educating citizens on money management skills and protecting consumers from fraudulent activity.

3. Policy Implications

Policies that promote digital entrepreneurship should differentiate between what people can do with technology (access) and what they have accomplished using that technology (outcomes). A good way to measure if a policy is being implemented successfully is by counting how many merchants are using digital payment systems. However, this measurement alone cannot prove that the merchants will make

more money or stay in business longer. Therefore, evaluation of continued use, transaction reliability, digital literacy, user experience and measurable business results must be considered.

LIMITATIONS OF THE STUDY

This paper has several limitations.

1. The study uses existing literature and organizational data instead of collecting primary data directly from entrepreneurs in rural areas of Assam.
2. In addition to being based on different populations such as bank customers, household earners, merchants and SMEs, the studies reviewed also report on different types of respondents. Therefore, the findings of these studies cannot be used in conjunction with one another as if they had all been conducted using a single representative sample.
3. Most of the data used is based on how people were using digital financial services during the early stages of the pandemic, which could be different than their use now.
4. The review is a structured narrative synthesis rather than an extensive systematic review. Other academic database search strategies or official data sets might yield more relevant studies.
5. It is not possible for this study to determine if adopting FinTech has led to increased business sustainability for rural entrepreneurs in Assam. This determination will require an empirical research design that is suitable for such purposes.

CONCLUSION

The introduction of FinTech can aid rural entrepreneurs in conducting business through digital means, obtaining financial assistance and managing financial data. But the advantages of the use of FinTech are dependent upon successful implementation of the technology, dependable infrastructure, financial knowledge, confidence in the technology and the availability of suitable assistance.

The literature reviewed has demonstrated that there is an increasing number of bank customers and household earners who are adopting FinTech, as well as significant opportunities for digitising merchants throughout Northeast India. Additionally, international research has shown a relationship between FinTech and SME performance and sustainability. While these sources show that FinTech can be relevant to rural enterprise development, none of them provide definitive evidence of how FinTech will impact the long-term sustainability of rural enterprises in Assam.

Fintech can serve as a mean for achieving business success but does not provide a guarantee. Digital financial services will help to create long-term sustainability in businesses if they are easy to access, dependable, affordable, and integrated into sound financial management practices. Therefore, the addition of training, consumer protection, connectivity, and relevant financial products to digital technologies can complement the adoption process.

As a result, a main focus of future studies will be to gather empirical data directly from the rural entrepreneurs of Assam, so that the relationship between the adoption of FinTech and quantifiable business performance can be tested. Until these types of studies are conducted and the results are published, any conclusion regarding the impact of FinTech on the sustainability of businesses in rural areas should be made cautiously and based upon evidence.

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--Chapter--

Financial Technology for Rural Transformation: Bridging the Financial Inclusion Divide

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FinTech Adoption and Financial Empowerment of College Students: With Special Reference to Different Colleges of Nagaon District

Pritom Borah[1], Preety Borah[2]

ABSTRACT

Financial Technology (FinTech) has emerged as an important component of the modern financial system, transforming the way individual access and use financial services. The growing use of smartphone, internet connectivity, and digital platforms such as UPI, mobile banking, internet banking, and digital wallets has increased FinTech adoption, particularly among the younger generation. However, the FinTech adoption among college students have not been explored in a way as it should be particularly in under developed region like Nagaon district of Assam. The present study examined the role of FinTech adoption in enhancing the financial empowerment and financial independence of college students. The study also focuses on the frequency and purpose of FinTech usage and its role in improving students' access to financial services. By examining students from different colleges in Nagaon District, the study seeks to understand the relationship between FinTech adoption and students' ability to manage their financial activities independently. The results have revealed a significant role of digital financial services in promoting financial empowerment among college students.

Keywords: FinTech, Financial Empowerment, Financial Independence, Digital Financial Services, Digital payment, College Students, Nagaon, Assam

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INTRODUCTION

Financial technology (FinTech) has emerged as an important force in transforming the way individual access and use financial services. The rapid growth of digital platforms such as Unified Payments Interface (UPI), mobile banking, digital wallets, internet banking, and online investment services has made financial transactions faster, more convenient, and accessible *(RBI, 2024).* For young people, particularly college students, FinTech has become an increasingly important part of their financial activities, including making payments, transferring money, saving, budgeting, and accessing various financial services *(NPCI, 2025; RBI, 2024).* In India, the expansion of digital payment infrastructure and

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increasing smartphone usage has contributed significantly to the growth of FinTech services. However, differences in geographical location, educational background, socioeconomic conditions, and digital awareness can influence the extent to which individuals adopt and benefit from these services. Therefore, examining FinTech adoption among college students at the local level is important for understanding whether technological access is translating into meaningful financial empowerment. Assam has been experiencing a gradual shift towards digital financial services, supported by the expansion of digital payment infrastructure, including UPI, mobile banking, and other digital payment facilities. The Reserve Bank of India reported that digital-payment awareness in Assam was 75.8%, compared with 77.2% for India as a whole, indicating substantial awareness of digital payment services in the state *(RBI, 2024).* Digital payments provide faster, convenient, and cost-effective access to financial services and can contribute to financial inclusion by reducing geographical and other barriers to formal financial services *(RBI, 2024).* The younger population, including college students, is also increasingly exposed to digital financial services as UPI and other digital payment systems facilitate payments and money transfers through smartphone and internet-enabled devices *(RBI, 2020).* However, differences in digital literacy, awareness, connectivity, and access to financial infrastructure can influence the adoption of digital financial services, particularly across different geographical and socioeconomic settings *(RBI, 2021).* Therefore, examining FinTech adoption among college students in different colleges of Nagaon District can provide useful insights into their digital financial behaviour, financial awareness, access to financial services, and financial empowerment. The present study focuses on students' awareness, usage patterns, purposes of FinTech adoption, access to financial services, and their ability to manage financial activities independently. The study is expected to contribute to a better understanding of the role of FinTech in promoting financial capability and independence among college students in Nagaon District, Assam.

REVIEW OF LITERATURE

Raval, Agrawal, and Lukka (2022) examined the role of digital finance in promoting financial inclusion. The study highlighted that digital finance uses technologies such as mobile phones, computers, cards, and the internet to provide financial services, including payments, transactions, savings, insurance, and credit. The study emphasized the growing importance of digital financial services in improving access to financial services and supporting financial inclusion. *Kumari, Srivastava, and Saxena (2024)* examined financial awareness among students of central universities in India, with particular attention to financial literacy, financial planning, and FinTech awareness. The study highlighted that financial literacy and FinTech awareness are important for students to manage money effectively, adapt to the digital financial environment, and develop better financial decision-making abilities. The authors also emphasized the need to integrate financial education into academic programmes and use technology to strengthen students' financial awareness.

Dheepiga and

Kumar (2024) investigated digital financial literacy and knowledge of digital financial services among college students. Based on a study of 200 students, the research examined students' awareness and knowledge of digital financial services and identified gaps in their digital financial knowledge. The study emphasized the need for stronger digital financial literacy programmes so that students can use digital financial platforms more effectively and safely. *Mulyono (2023)* examined the relationship between digital literacy, financial literacy, and FinTech service usage among college students. The study, based on 165 undergraduate and postgraduate students, found a positive and significant influence of digital literacy on FinTech service usage through financial literacy. The study suggested that digital and financial literacy should be incorporated into education to help students obtain greater benefits from FinTech services.

Joseph (2025) examined FinTech adoption and its impact on financial literacy and behaviour among college students in Kerala. The study focused on the extent of FinTech usage, perceived benefits, and changes in students' financial management behaviour. The findings indicated widespread use of

mobile payment applications and digital banking among students, while also highlighting that frequent FinTech usage does not necessarily result in higher financial literacy or improved financial behaviour. The study emphasized the importance of financial education, digital security awareness, and responsible use of FinTech services.

RESEARCH GAP

Although several studies have examined FinTech adoption, digital payments, financial literacy, and financial inclusion in India, limited research has specifically focused on college students and their financial empowerment through FinTech adoption in Assam. Existing studies often concentrate on general users, households, rural populations, or specific digital payment platforms such as UPI, while comparatively less attention has been given to how different FinTech services influence students' financial independence and ability to manage their finances. Moreover, there is a lack of localized empirical evidence comparing students from different colleges of Nagaon District. The existing literature also provides limited understanding of the relationship between the frequency and purpose of FinTech usage, access to financial services, and students' financial empowerment. Therefore, the present study attempts to address these gaps by examining FinTech adoption patterns and its role in enhancing the financial empowerment of college students in the district.

RESEARCH OBJECTIVES

1. To identify different FinTech services used by college students.
2. To examine the frequency and purpose of FinTech usage among college students.
3. To assess the role of FinTech adoption in enhancing the financial empowerment and financial independence of college students.
4. To examine the role of FinTech in improving student's access to financial services.

RESEARCH METHODOLOGY

The present study adopts a descriptive research design to examine the existing patterns of FinTech usage and its influence on the financial behaviour and decision-making of college students. Rather than testing a specific hypothesis, the study seeks to describe and interpret students' experiences, usage patterns, spending behaviour, and awareness regarding FinTech adoption.

The study is based on primary data collected through a structured questionnaire prepared using Google Forms**.** The questionnaire consisted of 14 questions covering various dimensions of the study, including demographic characteristics, FinTech usage patterns, spending habits, and awareness regarding FinTech adoption. The questionnaire was circulated online to obtain responses from students belonging to different colleges of Nagaon District. Due to practical considerations relating to time and accessibility, the study employed convenience sampling for selecting the respondents. A total of 200 students participated in the survey, with the respondents ranging in age from 16 to 24 years, representing the typical college-going student population in India.

The collected data were systematically organized and analysed using frequency distributions and percentage analysis. These statistical techniques were used to identify major response patterns, understand the behaviour of the respondents, and interpret the findings in relation to the objectives of the study.

RESULTS AND DISCUSSION

Table 1: Demographic profile of respondents

Particular		Frequency	Percentage
Gender	Male	122	61%
	Female	78	39%
Age	16 to18	6	3%
	18 to 20	105	52.50%
	20 to 22	63	31.50
	22 to 24	26	13%
Level of Education	Under Graduate	168	84%
	Post Graduate	25	12.50%
	Others	7	3.50%

Sources: Field Study, 2026

Table 1 shows that 61.00% of respondents were male and 39.00% were female. It indicates that 3.00% of respondents were aged 16-18 years, 52.50% were aged 18-20 years, 13.00% were aged 20-22 years, and 13.00% were aged 22-24 years. As shown in Table 3, 84.00% of respondents were undergraduate students, 12.50% were postgraduate students, and 3.50% were enrolled in other courses

Table 2: Awareness on FinTech services among students

Particular	Frequency	Percentage
Yes	173	86.50%
No	23	13.50%

Sources: Field Study, 2026

Table 2 shows that 86.50% of students were aware of FinTech services, while the remaining 13.50% were not.

Table 3: FinTech services currently using by students

Particular	Frequency	Percentage
UPI	179	89.50%
Mobile Banking	85	42.50%
Internet Banking	70	35%
Digital Wallet	50	25%
Others	5	2.50%

Sources: Field Study, 2026

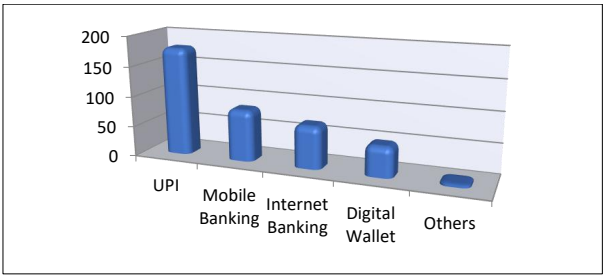


Fig 1: FinTech services currently using by students

Table 3 shows that UPI was the most widely used FinTech service among students (89.50%), followed by mobile banking (42.50%) and digital wallets (35.00%). A further 2.50% reported using other types of FinTech services.

Table 4: Period of using FinTech services

Particular	Frequency	Percentage
1 – 2 Years	99	49.50%
3 – 4 Years	77	38.50%
4 – 5 Years	14	7%
More than 5 Years	10	5%

Sources: Field Study, 2026

Table 4 shows that 49.50% of students had been using FinTech services for 1-2 years, while 38.50% had been using them for 3-4 years. A further 7.00% had used them for 4-5 years, and the remaining 5.00% had been using FinTech services for more than 5 years.

Table 5: Frequency in the usage of FinTech services

Particular	**Frequency**	**Percentage**
Daily	105	52.50%
Weekly	50	25%
Occasionally	19	9.50%
Rarely	26	13%

Sources: Field Study, 2026

As shown in Table 5, more than half of the students (52.50%) reported using FinTech services on a daily basis, while 25.00% used them weekly. A further 13.00% used these services rarely, and 9.50% used them only occasionally.

Table 6: Prime cause of using FinTech services

Particular	Frequency	Precentage
Money Transfer	175	87.50%
Payments for shopping	125	62.50%
Payment for educational expenses	100	50%
Receiving financial scholarships	69	34.50%
Others	5	2.50%

Sources: Field Study, 2026

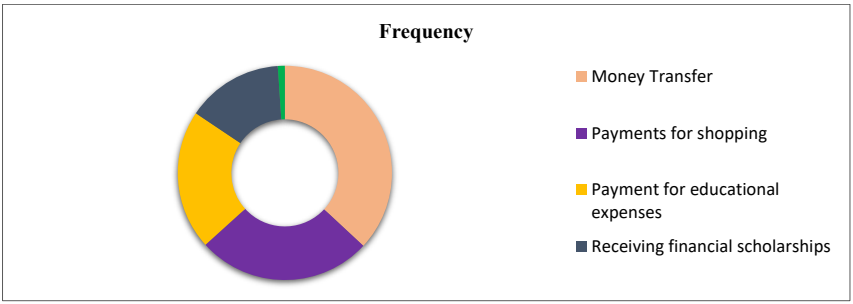


Fig 2: Prime cause of using FinTech services

Table 8 shows that money transfers were the most common purpose for using FinTech services (87.50% of students), followed by online shopping (62.50%), payment of educational expenses (50.00%), and receipt of scholarships (34.50%). A further 2.50% used FinTech platforms for other purposes.

Table 7: Widely used FinTech services

Particular	Frequency	Percentage
UPI	179	89.50%
Mobile Banking	66	33%
Internet Banking	56	28%
Digital Wallet	40	40%
Banks own payment app	19	9.50%
Others	2	1%

Sources: Field Study, 2026

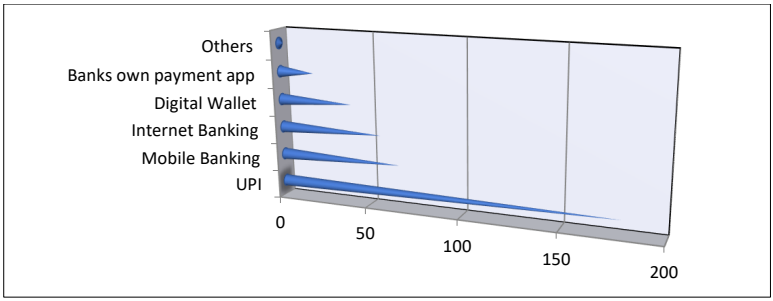


Fig 3: Widely used FinTech services

Table 9 shows that UPI was the most frequently used FinTech service (89.50% of students), followed by digital wallets (40.00%), mobile banking (33.00%), and internet banking (28.00%). In addition, 9.50% used their bank's own application, and 1.00% used other services.

Table 8: Major benefits to students in the usage of financial services

Particular	**Frequency**	**Percentage**
Financial transactions make easier	140	70%
Improves access to financial services	92	46%
Anytime, anywhere access to financial services	86	43%
Reduces the need to visit banks	62	31%
Ease of Sending and receiving money	44	22%
Others	2	1%

Sources: Field Study, 2026

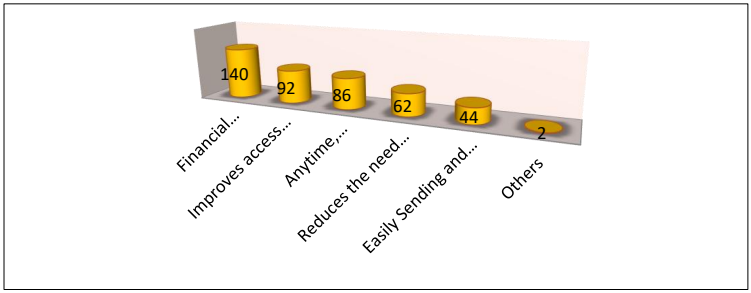


Fig 4: Major benefits to students in the usage of financial services

Table 10 shows that 70.00% of students used FinTech because of its easy transaction process. In addition, 46.00% believed that it improves access to financial services, and 43.00% valued the ability to access financial services anytime and anywhere. Further, 31.00% felt that FinTech reduces the need to visit a bank, 22.00% said it makes sending and receiving money easier, and 1.00% cited other advantages.

Table 9: Contribution of FinTech to students's financial empowerment

Particular	Frequency	Percentage
Helps in managing finances independently	141	70.50%
Increases financial independence	105	52.50%
Manage the expenses	97	48.50%
Increase confidence in financial decision	74	37%
Help in taking quick and convenient financial decision	53	26.50%
Others contributions	3	1.50%

Sources: Field Study, 2026

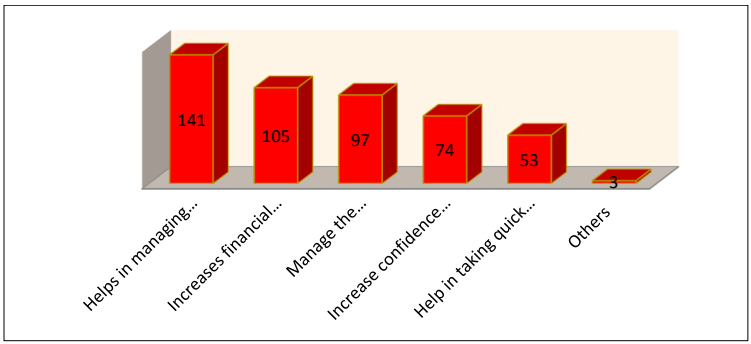


Fig 5: Contribution of FinTech to student's financial empowerment

Table 9 shows that 70.50% of respondents believed that FinTech helps them manage their finances independently, and 52.50% believed that it increases their financial independence. In addition, 48.50% agreed that it helps them manage expenses, 37.00% reported greater confidence in making financial decisions, and 26.50% said it enables quicker and more convenient financial decisions. A further 1.50% gave other reasons.

FINDINGS

The empirical findings reveal a substantial level of FinTech adoption among college students in Nagaon District, with digital financial services becoming an increasingly integrated component of their routine financial activities. The high level of awareness of FinTech services, reported by 86.50% of the students, provides an important foundation for this adoption. More importantly, the pattern of actual usage indicates that awareness has translated into regular engagement with digital financial platforms. UPI occupies a particularly prominent position, being used by 89.50% of the students, while mobile banking, internet banking, and digital wallets are used to varying degrees. The predominance of UPI suggests that students' engagement with FinTech is currently concentrated around simple, accessible, and transaction-oriented digital payment services rather than a broad range of sophisticated financial products.

The frequency and purpose of usage further demonstrate that FinTech has moved beyond occasional use and has become part of students' everyday financial routines. More than half of the students (52.50%) reported using FinTech services on a daily basis, while another 25% used them weekly. Money transfer represents the dominant purpose of usage, accounting for 87.50% of students, followed by shopping payments (62.50%) and educational expenses (50%). FinTech platforms are also used for receiving scholarships, although by a comparatively smaller proportion of students. Taken together, these findings indicate that students primarily engage with FinTech to facilitate routine financial transactions and immediate payment requirements, reflecting the practical and transactional character of their digital financial behaviour.

The findings also point towards a meaningful contribution of FinTech to students' access to and convenience in using financial services. Seventy percent of students identified easier financial transactions as an important advantage, while 46% perceived improved access to financial services and 43% valued the ability to access such services anytime and anywhere. The time-saving attribute of FinTech received the highest recognition among the identified features, with 73.50% of students selecting it, followed by convenience (55.50%) and easy access to financial services (53.50%).

Beyond convenience and accessibility, the results provide evidence of a positive association between FinTech usage and dimensions of students' financial empowerment. About 70.50% of students reported that FinTech helps them manage their finances independently, while 52.50% perceived an increase in their financial independence and 48.50% indicated that it assists them in managing expenses. These findings are particularly relevant to the central concern of the study because they suggest that FinTech is not merely functioning as a payment mechanism; for a considerable proportion of students, it is also facilitating greater involvement in their own financial management. At the same time, the comparatively lower proportions reporting increased confidence in financial decision-making (37%) and the ability to take quick and convenient financial decisions (26.50%) indicate that access to digital financial tools does not necessarily translate uniformly into broader financial capability.

SUGGESTIONS

We have put forwarded certain suggestions in order to avoid certain problems that we have spotted in the study regarding FinTech awareness and financial education. The suggestions are listed below:

1. **Strengthen FinTech awareness:** Although the majority of students are aware of FinTech, awareness programmes should be conducted for students who have limited knowledge of digital financial services.
2. **Promote digital financial education:** Colleges should provide basic financial and digital literacy programmes covering UPI, mobile banking, internet banking, digital wallets, responsible digital payments, and financial management.

3. **Encourage responsible use of FinTech:** Since FinTech is increasingly becoming part of students' daily financial activities, students should be encouraged to use digital financial services responsibly and maintain proper control over their financial transactions.
4. **Improve financial management skills:** Students should be encouraged to use available digital tools not only for making payments and transferring money but also for budgeting, monitoring expenses, saving, and managing personal finances**.**
5. **Increase awareness of financial security:** Educational institutions and financial service providers should provide students with practical awareness regarding secure digital transactions, protection of personal information, passwords, PINs, and other basic security practices.
6. **Improve access and reliability:** Financial service providers should work towards making FinTech platforms more accessible, user-friendly, reliable, and convenient so that students can use financial services effectively.
7. **Role of educational institutions:** Colleges can organise workshops, seminars, and awareness campaigns on digital finance and financial management to help students develop the skills required for independent financial activities.
8. **Focus on financially independent behaviour:** Students should be encouraged to use FinTech as a tool for developing financial independence rather than merely as a convenient payment mechanism.

CONCLUSION

FinTech has become an increasingly important component of the financial activities of college students. The present study, conducted among 200 students from different colleges of Nagaon District, shows a high level of FinTech awareness and adoption among the students. UPI is the most widely used service, while money transfer, shopping payments, and educational expenses are the major purposes of FinTech usage. The high frequency of usage further indicates that digital financial services have become a regular part of students' financial activities.

The findings further demonstrate that students perceive FinTech as a convenient and time-saving means of accessing and managing financial services. A substantial proportion of students reported that FinTech makes financial transactions easier, improves access to financial services, and provides access to financial services anytime and anywhere. More importantly, the findings indicate its contribution to financial empowerment, as many students reported that FinTech helps them manage their finances independently, increases financial independence, and assists them in managing expenses.

Therefore, the study indicates that FinTech adoption is contributing to financial empowerment and greater financial independence among the surveyed college students in Nagaon District**.** However, the relatively lower responses regarding financial confidence, quick financial decision-making, and better money management suggest that access to digital financial services alone may not be sufficient to develop comprehensive financial capability. Greater emphasis on digital financial education, responsible usage, financial management, and security awareness can help students derive broader benefits from FinTech.

Overall, the study highlights the growing importance of FinTech in shaping the financial behaviour of young people and provides localized empirical evidence from Nagaon District. At the same time, the findings should be interpreted within the limitations of the study, particularly its convenience sampling, sample size of 200, concentration of students in urban areas, and reliance on self-reported information.

LIMITATIONS OF THE STUDY

The study is subject to certain limitations. As the information was obtained through self-reported responses, the possibility of response bias or inaccuracies cannot be completely ruled out. Furthermore, the sample consists of only 200 students and is relatively concentrated in urban areas, which may limit

the representativeness of the findings for the wider student population. Therefore, the findings should be interpreted within the scope and characteristics of the selected sample.

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--Chapter--

Financial Technology for Rural Transformation: Bridging the Financial Inclusion Divide

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FinTech Adoption among Rural MSMEs: Opportunities, Challenges and Business Sustainability

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ABSTRACT

India's evolving digital revolution has fundamentally transformed the financial ecosystem, enabling the rapid emergence and expansion of Financial Technology (FinTech) through initiatives such as digital payment systems, mobile banking, Unified Payment Interface (UPI), digital lending platforms, Aadhaar-based KYC and government-supported digital initiatives that have significantly contributed the growth of Micro, Small and Medium Enterprises (MSMEs), particularly in rural areas. Despite their significant contribution, MSMEs face enduring obstacles including limited access to formal credit, inadequate technological resources, and weak financial infrastructure, which hinder their growth and sustainability. This chapter explores the opportunities, challenges, and impact of FinTech-driven financial inclusion on the sustainable livelihoods of rural MSMEs in the North Eastern states of India, with particular reference to rural transformation and financial inclusion. The chapter critically examines how digital financial services enhance operational efficiency, improve access to credit, facilitate digital payments, and promote sustainable business practices. The chapter also addresses impediments such as inadequate digital infrastructure, cybersecurity concerns, low digital literacy, and regulatory challenges that hinder widespread adoption of FinTech solutions. Drawing upon recent literature, policy initiatives, and practical examples, the chapter proposes strategic recommendations for strengthening the FinTech ecosystem to ensure sustainable growth of rural enterprises.

Keywords: FinTech, Rural MSMEs, Financial inclusion, Digital payments, Business sustainability, Digital lending.

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INTRODUCTION

The financial sector is undergoing a major transformation as digital technologies increasingly replace traditional methods of financial intermediation. This shift has become particularly important for Micro, Small, and Medium Enterprises (MSMEs), which play an important role in employment generation, entrepreneurship, and local economic development in rural India. In Assam and other parts of the North

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Eastern Region, rural MSMEs contribute significantly to household incomes and local economic activity. However, many of these enterprises continue to face difficulties in accessing formal financial services, particularly institutional credit, banking facilities, and reliable financial infrastructure.

The World Bank's Global Findex Database (2021) highlights the growing importance of digital financial services in improving financial access and supporting economic resilience. The increasing use of digital payments has enabled small businesses and households to conduct financial transactions more conveniently, particularly during periods of economic disruption. Similarly, the World Trade Organization (WTO) *World Trade Report (2023)* emphasizes the growing role of digital platforms in connecting small businesses with wider markets. For rural producers and artisans, such platforms can reduce the limitations created by geographical distance and provide opportunities to participate in broader domestic and international value chains.

In India, the expansion of digital financial services has been supported by the development of a strong digital payment ecosystem and regulatory initiatives. The *Reserve Bank of India (RBI) Annual Report (2023–24)* indicates continued growth in digital payments, as reflected in the rise of the RBI Digital Payments Index (RBI-DPI). The RBI has also introduced various measures to encourage financial innovation while maintaining consumer protection. These include Know Your Customer (KYC) requirements, guidelines for digital lending, and the regulatory sandbox framework for testing innovative financial products and services *(Bhoi & Amin, 2026)*.

Technology-enabled banking has also becoming increasingly important for rural financial inclusion. The *NABARD Annual Report (2023–24)* points to the growing use of digital technologies in the rural non-farm sector. Digital KYC, technology-based lending and other digital banking services can reduce transaction time and improve the delivery of financial services to underserved communities. For rural MSMEs, these developments can make access to financial services more convenient and potentially reduce some of the difficulties associated with traditional credit processes. *(NABARD, 2024,)*.

Among the various developments in India's digital financial ecosystem, the Unified Payments Interface (UPI) has emerged as one of the most significant. The rapid expansion of UPI and other digital payment systems has changed the way consumers and small businesses make and receive payments. According to *NPCI (2023)*, the Indian FinTech ecosystem experienced substantial growth during the period, with the number of FinTech firms increasing considerably. The large volume of digital transactions recorded through UPI further demonstrates the growing acceptance of digital payments in the Indian economy. For micro-enterprises, digital payment facilities can provide a convenient alternative to cash transactions and can also create digital records of business activities.

Despite these developments at the national level, the adoption of FinTech among rural MSMEs in Assam cannot be understood solely through national statistics. The North Eastern Region has its own geographical, infrastructural, and socio-economic characteristics that may influence the adoption and effective use of digital financial services. Issues such as limited digital literacy, inadequate internet connectivity, lack of awareness, concerns regarding digital security and differences in technology acceptance may continue to affect the use of FinTech among rural entrepreneurs.

Against this background, the present chapter examines the role of FinTech in improving the financial accessibility and sustainability of rural MSMEs, with particular attention to the context of Assam. It focuses on the opportunities created by digital payments, digital banking, digital lending, and other technology-enabled financial services, while also considering the impediments that may restrict their adoption. Understanding these opportunities and challenges is important for developing a more inclusive digital financial ecosystem that can support the long-term growth and sustainability of rural MSMEs.

REVIEW OF LITERATURE

Barki (2025) examined the role of FinTech platforms in enhancing MSME financial inclusion in Haveri District. The study conceptualizes FinTech as a mechanism for improving access to formal finance through digital lending, UPI, Aadhaar-based KYC and other digital financial services. The study highlights that FinTech platforms can reduce dependence on traditional banking procedures and facilitate access to micro-credit, particularly for small and rural entrepreneurs. It also emphasizes the importance of digital literacy and institutional support for ensuring sustainable financial inclusion.

Bhoi and Amin (2026) studied the development of FinTech and its role in MSMEs in India. Their study presents FinTech as a combination of finance and technology that enables digital payments, banking, lending and other financial activities. The authors argue that India's digital transformation, supported by initiatives such as Digital India, Aadhaar and UPI, have created a favourable environment for FinTech development. From an MSME perspective, FinTech can reduce documentation, simplify loan procedures and provide quicker access to finance.

Kumarasamy and Harshini (2026) examined FinTech's role in enhancing financial inclusion and sustainable growth of MSMEs in Coimbatore. Their study conceptualizes financial inclusion as access to affordable, accessible and timely financial services, while FinTech provides the technological infrastructure through which such services can be delivered. Digital payments, mobile banking, online lending platforms and electronic wallets are identified as important tools that can improve financial accessibility, transparency and business efficiency. The study further connects FinTech adoption with sustainable MSME development through improved financial management and operational efficiency.

Kumar (2025), in the study Opportunities and Challenges Faced by MSMEs, discusses the broader transformation of the MSME sector. The study identifies digital transformation, e-commerce, cloud computing, artificial intelligence and digital payment systems as important opportunities for MSMEs. These technologies can reduce transaction costs, improve supply-chain efficiency, expand market access and support data-driven decision-making. The conceptual perspective therefore extends beyond financial inclusion and considers technology as a broader instrument of competitiveness, innovation, and market expansion and business sustainability.

Kapoor and Singh (2025) discuss Recent Advances in Management and Technology in the MSME Sector and Their Impact on Innovation, Productivity and Sustainability. Their work conceptualizes technological advancement as an important driver of MSME transformation. Technologies such as ERP, CRM, HRM systems, artificial intelligence, IoT and big-data analytics can improve operational efficiency, customer responsiveness, productivity and strategic decision-making. This perspective suggests that FinTech should not be viewed only as a financial-access mechanism but as part of a wider technological transformation of MSMEs.

RESEARCH GAP

Although existing studies highlight the potential of Financial Technology (FinTech) to support MSME development and improve financial inclusion, several research gaps still remain. First, there is a clear regional gap, as limited empirical research has focused on the North-Eastern Region of India, particularly Assam. There is also insufficient understanding of the rural–urban differences in FinTech adoption, especially since rural MSMEs face specific challenges related to infrastructure, financial access, and technology. Moreover, many studies are concentrated in urban districts and cities, with less attention given to remote and underserved rural areas. Another important gap concerns the digital literacy of MSME owners and their ability to effectively use FinTech services. Finally, more longitudinal research is needed to understand the long-term effects of FinTech adoption on business sustainability, including the profitability, survival, and sustainable growth of rural MSMEs.

OBJECTIVES OF THE STUDY

1. To examine the development of FinTech in rural MSMEs in North-Eastern Region of India, particularly in Assam.
2. To identify opportunities and challenges faced by MSMEs in adopting FinTech.
3. To suggest policy measures for promoting effective FinTech adoption among rural enterprises.

RESEARCH METHODOLOGY

This chapter adopts a descriptive and analytical research design, as its primary objective is to examine the opportunities and challenges of FinTech adoption among rural MSMEs and its implications for business sustainability. The study is conceptual in nature and is based on secondary data; therefore, no separate primary sample of rural MSMEs was drawn for the present study. For contextualizing the MSME evidence, the *NCAER (2025)* survey of Assam covered 1,214 MSMEs across 31 districts, comprising 607 registered and 607 unregistered enterprises. These enterprises constitute part of secondary evidence used in this chapter and are not considered the primary sample of the present study. The secondary sources were purposively selected based on their relevance to FinTech adoption, digital payments, financial inclusion, MSME development, and sustainability, with preference given to credible and authoritative sources, including RBI, NPCI, NCAER, the World Bank, government publications, peer-reviewed journal articles, books, and research reports. The collected information was analyzed using descriptive and comparative approaches to interpret reported statistics, trends, and findings across Assam and the other North-Eastern states. Since the chapter does not involve the collection of original survey data, no primary inferential statistical tests were conducted.

ASSAM AND NORTHEASTERN STATES: A STRONG BUT UNEVEN FINTECH ADOPTION STORY

There are several reasons why Fintech adoption in North East India deserves careful study. The region has a distinctive demographic and economic structure, characterized by diverse ethnic communities, languages, cultures, and geographical conditions. A significant proportion of the population lives in rural and semi-urban areas. Therefore, it is important to understand whether different Fintech services are suitable for the specific needs and circumstances of the people living in these areas.

Assam provides one of the most interesting cases for studying FinTech adoption among MSMEs in the North-East. A NCAER survey conducted in 2025 for the Directorate of Economics and Statistics, Assam, found that approximately 87% of MSMEs in Assam had adopted at least one form of digital payment. Adoption was particularly high among medium enterprises at 95.5%, followed by small enterprises at 87.5% and micro enterprises at 86.7% *(Baruah et al., 2025)*.

NPCI's state-wise UPI statistics for August 2025 recorded approximately 203.78 million UPI transactions in Assam, with a transaction value of about ₹21,464.88 crore. Assam accounted for around 1.02% of reported state/UT UPI transaction volume in that dataset. Empirical evidence from the wider North-Eastern Region (NER) shows considerable differences in FinTech engagement among the states. According to National Payments Corporation of India (NPCI) data for August 2025, Assam recorded the highest absolute volume of Unified Payments Interface (UPI) transactions, with 203.78 million transactions. It was followed by Arunachal Pradesh (21.40 million), Meghalaya (15.91 million), Manipur (14.85 million), Tripura (14.59 million), Nagaland (12.24 million), Mizoram (11.86 million), and Sikkim (8.11 million). However, these figures represent the overall volume of transactions and do not directly indicate individual adoption rates, as the states differ considerably in population and economic size.

Table- 1: UPI Adoption in NER Region

State	UPI Volume, August 2025 (million)	Volume Share
Assam	203.78	1.02%
Arunachal Pradesh	21.40	0.11%
Manipur	14.85	0.07%
Meghalaya	15.91	0.08%
Mizoram	11.86	0.06%
Nagaland	12.24	0.06%
Tripura	14.59	0.07%
Sikkim	8.11	0.04%

Source: NPCI (2025), State-wise UPI Product Statistics, August 2025.

A different pattern emerges when digital transactions are measured on a per-capita basis. According to IMPRI data for September 2023, Sikkim recorded the highest number of digital transactions per capita in the region at 2.139, followed by Assam (1.764), Tripura (1.114), and Arunachal Pradesh (1.041). Manipur (0.800), Meghalaya (0.765), Nagaland (0.584), and Mizoram (0.548) recorded comparatively lower levels of per-capita digital transactions.

Table-2: State wise Digital Transactions Per Capita

State	Digital Transactions per capita*
Sikkim	2.139
Assam	1.764
Tripura	1.114
Arunachal Pradesh	1.041
Manipur	0.800
Meghalaya	0.765
Nagaland	0.584
Mizoram	0.548
NER average	1.094
India average	3.85

Source: Impact and Policy Research Institute (IMPRI), September 2023.

Analysis of FinTech engagement across the North-Eastern Region (NER) reveals significant growth alongside persistent differences among the states. Assam and Sikkim show relatively higher levels of digital financial activity, while the regional average remains considerably below the national average, indicating substantial scope for further digital adoption. However, the pattern differs depending on the measurement used. Assam has the largest digital-finance ecosystem in terms of absolute transaction volume, whereas Sikkim records a higher frequency of digital transactions on a per-capita basis. These differences highlight the importance of using both aggregate transaction volumes and population-adjusted indicators to assess FinTech adoption and the progress of rural digital transformation accurately. Thus, the FinTech story of Assam and Northeast India can best be described as “strong but uneven.” The variation in FinTech engagement across the NER also suggests that a uniform regional strategy may not be equally effective for all states. Instead, state-specific approaches are required to address differences in infrastructure, socio-economic conditions, and levels of digital literacy. Such targeted measures can help strengthen financial inclusion and promote a more resilient and inclusive digital economy across the region.

CRITICAL COMPARATIVE ASSESSMENT

The evidence suggests that Assam currently represents one of the stronger digital-payment markets within the North-East, but its experience also demonstrates that adoption is not equivalent to intensive usage. The broader NER picture is heterogeneous:

1. **Sikkim**: Relatively high digital transactions per capita in the cited 2023 comparison.

2. **Assam**: Large absolute UPI activity and high MSME digital-payment adoption. However, cash remains a preferred mode of payment for many consumers, particularly in rural areas.
3. **Tripura and Arunachal Pradesh**: Moderate levels of digital transaction activity relative to other NER states.
4. **Manipur and Meghalaya**: Digital-payment activity exists but remains comparatively lower when compared with the stronger performances of Assam and Sikkim in the cited data.
5. **Nagaland and Mizoram**: Lower transaction activity in the cited per-capita comparison, indicating considerable scope for expanding digital-financial services and supporting rural transformation.

These differences demonstrate that a uniform "one-size-fits-all" FinTech strategy may not be suitable for the North Eastern Region. State-specific approaches are required.

STRATEGIC BENEFITS OF FINTECH ADOPTION FOR MSMES

The adoption of Fintech solutions has proven to be transformative for MSMEs, delivering multiple benefits that enhance their efficiency, competitiveness, and resilience:

1. **Improved Financial Access**: Traditional financial institutions often hesitate to serve MSMEs due to high operational risks, lack of credit history, and limited collateral. Fintech platforms address these gaps by offering digital credit services that require minimal paperwork, making financing more accessible and affordable. This has enabled MSMEs to fund expansion, invest in innovation, and improve their market presence.
2. **Operational Efficiency**: Fintech tools, such as automated accounting systems and invoice management platforms, simplify routine administrative tasks, saving time and reducing errors. These tools allow MSMEs to focus on strategic growth rather than operational bottlenecks.
3. **Cash Flow Management**: Real-time transaction tracking and automated reconciliation tools offered by fintech platforms provide MSMEs with better visibility into their cash flow. Timely receipt of payments and efficient monitoring of receivables ensure liquidity, which is critical for small businesses.
4. **Market Expansion**: Digital marketing tools integrated into fintech solutions enable MSMEs to identify and reach new customers. Data-driven insights on customer behavior allow for personalized marketing strategies, fostering customer loyalty and retention.
5. **Poverty Reduction**: FinTech improves access to affordable credit, digital payments, savings, and other financial services for rural MSMEs. This helps small businesses expand their operations, increase income, and improve the economic conditions of rural households.
6. **Employment Generation**: Access to digital finance enables rural MSMEs to start, expand, and diversify their businesses. As these enterprises grow, they create more job opportunities and support employment within local communities.
7. **Women Entrepreneurship**: FinTech has emerged as an important instrument for women's economic empowerment. Rural women entrepreneurs operating through Self-Help Groups (SHGs) increasingly use digital banking for savings, loan repayments, and business transactions. Digital financial services reduce dependence on intermediaries while strengthening women's financial independence.

CHALLENGES OF FINTECH ADOPTION AMONG RURAL MSMES

Despite the rapid growth of the digital landscape, the adoption of Financial Technology (FinTech) among rural Micro, Small, and Medium Enterprises (MSMEs) remains uneven. This variation is mainly caused by a combination of structural, technological, and socio-economic challenges that affect the ability and willingness of rural businesses to adopt digital financial services.

1. **Obstacles in Digital and Financial Literacy:** One of the major barriers to the wider adoption of technology-based financial services is the limited level of digital and financial literacy in rural

communities. Many rural entrepreneurs do not have sufficient knowledge or technical skills to use mobile applications, internet banking, and digital record-keeping systems effectively. This challenge is particularly noticeable among older business owners, who may be less willing to adopt new technologies because they perceive them as risky. Their hesitation often comes from concerns about making financial mistakes or losing money through digital transactions. Therefore, localized and practical training programs provided by educational institutions, banks, and government agencies are important for improving digital and financial awareness among rural entrepreneurs.

2. **Deficiencies in Digital Infrastructure:** A reliable digital infrastructure is essential for the successful adoption of cashless financial services in rural areas. However, many rural regions, particularly those in the North Eastern Region, continue to face problems such as unstable internet connectivity and frequent power interruptions. These infrastructure-related challenges can discourage small business owners from depending on digital payment and financial platforms, especially when such services may not work properly during important business hours. Therefore, improving internet connectivity and electricity supply is necessary to create a reliable digital financial environment for rural MSMEs.
3. **Cybersecurity Vulnerabilities and Risk Mitigation**: The growing use of FinTech has also increased concerns about cybersecurity and digital financial risks. Rural entrepreneurs may be exposed to threats such as phishing, OTP fraud, identity theft, and fake payment screenshots. These risks become more serious when business owners have limited knowledge of basic cybersecurity practices and safety measures. Such experiences can reduce their trust in digital financial services and discourage further adoption. Therefore, building confidence in FinTech among rural MSMEs requires not only stronger security systems but also effective awareness and training programs that help entrepreneurs understand how to identify and prevent common digital frauds.

ROLE OF GOVERNMENT POLICIES AND INITIATIVES

The integration of Financial Technology into rural economic fabric is significantly bolstered by targeted government initiatives. The Indian government has recognized the importance of fintech in enabling MSMEs growth and has introduced several initiatives to foster adoption:

1. **Pradhan Mantri Mudra Yojana (PMMY):** The Pradhan Mantri Mudra Yojana (PMMY) is an important government scheme that provides microfinance to MSMEs that have traditionally faced difficulties in accessing formal credit. The impact of PMMY is further strengthened by FinTech companies, which use digital lending solutions to make the loan application process easier, improve credit assessment, and speed up the disbursement of formal credit to rural entrepreneurs.
2. **Startup India Scheme:** The Startup India Scheme supports the growth of startups by providing tax benefits and simplifying regulatory procedures. This initiative also encourages the development of a supportive environment for FinTech startups. These startups play an important role in creating localized digital financial solutions that address the specific needs of rural MSMEs. In this way, FinTech-based innovations can help reduce the gap in access to financial services and promote greater financial inclusion.
3. **ZED (Zero Defect Zero Effect) Certification**: The ZED (Zero Defect Zero Effect) Certification encourages MSMEs to adopt sustainable and efficient manufacturing practices while making use of modern technologies. The integration of FinTech solutions for financial management and operational monitoring can help enterprises improve efficiency, manage resources more effectively, and strengthen their competitiveness in both domestic and global markets. In the long run, this combination of sustainable practices and digital financial tools can contribute to the overall sustainability of MSMEs.
4. **Pradhan Mantri Jan Dhan Yojana (PMJDY):** PMJDY has promoted financial inclusion by encouraging savings, enabling direct benefit transfers, and supporting digital payments. In addition,

Aadhaar-based authentication and the Aadhaar Enabled Payment System (AePS) have simplified customer verification and access to banking services, particularly in rural areas.

5. Digital payment initiatives: Initiative such as FASTag, BharatQR, and UPI QR codes have encouraged cashless transactions and made it easier for small businesses to accept digital payments. These initiatives have improved the convenience, speed, and accessibility of digital financial transactions.

IMPLICATIONS FOR RURAL MSME SUSTAINABILITY

The regional evidence observed in the North Eastern landscape suggests three primary implications for the long-term viability and growth of rural enterprises. These dimensions- economic, social, and competitive form the triad of sustainability essential for fostering holistic rural development. The sustainability effect is not created by digital technology alone; it depends on whether digital financial services are used consistently and meaningfully to improve business continuity, inclusion, productivity and market access.

1. **Economic sustainability:** FinTech can strengthen the financial stability and operational continuity of rural MSMEs by facilitating faster payments, improving transaction transparency, and supporting more systematic cash-flow management. The development of digital transaction histories can provide micro-enterprises with stronger financial documentation, which may facilitate their transition from informal sources of finance to institutional credit. For micro-scale entrepreneurs, technology-enabled financial services can support more effective working-capital management and reduce dependence on high-cost informal financial sources. Thus, the contribution of FinTech to economic sustainability extends beyond improving financial efficiency; it can enhance the capacity of rural MSMEs to manage resources effectively and maintain resilience in the face of short-term liquidity pressures and broader economic uncertainties.
2. **Social sustainability:** The adoption of FinTech can contribute significantly to social sustainability by expanding financial access and facilitating the participation of underserved groups in the formal economy. By increasing access to digital payments and mobile banking services, FinTech can help address the geographical and institutional barriers that have traditionally constrained rural entrepreneurship. This is particularly relevant for women-led enterprises and underserved communities in the North-Eastern Region, where geographical isolation and infrastructure constraints may limit access to conventional banking facilities. However, the realization of these social benefits depends on an enabling environment supported by adequate digital literacy, affordable connectivity, and effective grievance-redress mechanisms. Such conditions are essential to ensure that digital financial services remain accessible, secure, and understandable to diverse groups of rural entrepreneurs.
3. **Competitive sustainability:** FinTech can strengthen the competitive position of rural MSMEs by integrating financial services with contemporary digital business practices, including e-commerce, digital marketing, and business-management tools. These technologies can enable rural producers in Assam and the wider North-Eastern Region to overcome certain localized market constraints and reach a broader consumer base. By reducing some of the market-access disadvantages associated with geographical remoteness, FinTech can help enterprises respond more effectively to changing market conditions. Over the long term, the integration of financial digitization with market-oriented digital technologies can contribute to improved productivity, broader market participation, and enhanced business sustainability.

   However, these benefits will remain limited if digitalization is confined to the installation of QR codes. Sustainable FinTech adoption requires meaningful usage, financial literacy, cybersecurity, reliable infrastructure and customer participation. In practical terms, the three dimensions are interdependent: better digital financial records can support economic sustainability; broader and safer

access can support social sustainability; and improved payment, marketing and market-linkage capabilities can support competitive sustainability. FinTech should therefore be viewed as an enabling mechanism whose long-term sustainability effects depend on the quality, inclusiveness and continuity of its use by rural MSMEs.

CONCLUSION

The digital revolution in India has brought major advancements to the financial sector, making Financial Technology (FinTech) an important tool for rural transformation. For rural MSMEs, particularly those in the North-Eastern Region of Assam, FinTech is more than a set of digital tools; it provides an important means of narrowing the financial inclusion gap. Technologies such as the Unified Payments Interface (UPI), Aadhaar-based KYC, and digital lending platforms can help rural enterprises overcome traditional difficulties in accessing institutional credit and upgrading their business operations. Since rural MSMEs contribute significantly to employment generation and poverty reduction, their integration into the digital financial system is important for inclusive economic development. However, FinTech adoption also faces several challenges. Inadequate digital infrastructure, cybersecurity risks, and limited digital and financial literacy continue to restrict the effective use of digital financial services in rural communities. Therefore, simply providing digital tools is not enough. Greater attention must be given to improving digital skills, building trust, strengthening cybersecurity, and encouraging meaningful and long-term use of technology. The sustainability and competitiveness of rural MSMEs also require collaboration among government agencies, financial institutions, FinTech companies, researchers, and other stakeholders. Public-private partnerships, supportive policies, and targeted investments in digital infrastructure can help surmount existing barriers. By addressing these challenges, the FinTech ecosystem can promote inclusive and resilient rural transformation in Assam, harness the economic potential of rural MSMEs, and support their long-term business sustainability in the digital age.

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12

--Chapter--

Financial Technology for Rural Transformation: Bridging the Financial Inclusion Divide

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Digital Financial Literacy and UPI Utilisation among College Students: An Empirical Study across Colleges in Nagaon District, Assam

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ABSTRACT

The rapid growth of digital financial services has significantly transformed the way individual access and manage financial transactions. Among these developments, the Unified Payments Interface (UPI) has emerged as an important digital payment system in India, particularly among young people and students. However, effective utilisation of UPI depends not only on access to technology but also on an individual's level of digital financial literacy. The present study, titled "Digital Financial Literacy and UPI utilisation among College Students: An Empirical Study across Colleges in Nagaon District, Assam," aims to examine the level of digital financial literacy among college students and analyse their awareness, usage, and utilisation of UPI services. The study also seeks to identify the relationship between digital financial knowledge and the effective use of UPI among students, along with the challenges they face while using digital payment platforms. The study is based on primary data collected from students of different colleges in Nagaon District, Assam. The findings of the study are expected to provide insights into students' digital financial behaviour and highlight the importance of improving digital financial literacy for promoting safe, informed, and effective use of UPI and other digital financial services. The study may also contribute to strengthening financial awareness and encouraging responsible participation in the growing digital economy.

Keywords: Digital Financial Literacy, UPI, Digital Payments, College Students, Financial Awareness, Nagaon, Assam.

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INTRODUCTION

"The financial preparedness of our nation's youth is essential to their well-being and of vital importance to our economic future" (Bernanke, 2008).

"A landmark example of our commitment to innovation is the UPI, which has been a game changer for India's digital payment ecosystem. It has helped drive financial inclusion by bringing millions of unbanked individuals into the formal financial system" (Das, 2023).

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The rapid development of digital technology has significantly transformed financial systems across the world. Digital financial services, including mobile financial services, online financial services, electronic money, digital wallets, and digital payment platforms, have expanded the ways in which individuals' access and use financial services *(OECD, 2024; World Bank, n.d.)*. These technologies can make financial transactions more convenient and accessible and can contribute to financial inclusion by reducing geographical and other barriers to financial services *(OECD, 2021; S et al., 2024))*. However, the growing use of digital financial services also creates a need for adequate digital financial literacy, which involves the knowledge, skills, attitudes, and behaviour required to use digital financial services safely and effectively *(OECD, 2024)*. Young people are particularly important participants in the digital financial ecosystem, as evidence shows that they increasingly engage with digital financial products and services, including online purchases and mobile payments *(OECD, 2023)*. Therefore, developing digital financial literacy among young people and students is important for enabling them to make informed and responsible decisions while using digital financial services.

In India, the digital payment landscape has experienced remarkable growth over the last decade. A major milestone in this transformation was the introduction of the Unified Payments Interface (UPI) by the National Payments Corporation of India (NPCI) in 2016 *(NPCI, 2016)*. UPI simplified digital transactions by enabling instant bank-to-bank transfers through mobile applications and has become an important part of India's digital payment ecosystem. Its convenience, speed, accessibility, and interoperability have encouraged widespread adoption among different sections of society, particularly the younger generation.

The background of UPI can be understood within India's broader journey from traditional cash-based transactions towards a digitally enabled financial system. Before the introduction of UPI, digital payments were mainly dependent on cards, internet banking, and other electronic payment methods. The introduction of UPI provided a simpler and more convenient platform for instant digital transactions, contributing significantly to the growth of digital payments and financial inclusion *(RBI, 2024)*. Over time, UPI has developed into one of the world's largest real-time payment systems, demonstrating the rapid expansion of India's digital payment infrastructure.

Despite the increasing utilisation of UPI and other digital payment services, the ability to use digital financial services effectively and safely remains an important concern. Digital financial literacy involves having the knowledge and skills required to understand digital financial services, conduct transactions securely, recognised potential risks, and make informed financial decisions. The rapid expansion of digital payments in India has increased the importance of such knowledge, particularly as digital technologies continue to transform the payment landscape. Merely having access to a smartphone or digital payment application does not necessarily ensure that users possess adequate financial knowledge or understand appropriate security practices. Therefore, awareness of digital transactions, security measures, fraud prevention, and responsible use of digital financial services is important for effective participation in the digital financial system. The Reserve Bank of India has also emphasised financial literacy and education through initiatives aimed at students and young people.

In Assam, the expansion of digital technology and digital financial services has created greater opportunities for individuals to participate in digital transactions. Government initiatives such as the Pradhan Mantri Gramin Digital Saksharta Abhiyan (PMGDISHA) have specifically promoted digital literacy and included the use of digital financial tools and electronic payment systems in their training objectives *(PMGDISHA, 2026)*. However, effective use of digital financial services can also depend on users' knowledge, skills, awareness, and access to appropriate digital facilities. In the context of Nagaon District, *Loskar (2017)* examined financial literacy among college students and highlighted the importance of financial literacy programmes for students.

Against this background, college students in Nagaon District represent an important group for examining the relationship between digital financial literacy and UPI utilisation. Although students are

generally familiar with smartphones and digital technology, their level of knowledge regarding the safe, responsible, and effective use of digital financial services may vary. Therefore, the present study aims to examine the level of digital financial literacy and the utilisation of UPI among college students and to understand the relationship between digital financial knowledge and the effective use of UPI services.

SIGNIFICANCE OF THE STUDY

The present study is significant because digital financial services have become an important part of the modern financial system, particularly among young people. With the rapid growth of UPI and other digital payment platforms, college students are increasingly using digital methods for their daily financial transactions. Therefore, understanding their level of digital financial literacy and UPI utilisation is important.

The study will help to identify whether college students possess adequate knowledge and awareness to use UPI and other digital financial services safely and effectively. It will also highlight possible gaps in areas such as digital financial knowledge, online security, fraud awareness, and responsible financial decision-making.

The findings of the study may be useful for students, educational institutions, policymakers, banks, and FinTech service providers. Educational institutions may use the findings to promote digital financial literacy programmes among students. The study may also help policymakers and financial institutions develop appropriate awareness and training programmes for young users of digital financial services.

Further, the study is particularly significant in the context of Nagaon District, Assam, as it provides empirical evidence regarding digital financial literacy and UPI utilisation among college students across different colleges. The findings may contribute to a better understanding of the relationship between digital financial literacy and the effective utilisation of UPI among students.

REVIEW OF LITERATURE

A literature review is conducted to provide an overview of the existing body of knowledge, identify relevant theories and methodologies, and determine gaps in previous research *(Lim et al., 2022).* Literature review is essential to avoid the repetition of other's work and getting a required knowledge to frame the particular topic.

Roy, Roy and Rohra (2026) examined how UPI influences the spending habits, savings behaviour, impulsive buying, and financial awareness of college students. The study found that UPI provides convenience and makes financial transactions easier; however, its easy and frictionless nature may also increase spending and encourage impulsive purchases. The study further highlighted the need for improving digital financial literacy and awareness about fraud and responsible financial behaviour among college students.

Rajashree Gogoi Borgohain (2025) examined the awareness, knowledge, skills, behaviour, attitude, confidence, and motivation of college teachers regarding financial literacy and investment decisions. The study found that respondents possessed awareness of basic financial concepts and investment principles but showed weaknesses in certain financial skills, particularly the use of online tools and FinTech applications for investment research. The study also identified the presence of behavioural biases such as familiarity, conservatism, illusion of control, and optimism bias, which influence investment decisions. Overall, the study emphasised the importance of improving financial literacy, financial planning, disciplined investment behaviour, and awareness of financial regulations among college teachers.

Kiliyanni (2019) studied the level of financial literacy among educated young adults and college students in Kerala. The study found that both groups had relatively low levels of financial literacy despite Kerala's high general literacy and socio-economic development. The study reported that educated young

adults scored an average of 44 per cent, while college students correctly answered an average of 48 per cent of the financial literacy questions. It also found that many respondents overestimated their own financial knowledge.

Further, the study identified factors such as gender, age, income, occupation, cognitive ability, and financial behaviour as important influences on financial literacy. It also emphasised the role of financial education and highlighted the need to include financial knowledge and skills in educational curricula.

RESEARCH GAP

The review of existing literature reveals that, although previous studies have examined financial literacy, digital financial services, and UPI usage among young people, limited research has specifically focused on the relationship between digital financial literacy and UPI utilisation among college students in Nagaon District, Assam**.** Existing studies have mainly focused on general financial literacy, spending and saving behaviour, or investment decisions, with comparatively less attention to students' practical digital financial knowledge, UPI usage patterns, transaction security, fraud awareness, and responsible digital payment behaviour. Moreover, there is limited comparative evidence across different colleges within the same district. Therefore, the present study attempts to fill this gap by examining the level of digital financial literacy, extent and purpose of UPI utilisation, awareness of digital risks, and the relationship between financial literacy and UPI usage among college students in Nagaon District, Assam.

RESEARCH OBJECTIVES

1. To examine the awareness and extent of UPI and digital payment adoption among students of different colleges in Nagaon District.
2. To assess the major challenges and problems faced by students while using UPI and other digital Payment Platforms.
3. To identify the key factors influencing student's adoption of UPI and digital payment services.

RESEARCH METHODOLOGY

This study follows a descriptive research design, as it focuses on understanding and analysing existing behaviour rather than testing any specific hypothesis. The aim is to provide a clear picture of financial literacy and UPI utilization of students.

Primary data was collected through a structured questionnaire consisting of 18 questions. These questions were carefully designed to cover multiple aspects such as demographic details, usage patterns, spending habits, influencing factors and awareness about digital finance. The questionnaire was distributed online to ensure a diverse set of responses. Convenience sampling was used due to practical constraints such as time and accessibility to collect data. While this method may limit the generalizability of the findings, it provides useful insights into current trends and behaviours. A total of 200 students participated in our study by filling the questionnaire. The respondents belong to different colleges of Nagaon District. Their ages ranged between 16 and 24 years, representing typical college going students in India.

The collected data was analysed using basic statistical tools such as percentages and frequency distributions. The focus was on identifying patterns and drawing meaningful interpretations from the responses.

DATA ANALYSIS AND INTERPRETATION

Table 1: Demographic profile of respondents

Particulars		Frequency	Percentage
Gender	Male	106	53%
	Female	94	47%
Age	16 to 18	3	1.50%
	18 to 20	102	51%
	20 to 22	67	33.50%
	22 to 24	28	14%
Education Qualification	Graduation	174	87%
	Post Graduation	20	10%
	Others	6	3%

Source: Field Study, 2026

In table 1, the gender distribution is shown where 53% of the total respondent is male and 43% is Female respondent. The table shows that 1.50% of respondents belong to the 16 to 18 years group, 51% respondents are the 18 to 20 years age group, 33.50% are 20 to 22 years age group and 14% are 22 to 24 years age group. The majority of the respondents are graduate level at 87% and other 20% are Post Graduate level. The rest 6% study other courses.

Table 2: Awareness and usage of UPI and digital Payments

Particular		Frequency	Percentage
Awareness on UPI and Digital Payment	Yes	89	94.5%
	No	1	5.5%
Currently Use UPI and Other digital Payment Platforms	Yes	83	91.5%
	No	7	8.5%

Source: Field Study, 2026

Table 2 showed that maximum respondents are aware about UPI at 94.5% other than only 5.5% not aware. The Table shows that 91.5% respondent currently use UPI, only 8.5% respondent does not use UPI.

Table 3: Digital payment methods used by respondents

Particulars	Frequency	Percentage
UPI	178	89%
Mobile Banking	49	24.50%
Digital Wallets	24	12%
Debit/Credit Card Payment	43	21.50%
Internet Banking	29	14.5%
Others	3	1.50%

Source: Field Study, 2026

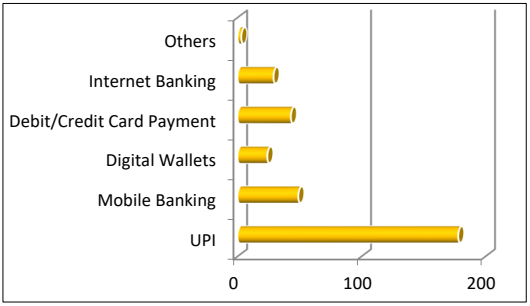


Fig 1: Digital payment methods used by respondents

Table 3 showed that 89% of the respondents use UPI, 24.5% use Mobile banking, 12% use Digital Wallets, 21.50% use Debit and credit card payment, 14.5 % use Internet Banking and 1.50% use other payment methods.

Table 4: The Frequency distributions of Use of UPI and digital Payments

Particular	Frequency	Percentage
Daily	125	62.50%
Weekly	33	16.50%
Occasionally	24	12%
Rarely	9	9%

Source: Field Study, 2026

In table 4 it is shown that the majority of total respondents use UPI and digital payments at 62.50%, 16.50% used weekly, 12% Used occasionally and 9% rarely use UPI and digital payments.

Table 5: Major Causes of using UPI and digital Payments

Series	Particular	Frequency	Percentage
1	Shopping	129	64.50%
2	Payment college related expenses	121	60.50%
3	Food and Transportation	119	59.50%
4	Money transfer to friends/family	125	62.50%
5	Others	6	3%

Source: Field Study, 2026

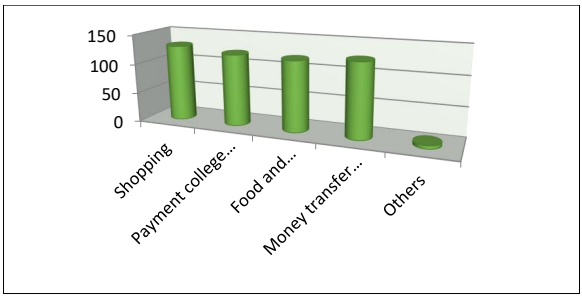


Fig 2: Major Causes of using UPI and digital Payments

In Table 5, it is shown that 64.50% respondent use UPI and digital payments for shopping, 60.50% use for Payment College related expenses, 59.50% use for food and transportation, 62.50% use money transfer and 3% use for any other purpose.

Table 6: Proportion of regular payments done by respondents digitally

Particular	Frequency	Percentage
10% to 25%	84	42%
25% to 50%	50	25%
50% to 75%	48	24%
75% to 100%	18	9%

Source: Field Study, 2026

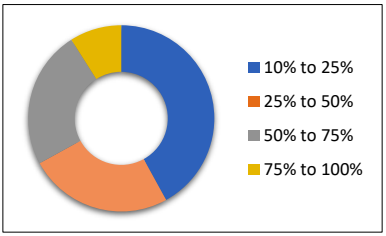


Fig 3: Proportion of regular payments done by respondents digitally

In the Table 6 shows that 42% of the total responses pay their payments 10% to 25% digitally regularly, 25% respondent pay their payments 25% to 50% through digitally, 24% respondent pay 50% to 75% payment digitally and 9% respondent pay 75% to 100% of their payments digitally.

Table 7: Factors influencing the adoption of UPI and digital payment platforms

Particular	Frequency	Percentage
Easy to learn and use	104	52%
Faster payments and more convenient	125	62.50%
Cashback, rewards, and offers	65	32.50%
Availability 24 /7	110	55%
Other factors	1	0.50%

Source: Field Study, 2026

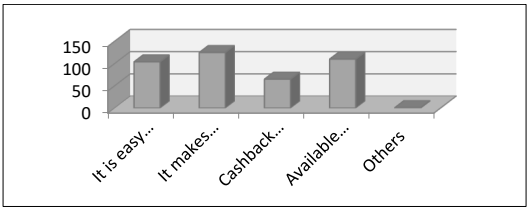


Fig 4: Factors influencing the adoption of UPI and digital payment platforms

In table 7 it is shown that 52% of the total respondent influenced by easy learning and use factor, 62.50% respondent influenced by Fast payment and convenient factor, 32.50% respondent influenced by cashback, rewards, and offers given by digital payment platforms, 55% of total respondents influenced by its 24/7 availability and only 0.50% respondent choose others.

Table 8: Frequency of problems while using UPI or digital payment services

Particular	Frequency	Percentage
Frequently	27	13.50%
Sometimes	160	80%
Never	13	6.50%

Source: Field Study, 2026

The table 8 shows that 13.50% respondent frequently faced problems while using UPI and digital payment system, 80% respondent faced problems sometimes and 6.50% never faced any problem while they use UPI and digital platforms.

Table 9: Types of problems faced by respondents

Particular	Frequency	Percentage
Transaction failure	117	58.50%
Poor internet connectivity	131	65.50%
Difficulty in understanding its usage	30	15%
Fear of fraud or scams	57	28.50%
Wrong transaction/payment	43	21.50%
Other factors	2	1%

Source: Field Study, 2026

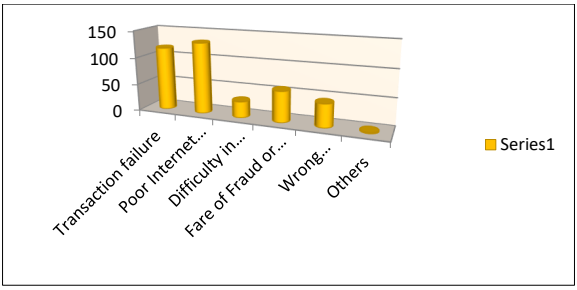


Fig 5: Types of problems faced by respondents

The table 9 shows that 58.50% faced transaction failure, 65.50% faced Poor internet connectivity, 15% faced difficulties to use and understand the service, 28.50% have feel fare of fraud and scams, 21.50% faced wrong transaction/payments problems and 1% of the total respondent faced other problems.

Table 10: Confidence level in respondents in using UPI and digital payment platforms

Particular	Frequency	Percentage
Confident	109	54.50%
Neutral	85	42.50%
Not very Confident	6	3%

Source: Field Study, 2026

Table 10 shows that 54.50% of respondents are confident in using UPI and digital payments independently, 42.50% are Neutral and 3% are not very confident.

Table 11: Convenience of UPI and digital payments relative to cash payments

Particular	Frequency	Percentage
Convenient	125	62.50%
Neutral	66	33%
Not Convenient	9	4.50%

Source: Field Study, 2026

Table 11 shows that 62.50% of total respondents are convenient when comparing digital payments with cash payments, 33% are Neutral and 4.50% are not convenient.

Table 12: Future probable increase in UPI usage and digital payments

Particular	Frequency	Percentage
Yes	142	71%
No	6	3%
May be	52	26%

Source: Field Study, 2026

The table shows that 71% of total respondents believe that their Uses of digital payments will be increased in future, 3% denied and 26% respondent is not clearly sure about it.

Table 13: Measures to make the UPI and digital payments safe and effective among students

Particular	Frequency	Percentage
Better internet connectivity	125	62.50%
Awareness and training programmes	64	32%
Improved security features	113	56.50%
Faster resolution of failed transactions	75	37.50%
Stronger protection against fraud	91	45.50%
More reliable digital payments applications	46	23%
Other measures	1	0.50%

Source: Field Study, 2026

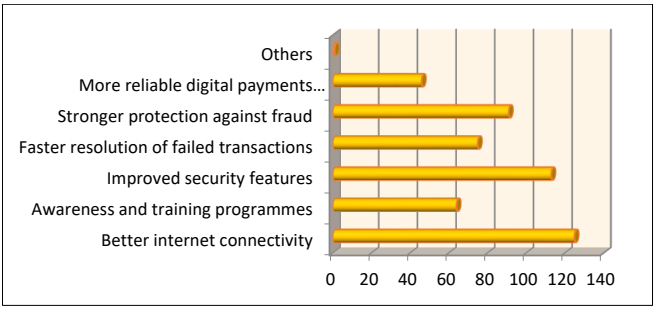


Fig 6: Measures to make the UPI and digital payments safe and effective among students

The table 16 shows that 62.50% wants better connectivity, 32% believes awareness and training programmes help in increasing use of UPI and digital payments, 56.50% wants to improve the features of

digital payment platforms, 37.50% wants fast resolution of failed transactions, 45.50% wants the strong protection against fraud, and 0.50% wants other betterments of digital payments.

FINDINGS OF THE STUDY

1. **Awareness of UPI among College Students:** The study found that awareness of UPI among college students is very high. Out of the total respondents, 94.5% reported that they were aware of UPI, while only 5.5% were not aware of it. This indicates that UPI has achieved a high level of recognition among college students in Nagaon District. The high level of awareness may be associated with the increasing availability of smartphones, digital payment applications, and the growing use of UPI in everyday transactions.
2. **Usage of UPI among College Students:** The findings indicate a high level of UPI usage among the respondents. About 91.5% of the students reported that they currently use UPI, whereas only 8.5% stated that they do not use it. This demonstrates that UPI has become an important digital payment facility among college students. The high adoption rate also indicates that students are increasingly participating in the digital payment ecosystem for their regular financial transactions.
3. **UPI as the Most Used Digital Payment Method:** Among the different digital payment methods considered in the study, UPI was the most widely used, with 89% of respondents reporting its use. Mobile banking, debit and credit cards, internet banking, and digital wallets were comparatively less preferred. The finding indicates the prominent position of UPI among college students. Its simple transaction process, quick payment mechanism, and accessibility through mobile applications may contribute to its widespread use among students.
4. **Frequency of Digital Payment Usage:** The study found that digital payments have become a regular part of the financial activities of many respondents. A majority of the students, 62.5%, reported using UPI and other digital payment services daily, while 16.5% reported weekly usage. The remaining respondents used digital payments occasionally or rarely. The relatively high frequency of usage indicates that digital payment services are increasingly being integrated into the everyday financial activities of college students.
5. **Purposes of UPI and Digital Payment Usage:** The respondents reported using UPI and other digital payment services for a variety of purposes. Shopping was reported by 64.5% of respondents, followed by money transfers to friends and family at 62.5%. College-related expenses accounted for 60.5%, while food and transportation accounted for 59.5%. These findings demonstrate that UPI is not restricted to a particular type of transaction. Instead, students use it for personal, educational, social, and routine expenditure, reflecting its integration into their everyday financial activities.
6. **Extent of Digital Payments Compared with Cash Payments:** Although digital payment usage among students is high, the findings indicate that cash has not been completely replaced. The largest group of respondents, 42%, reported that only 10% to 25% of their regular payments were made digitally. Only a relatively small proportion of respondents reported making most of their payments digitally. This suggests that students are adopting digital payment methods while continuing to use cash for a significant portion of their financial transactions. Therefore, the findings indicate a transition towards digital payments rather than a complete shift away from cash.
7. **Factors Influencing the Adoption of UPI and Digital Payments:** Fast and convenient payment was identified as the most important factor influencing the adoption of UPI and digital payments, reported by 62.5% of respondents. This was followed by 24/7 availability at 55% and ease of learning and use at 52%. Cashback, rewards, and promotional offers influenced 32.5% of respondents. The findings suggest that functional benefits such as convenience, speed, accessibility, and ease of use are important considerations in students' adoption of digital payment services.

8. **Problems Experienced While Using Digital Payments:** Despite the high level of UPI usage, many students reported experiencing difficulties while using digital payment services. About 80% of respondents stated that they sometimes face problems while using UPI and other digital payment services, while 13.5% reported experiencing problems frequently. Only 6.5% stated that they never experience such problems. This finding indicates that high adoption of digital payments does not eliminate technical and operational difficulties. Such problems may affect users' confidence and their ability to use digital financial services effectively.
9. **Major Problems Faced by Students in Digital Payment Usage:** Poor internet connectivity was identified as the most common problem, reported by 65.5% of respondents. Transaction failure was reported by 58.5%, while fear of fraud and scams was reported by 28.5% of respondents. Wrong transactions or payments were reported by 21.5%, and 15% experienced difficulty in understanding the service. These findings indicate that both technical and security-related issues remain concerns for students. In particular, poor connectivity and transaction failures may directly affect the reliability of digital payments, while concerns about fraud indicate the importance of strengthening digital financial awareness and security knowledge.
10. **Confidence in Using UPI and Digital Payments Independently:** The study found that 54.5% of respondents were confident about using UPI and digital payments independently. However, 42.5% remained neutral, while 3% reported that they were not very confident. Although more than half of the respondents expressed confidence, the substantial proportion of neutral respondents suggests that regular usage does not necessarily imply a high level of confidence or complete understanding of digital financial services. This finding highlights the need for greater awareness and digital financial literacy among students.
11. **Perceived Convenience of Digital Payments Compared with Cash:** The findings show that 62.5% of respondents considered UPI and digital payments more convenient than cash payments. However, 33% remained neutral, while 4.5% did not consider digital payments more convenient. The results indicate that a majority of students have a positive perception of the convenience of digital payments. At the same time, the relatively large proportion of neutral respondents suggests that perceptions of convenience are not uniform among all students.
12. **Expected Future Use of Digital Payments:** The study found that 71% of respondents expected their use of UPI and digital payments to increase in the future. Only 3% did not expect their usage to increase, while 26% were uncertain. This finding indicates that a substantial proportion of students anticipate greater use of digital payment services in their future financial activities. The result also suggests continued scope for the expansion of digital payment usage among the student population.
13. **Requirements for Safer and More Effective Digital Payment Usage:** The respondents identified several areas that could improve their experience with UPI and digital payment services. Better internet connectivity was the most frequently identified requirement, reported by 62.5% of respondents. This was followed by improved security features at 56.5% and stronger protection against fraud at 45.5%. Faster resolution of failed transactions was identified by 37.5%, while 32% suggested awareness and training programmes and 23% called for more reliable digital payment applications. These findings indicate that effective digital payment usage depends not only on access to technology but also on reliable infrastructure, security mechanisms, effective grievance resolution, and user awareness.
14. **Relationship between UPI Usage and Digital Financial Literacy:** Taken together, the findings indicate a potential gap between the high level of digital payment usage and the broader dimensions of digital financial literacy among college students. The study records high levels of UPI awareness and usage, but students also report frequent technical problems, concerns about fraud, neutral levels of confidence, and a need for awareness and training programmes. These findings suggest that being a regular user of UPI does not necessarily mean that a student possesses adequate knowledge of digital

financial security, fraud prevention, responsible financial behaviour, or the appropriate procedures for dealing with failed or incorrect transactions. Therefore, the findings highlight the importance of strengthening digital financial literacy alongside the continued expansion of digital payment usage among college students.

SUGGESSIONS OF THE STUDY

The findings of the study indicate that college students in Nagaon District have a high level of awareness and utilisation of UPI and other digital payment services. However, the study also identifies concerns relating to internet connectivity, transaction failures, digital fraud, security awareness, and students' confidence in using digital financial services independently. The suggestions are therefore focused on addressing these identified issues and strengthening students' digital financial literacy and safe use of digital payments.

1. **Improve Digital Financial Literacy among Students:** Colleges and educational institutions should organise digital financial literacy programmes to improve students' knowledge of digital payments, financial management, online security, and responsible use of financial technology. Students should be educated not only about how to use UPI but also about how to use it safely and responsibly.
2. **Organise Regular Awareness and Training Programmes:** Regular seminars, workshops, and practical training programmes should be conducted to improve students' awareness of safe UPI transactions, fraud prevention, protection of PINs and passwords, identification of suspicious links and messages, and appropriate handling of failed transactions. Such programmes can help students develop greater confidence and awareness while using digital financial services.
3. **Improve Internet Connectivity:** Poor internet connectivity was identified as the major problem faced by respondents. Therefore, efforts should be made to improve internet and mobile network connectivity, particularly in areas where students experience network-related difficulties. Reliable connectivity can help reduce transaction failures and improve the effective use of UPI and other digital payment services.
4. **Strengthen Digital Payment Security and Fraud Awareness:** Banks and digital payment service providers should continue to strengthen security mechanisms to protect users from fraud, scams, and unauthorised transactions. At the same time, students should be made aware of common forms of digital fraud, including phishing links, fake payment requests, OTP fraud, QR-code scams, and fake customer-care numbers. They should also be clearly advised never to share their UPI PIN, OTP, passwords, or other confidential financial information with unknown persons.
5. **Develop Faster Systems for Failed Transactions and Grievance Redressal:** Since transaction failure was one of the major problems reported by respondents, banks and digital payment service providers should ensure timely resolution of failed, pending, or incorrect transactions. Easily accessible customer support and effective grievance-redressal mechanisms can help students resolve payment-related problems and maintain confidence in digital payment services.
6. **Provide Practical Training on Safe UPI Usage:** Educational institutions should provide practical demonstrations on sending and receiving money, checking transaction history, verifying payment details, handling failed transactions, using security features, reporting suspected fraud, and contacting official customer-support channels. Practical training can help students develop the skills required to use digital financial services safely and independently.
7. **Promote Responsible Digital Spending:** Students should be encouraged to use digital payment services responsibly by developing habits such as budgeting, tracking digital expenditure, saving regularly, and avoiding unnecessary spending. Digital financial literacy programmes should therefore address not only the technical use of UPI but also responsible financial decision-making.

8. **Strengthen Consumer Protection and Support Mechanisms:** Banks, payment service providers, and relevant institutions should ensure that students have easy access to information about complaint procedures, transaction-related assistance, and fraud-reporting mechanisms. Clear information regarding where and how to report unauthorised or fraudulent transactions can help students respond more effectively to digital payment problems.
9. **Encourage the Use of Reliable and Authorised Digital Payment Applications:** Students should be encouraged to use authorised and reliable digital payment applications and keep their applications updated. They should also be advised to verify the recipient, payment amount, and transaction details carefully before confirming a payment. This can reduce the risk of incorrect transactions and other avoidable payment-related problems.
10. **Collaboration between Colleges and Financial Institutions:** Colleges can collaborate with banks, financial institutions, and authorised digital payment service providers to organise financial literacy programmes, digital payment workshops, and cybersecurity awareness sessions. Such collaboration can provide students with practical and updated information on safe digital payment practices and available financial services.

CONCLUSION

The present study highlights the growing importance of digital financial services in the daily lives of college students. The findings of the study clearly indicate that awareness and utilisation of UPI among students are considerably high. A large majority of respondents are aware of UPI and actively use it for various purposes, including shopping, money transfers, college-related expenses, food, and transportation. The convenience, speed, ease of use, and 24-hour availability of digital payment services have emerged as the major factors encouraging students to adopt UPI and other digital payment platforms.

However, the study also reveals that widespread usage of UPI does not necessarily mean that all students possess complete digital financial literacy. Although many students regularly use digital payment services and feel confident about conducting transactions independently, a significant number still face various problems. Poor internet connectivity, transaction failures, fear of fraud and scams, wrong transactions, and difficulties in understanding certain aspects of digital payment services remain important challenges. These findings indicate the existence of a gap between the use of digital financial technology and the knowledge required to use it safely, responsibly, and effectively.

The study further shows that students generally have a positive attitude towards digital payments and believe that their use of UPI and other digital payment services will increase in the future. This reflects the strong potential for further growth of digital payments among the younger generation. At the same time, students have expressed the need for better internet connectivity, improved security features, stronger protection against fraud, faster resolution of failed transactions, and greater awareness and training programmes.

Therefore, the study concludes that the future growth of digital payments should not be measured only by the increasing number of users and transactions. Equal importance must be given to developing digital financial literacy, cybersecurity awareness, responsible financial behaviour, and user confidence. Educational institutions, banks, financial service providers, and policymakers should work together to provide proper awareness and training to young users.

In the end, the study establishes that UPI has become an important part of the financial behaviour of college students in Nagaon District. While its convenience and accessibility have encouraged widespread adoption, the challenges identified in the study demonstrate the need for continuous improvement in digital infrastructure, security, financial awareness, and consumer protection. Strengthening these areas will help students move beyond simply using digital payment platforms towards

becoming digitally aware, financially responsible, confident, and secure users of financial technology, thereby contributing to the development of a safer and more inclusive digital economy.

LIMITATIONS OF THE STUDY

The study has certain limitations that should be considered while interpreting its findings. First, the study is based on self-reported responses collected from 200 college students through a structured questionnaire. Therefore, the possibility of response bias or inaccuracies in reporting their awareness, usage patterns, and experiences with UPI and digital payment services cannot be completely ruled out. Second, the study is limited to college students from different colleges in Nagaon District, Assam; hence, the findings may not be applicable to college students in other districts or regions. Third, the study used convenience sampling, which may limit the representativeness of the sample and the applicability of the findings to the wider student population. Finally, the study primarily focuses on awareness, usage patterns, problems, perceptions, and selected aspects of digital financial literacy related to UPI and digital payments. Other factors that may influence digital financial literacy and financial behaviour were not examined in detail. Future studies may overcome these limitations by using larger and more diverse samples, probability-based sampling methods, and broader geographical coverage.

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--Chapter--

Financial Technology for Rural Transformation: Bridging the Financial Inclusion Divide

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Financial Technology, Financial Inclusion and Gender Dimension: A Comprehensive Study of Rural Transformation

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ABSTRACT

Ever since the commencement of business or transactional activities, 'entrepreneurship' has left its footprints on every stage of its evolution either through providing employment, facilitating supply chain services to other businesses and industries or enhancing the national economic development as a whole. Entrepreneurs have always bridged the gap between innovation and the marketplace. Although various fragmented studies have been conducted on entrepreneurship and FinTech contributing to rural transformation in the North east region, a comprehensive study in this regard is still in need. This study mainly focuses on providing a conceptual framework over the factors such as entrepreneurship and FinTech for improving and transforming rural areas and eliminating gender disparity. The study provides a conceptual framework over the key variables 'Financial Technology', 'Financial Inclusion', and 'Rural Entrepreneurship' through offering a holistic overview towards how such variables relate and coordinate towards rural transformation. On a concluding note, the chapter offers few recommendations or suggestions for achieving the stated objective in an effective manner.

Keywords: Entrepreneurship, Financial Technology, Rural Transformation, Rural Development.

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INTRODUCTION

Ever since the emergence of telecommunication marked its commencement in the growing economic possibilities, millions of people developed their own ways of accepting and adapting such new evolutions. In this regard, during the year 2007, a small telecommunication experiment held in Kenya rewrote the beginning of new economic possibilities to people who never held a bank account in their entire lives *(Ahmad et al., 2020; Jack & Suri, 2011). Rapid Transition Alliance (n.d.)* specified the mobile money service of M-pesa, Safaricom, had been marked as the moment of financial technology moving from financial expansion to complete financial revolution (Rapid Transition Alliance, M-Pesa launch narrative). It all began as a simple mechanism or process to send a comparatively small amount of money

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between family members, friends and colleagues, which grew into a crucial infrastructure of availing credits, savings, insurance facilities and most importantly financing entrepreneurship intentions and actions in low income and rural communities in underserved regions. The literature of M-Pesa marked its footprints as an entry point since it captured the pivotal step of financial technology in the developing world where digital tools and applications eliminate the physical and institutional pitfalls.

Azmeh and A1-Raeei (2024) framed financial technology in developing economics as occupying either of the following two roles, and that are firstly it can assume the role of a supplement to traditional banking, therefrom extending the reach of existing institutions through digital channels, and it can act as a substitute to brick-and-mortar banking in the areas where infrastructure had never existed. Simply stating the two key dimensions of Fintech was specifically the adoption of digital payment and e-commerce via digital devices and traditional access indicators like the density of ATM machines and active bank branches. However, they also highlighted that where traditional could not (failed) to reach, digital devices like mobile phones have offered a low- cost delivery for financial services.

With a broad scholarly interest in this particular area, numerous literatures following a funnel structure offered their opinions in the area of Fintech and digital finance. Researching more comprehensively in this regard, some authors found that the innate features of digital technologies such as cost efficiency, ease of learning, ease of adaptation and management etc. have attracted the people and institutional authorities moving towards its regular consumption. *Ahmed, Green and Jiang (2020)* had framed a comprehensive study in the area of mobile money and its contribution to the economy through financial and food security, employment, and financial, human and social accumulation. Also there had been provided with various evidences on how increased financial inclusion marked positive impacts on key welfare outcomes among poor households and businesses.

In the course of time, more bibliometric analyses have been conducted to evaluate the global inclusion trends and key thematic developments, specifically in rural microfinance. In this regard, *Ghatode and Nimbarte (2025)* extracted valuable insights in the mentioned area, where through an empirical study the authors justified rural microfinance as a significant tool in global poverty alleviation efforts. The research highlighted its role in empowering women and supporting adaptation strategies specifically in low-income countries as well. However, the major gaps that are identified from the study include the integration of financial technology with microfinance and its role in promoting equitable access to energy for women.

Collected understanding from several such researches, the lesson is proposed to link those literatures systematically. Commencing from a broad approach to macro level relationship between variables such as financial technology, financial inclusion and economic growth, the article dives deep into the specific mechanisms of mobile money that drive entrepreneurship. The quantitative evidence from major Asian countries like China was thoroughly appraised and then the focus was driven towards social and gender dimensions of entrepreneurship among rural women as well. And, finally the lesson concludes with a necessary corrective attempt to review barriers, risks and digital divides and few recommendations for future extension of scope and geographical area of the study, to gain more generalized results and views in this regard.

FINANCIAL TECHNOLOGY AND FINANCIAL INCLUSION PAVING THE WAY FOR ECONOMIC GROWTH

In today's complex and dynamic business, social and environmental scenario, financial technology and improved financial inclusion is inevitable to achieve higher economic growth of a country. The foundational idea of this lesson is how fintech influences economic growth, especially in the context of rural transformation- through availing optimum financial inclusion in the form of access to affordable and appropriate financial services to the people in need. *Naili and Lemouchi (2022)* states that 'Financial

technology' refers to the technology used and applied in the financial service sectors including its involvement in mobile payments, money transfers, loans and fundraising and assets and property management. Simply stating, it is the companies or representatives of companies that combine financial services with modern, innovative technologies. On the other hand, 'financial inclusion' is the access to and use of formal financial services by households and firms. It is seen by policymakers as a way to improve people's livelihoods, reduce poverty, and advance economic development *(IMF, 2015)*. It may also be interpreted as having access to and using the type of financial services that meet the user's needs *(BIS, 2015)*. In this context, *Azmeh and A1-Raeei (2024)* had proven the above the statement in a much better way through the empirical results of the study, where the synergy between Fintech variable and financial inclusion resulted in greater efficacy of traditional financial inclusion strategies, boosting economic growth to a large extent. However, for many of the under developed or developing countries where banking sectors are still partially developed, fintech tends to act as a complementary activity, offering digital wallets, peer to peer lending platforms and other app-based services making daily operational tasks easier to the existing financial infrastructure. Specifically stating, for many rural regions fintech is still closer to an optional choice where a mobile money account is not even a complement to a physical bank account to people.

Over time, many empirical works have tested the framework across diverse settings. The study of *Jena 2025* proposed a theoretical framework of mixed method approach that integrated the 'Technological Acceptance Model (TAM), the Theory of Planned Behaviour (TPB) and the 'Technology Readiness Index (TRI) to analyse the factors influencing fintech adoption in rural India. The study's qualitative outlook added more weight to the fact that pure dependence over quantitative work that often misses the major factor of adoption decisions that are made in social networks acting collectively. The findings highlighted that fintech adoption in rural context is a social process as much as a technological one.

The effectiveness of fintech in improving financial inclusion depends on the availability of digital financial services and on the socio- economic conditions that influence the level of adoption and use by individuals. Some of the critically evaluated studies in this regard, that paved the way for understanding both the terms in a better manner, showed that education, income conditions and the overall financial environment can shape the extent of such adoption. *Mashoene et al. (2025)* on a causal approach examined the relationship between fintech and financial inclusion and assessed the factors influencing barriers to inclusion as well. The results statistically proved the positive influence of fintech in the financial inclusion index, on which education, Gross National Income per capita and broad money to Gross Domestic Product were found to affect the barriers to financial inclusion. The use of GMM in this area addresses the endogeneity concern which is methodologically crucial for cross- sectional fintech research. Additionally, the study underscored the importance of fintech in achieving 'Sustainable Developmental Goals' and offered some of the robust evidence of the influential direction from fintech to inclusion.

On a more systematic and comparative point of view, *Setiawan et al. (2025)* (conducted in the post-COVID period) further refined the technology acceptance model and explored the determinants of financial innovation or fintech adoption. On a behavioural approach, the particular impact of such consumption on use behaviour was investigated as well. Again, the study purposefully traced how these drivers differ between urban and rural populations- in terms of innovation of digital financial literacy, behavioural intentions and government support. Identifying notable differences between rural and urban population on the influence of digital financial literacy on behavioural intention, the study highlighted the strategic insights for digital finance innovation providers to tailor financial access. Such findings are significant to pinpoint the gap in adaptation level, which is definitely narrowing over time, but economic shocks like Covid-19 further widens the difference following disruptions to cash based and in person financial transactions and so on.

All the references reviewed above, established the base for this sub- theme: fintech is positively associated with and influencing financial inclusions and this relationship is hindered by rural-urban gap in adaptation behavior, education, exposure and awareness. This sets the foundation for the next sub theme, to address the influence of major fintech variables i.e. mobile money as an entrepreneurship driver.

MOBILE MONEY AS AN ENTREPRENEURSHIP DRIVER

Financial inclusion being the mechanism, mobile money is its most extensively used and studies application in the real-world scenario and African studies remains the most thoroughly documented case at the global level of literature. The foundation of economic analysis of M-Pesa by *Jach and Suri (2011)* remains the milestone references, documenting how mobile money reduced the cost of domestic remittances and improved the ability of rural households to smooth consumption against income shocks, when such conditions made households more willing to tolerate the risk of starting a small venture. Again, *Ahmad et al., (2020)* further extended this analysis with a comprehensive view of detailing the agent-network model that allowed services like M-Pesa to scale into rural areas without the capital expenditure that would have been required in the physical bank branches.

A more recent quantitative study in this context that sharpens the edges of this literature through the entrepreneurship- specific link is conducted spanning Kenya, Nigeria, Tanzania and Uganda *(Malkova, 2025)*. This study of 2025 directs its resources towards examining how mobile money not only facilitates transactions and business processes but also enables labour informality- finds mobile money to be closely associated with lower poverty levels, and promotes higher formalization rates for previously unbanked entrepreneurs. However notably, finds of the study of *Malkova, 2025* hold strongly in Kenya, Tanzania and Uganda and significantly weak in Nigeria. The contrasting results between Nigeria and other East African countries underscore the importance of various factors such as, regulatory frameworks, existing financial infrastructure and market security for determining the importance of digital financial services in promoting business formalization.

Such a study significantly provides evidence of the increasing use and adoption of fintech variables like, mobile money through which the level of financial inclusion amongst rural population has been shifted substantially. However, the gaps in this context which require more attention also need to be addressed and thus, it will form the later part of this lesson.

A field experiment conducted by *Batista and Vicente (2013)* assessed the impact of randomized mobile money dissemination in rural Mozambique. Such an experiment laid emphasis over the fact that marginal willingness to remit money is increased by the availability of mobile money. The case study evidence focused on Kenya extends the picture further while linking it to M-Pesa directly to productivity and income gains among the rural entrepreneurs.

DIGITAL TRANSFORMATION AND RURAL ENTREPRENEURSHIP

A quantitatively rich body of evidence from China can be reviewed as well, demonstrating digitally driven rural entrepreneurship to be a global phenomenon rather than a regionally specific one. For the purpose of rural transformation, a great importance should be given to digital transformation as well, along with mobile money adoption. 'Digital transformation' refers to the impact of digital technologies and data and their use on existing and new activities i.e. accelerating worldwide and affecting all sectors- offers immense opportunities for economies and societies yet poses important risks that must be addressed to reap its benefits *(OECD, 2024)*. Research conducted using large scale household panel data covering 2014 to 2020, finds digital transformation to drive rural entrepreneurship most strongly among households that possess the baseline level of financial literacy *(Deng et al., 2024; Li et al., 2024)*. A strand of this literature identifies that fintech access alone is necessary but not sufficient condition for entrepreneurial grasp *(Li, Wang, & Soh, 2024)*.

Another complementary research conducted specifically at the regional level traces the transmission pathway from digital finance penetration to broader rural industry revival *(Xu & Yang, 2025)*. And finally, a study at the country level analysis across China finds that digital inclusive finance is associated not simply with rural entrepreneurship in raw numerical terms but also with measurably higher quality entrepreneurship *(Yu et al., 2024)*. Such studies strengthen the concept of digital transformation through evidence drawn from different countries through their empirical analysis and results, which promotes the acceptance and emergence of digitalization towards rural transformation to a greater extent.

MICROFINANCE AND RURAL WOMEN ENTREPRENEURSHIP

The focus over rural entrepreneurship and financial inclusion is incomplete without addressing one of the most striking factors, gender. And thus, the literature here is both substantially and appropriately cautious in this regard. The term 'microfinance' refers to the process of providing financial services to low-income individuals or groups typically excluded from traditional banking systems due to poverty, lack of collateral or absence of credit history- the services of which include small loans, insurance and money transfer services with core aim of promoting financial inclusion *(UNESCO, n.d.)*. In connection with women entrepreneurship in rural areas, microfinance plays a pivotal role in facing challenges like borrower over- indebtedness, high interest rates and long-term impact of poverty. *Garikipati et al. (2017)* examined the claim that microfinance promotes gender equality- one of the main focuses of which was the questions of how microfinance has empowered women. The study further warns against uncritically optimistic narratives that treat microfinance access as an automatic empowerment mechanism and the repayment burdens that it can impose specifically on women borrowers.

Subsequent studies have identified positive conditional effects of microfinance. The research examining the microfinance institution's role in women entrepreneurship development identifies access to credit as a necessary prerequisite for business formation among rural women. On the other hand, empirical studies with a broader approach towards rural women empowerment depict measurable gains in households' decision-making authority and economic contribution. Research particularly examining Self- Help Groups in rural India traces microfinance access transforms women's both the direct economic activity and their broader social standing within their communities. A qualitative study from Pakistan in 2022 explored the everyday experience of women navigating microfinance- supported entrepreneurship, surfacing social- mobility and norm related barriers, while another related quantitative study focusing on rural women borrowers of Pakistan links microfinance access to measurable welfare gains at the household level *(Khursheed, 2022; Malki et al., 2024).*

In reference with all the studies stated above, it can be summed as microfinance is a powerful driver of rural women's entrepreneurship, though its effects are consistently intermediated by local social context.

BARRIERS OR RISKS OF FINANCIAL TECHNOLOGY

From a critical point of view, the limitations of fintech must be discussed as well. Several studies have marked their views in the context of fintech's pitfalls. A theoretical work by *Lokuge and Sedera (2020)* - drawing on Nambisan's information system entrepreneurship framework attempted to provide a holistic understanding of existing literatures on rural innovation and identified the opportunities for rural entrepreneurship in the digital era. However, the access to such opportunities is not evenly distributed among the rural population, since infrastructure quality, digital skill, and the choices of design in specific platforms decide who can participate and who will be excluded from that "opportunity structure". Furthermore, a systematic study of 2024 presented the "digital divide" i.e. characterized by inadequate technological infrastructure and low digital literacy that probes substantial barriers to digital advancements *(Nipo et al., 2024).* The reviews on the fintech- financial inclusion relationship and

vulnerable groups, drawn from Ghana reinforce this point directly, through listing the major challenges such as, limited connectivity, lack of digital literacy, inflexible regulatory framework and more structural limitations: lack of cultural and regional diversity and so on.

Researches specifically based on "opportunities and barriers" of financial inclusion highlight the traditional and modern world challenges posed by increase in financial inclusion, where traditional barriers include cost and risk factors, lack of money, lack of documentation, prohibitively high prices and geographic barriers *(Beck, 2020)*. On other hand, regulatory and competitive pitfalls include financial market competition and regulation by blurring regulatory boundaries and creating potential conflicts regarding financial stability and consumer protection *(Beck, 2020)*. Thus, the transformative potential of fintech towards rural entrepreneurship is increasingly well documented but conditional, unevenly distributed and challenging for underdeveloped regions.

CONCLUSION

The evidences served from the above discussion of multiple literatures clear the fact that financial technology, digitalized microfinance and inclusive digital platforms have expanded its access to rural population financial services. Moreover, in many well documented contexts, this access has translated into genuine increases in rural entrepreneurial activity, business formalization and household economic resilience. This pattern is visible in the East African mobile money ecosystem, China's longitudinal study of rural households and women entrepreneurship in South Asia and East Africa. In this regard, the adoption and consumption pattern of individuals majorly depends upon local regulatory conditions, financial and digital literacy and social variables.

Systematic reviews confirm that the field studies the relationship between fintech and financial access, where fewer studies trace the fuller chain from access through actual entrepreneurial behaviour change to explicitly measure the level of rural transformation. Further bibliometric analysis of the rural microfinance delivery, as an emerging theme approaches to assess digital financial services for rural communities.

Finally, as mobile money and digital finance penetration continues to deepen across the rural developing world- the transformation that began from a single mobile payment in Kenya in 2007is still continuing towards a comprehensive and complete financial inclusion of emerging entrepreneurs, whether thriving in urban or rural regions. Therefore, the chapter is still a continuation of this unfinished process, demanding the under-answered questions of how, for whom and under what conditions this transformation is most likely to endure.

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--Chapter--

Financial Technology for Rural Transformation: Bridging the Financial Inclusion Divide

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Digital Payments and the Growth of a Cashless Economy in India

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ABSTRACT

India's financial system has undergone a major transformation from a predominantly cash-based economy to one increasingly driven by digital payment mechanisms. This chapter explores the growth of digital payments in India and their contribution to the development of a cashless economy. It examines the evolution of payment methods from traditional cash and paper-based systems to modern technologies such as the Unified Payments Interface (UPI), mobile banking, digital wallets, and QR-code payments. The chapter also highlights the role of initiatives including Digital India, the Pradhan Mantri Jan-Dhan Yojana, Aadhaar, and the JAM Trinity in promoting financial inclusion and improving access to formal financial services. Furthermore, it considers how the 2016 demonetisation and the COVID-19 pandemic accelerated the adoption of digital modes of payment. Digital payments provide several advantages, including convenience, speed, transparency, lower cash-handling costs, economic formalisation, and wider financial accessibility. Nevertheless, the movement towards an increasingly cashless economy is accompanied by challenges such as cybercrime, digital fraud, limited digital literacy, the digital divide, connectivity problems, transaction failures, and regulatory issues. The chapter concludes that although India has achieved considerable progress in digitalising its payment ecosystem, continued investment in digital infrastructure, financial and cyber awareness, data security, and effective regulation is essential to develop a secure, inclusive, and sustainable cashless economy.

Keywords: Digital Payments, Cashless Economy, Financial Inclusion, Financial Technology (FinTech)

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INTRODUCTION

The Mahajanapadas of ancient India, including various republics and kingdoms, were among the early issuers of coins in the sixth century BCE *(Goyal 2017)*. Those coins were made of copper and silver, and money transfers were made possibly by the credit system, which included bills of exchange.

The Reserve Bank of India, established in 1935 got the authority to print "Rupya" or government of India notes. There are various words from which the name 'rupee' comes from such as the Sanskrit

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'raupya', 'rupya' or 'rupaya', meaning 'wrought silver, a coin of silver' *(Goyal, 2017)*. In January 1938, the Reserve Bank of India first printed and issued a five rupee note with the image of King George VI, which marked the very beginning of paper currency being printed and released by the RBI after the central bank was established. Additionally, in 1938, 10,000-rupee notes were also produced, but eventually, it was demonetized in the year 1946. It was again reintroduced in the year 1954, which was later permanently banned by the High Denomination Bank Notes (Demonetisation) Act in the year 1978 *(Trivedi, 2024)*.

The history of financial transactions in India has undergone a significant transformation over the past decades, moving from predominantly cash-based dealings to a digitally empowered payment system. This shift has been driven by a combination of policy initiatives, technological advancements, and changing consumer behaviour.

The advent of cashless economy in India predates to around the year 2004, when RTGS was introduced by RBI but it found its boost with the demonetization initiative taken by the NDA government under the leadership of PM, Shri Narendra Damodardas Modi in 2016. This shift brought the nation to the threshold of a digitalized financial landscape in a larger scale. An increasingly digitally aware population also helped the government guide. Adoption of digital platforms such as the Unified Payments Interface (UPI), Bharat Interface for Money (BHIM) and mobile wallets experienced a dramatic surge in usage by the people of India. Furthermore, the COVID-19 pandemic accelerated the growth of digital transaction making it a necessity rather than an option.

The government's continued push through schemes like Digital India, financial literacy programs, and the Jan Dhan-Aadhar-Mobile (JAM) trinity has further enhanced digital infrastructure and accessibility. Institutions such as the Reserve Bank of India (RBI) and the National Payments Corporation of India (NPCI) have played a pivotal role in promoting secure and interoperable payment frameworks.

CONCEPT OF DIGITAL PAYMENT

Digital payments have transformed the means of financial transactions. Now money is transferred swiftly, safely and more conveniently compared to physical cash-based payment methods. Digital payments, facilitated by technology, allow electronic transactions to be easily made by persons and businesses. For digital payment, a bank account, an online access to bank and a digital hand-set (smartphone) are required by the users. Digital payment can be achieved through digital channel and instruments, e.g., bank transfer, mobile payments, QR code, payment cards (credit, debit and pre-paid). Payment providers (banks, fintech companies) mediate these transactions, security and the on-the-spot-execution *(Easebuzz, 2025)*.

Simply put, digital payment is the transfer of funds between payment accounts using a digital device or channel. These payments can happen online or at physical stores. For example:

- Paying for an order on an e-commerce platform using UPI.
- Using a digital wallet, credit card, or mobile banking app at a local grocery store.
- Digital payments can be fully or partially digital, depending on how the transaction is processed *(Razorpay, 2026)*.

FROM QUEUES TO QR CODES: INDIA'S PAYMENT REVOLUTION FASTER, SIMPLER AND MORE INCLUSIVE TRANSACTIONS FOR EVERY INDIAN

India's financial journey has evolved over centuries from barter systems and cowrie shells to coins, paper currency, and cheques. For much of its modern history, cash remained the dominant mode of transaction. While cheques and demand draft formalised payments, they were slow and accessible only to a limited segment. Banking infrastructure was largely urban-centric, leaving rural and remote populations underserved. Not long ago, a simple financial transaction demanded time, effort, and patience. Paying

bills meant standing in long queues. Sending money required a visit to the bank, filling out forms, and waiting days for confirmation. That India, however, is now the past.

The early 2000s marked the beginning of digital transformation in payments. The Reserve Bank of India introduced systems like Real-Time Gross Settlement (RTGS) in 2004, Electronic Clearing Service (ECS) and National Electronic Funds (NEFT) in 2005 and Immediate Payment Service (IMPS) in 2010, enabling faster and round-the-clock transfers. These were significant milestones, but their reach remained limited to those already within the banking ecosystem and access to formal financial services remained limited for many.

JAM TRINITY: A STRUCTURAL BREAKTHROUGH FOR DIGITAL BANKING

India's digital payments transformation is built on a foundational architecture comprising three key pillars: Pradhan Mantri Jan-Dhan Yojana (Jan Dhan), Aadhaar and mobile connectivity, collectively known as the JAM Trinity. Each pillar serves a distinct purpose, but together they have strengthened the financial ecosystem by reducing leakages, enhancing trust in formal banking and preparing citizens to engage with digital services. Union Finance Minister, Nirmala Sitharaman has once very rightly said "The JAM Trinity catapulted our banking to a different level altogether."

The Pradhan Mantri Jan-Dhan Yojana has brought millions into the formal banking system by enabling the large-scale opening of zero-balance accounts, ensuring that even the most underserved populations are financially connected. Aadhaar has strengthened this foundation by providing a reliable digital identity, enabling precise targeting and seamless delivery of services. Complementing both, the rapid expansion of mobile connectivity and internet access has empowered citizens with a convenient, real-time interface for communication, authentication and transactions.

This integrated framework found its full expression through the Direct Benefit Transfer (DBT) system, which has streamlined the delivery of government benefits directly into bank accounts. By reducing intermediaries and enhancing transparency, DBT has improved efficiency while building confidence in digital systems.

Importantly, this transformation has gone beyond access, it has enabled participation. As citizens engaged with DBT, they became increasingly familiar with digital financial transactions, paving the way for the widespread adoption of platforms such as the Unified Payments Interface (UPI) *(PIB,2026)*

GROWTH OF DIGITAL PAYMENTS

The growth of digital payment was made possible by the government and banks with the help of the following initiatives:

1. **UPI:** Unified Payments Interface (UPI) is a real-time payment system that enables instant money transfers between bank accounts through a mobile application. It is built on the Immediate Payment Service (IMPS) infrastructure. UPI brings multiple bank accounts into a single app and supports various features such as fund transfers, merchant payments, and peer-to-peer payment requests, making digital transactions quick and convenient. Launched in 2016 by the National Payments Corporation of India, UPI has changed how people send and receive money in the country.

   This shift has taken India away from cash and card-based payments and pushed it towards a digital-first economy. Millions of individuals and small businesses now rely on UPI for safe and low-cost transactions. By making payments quick and accessible, UPI has become a powerful tool for financial inclusion.

   UPI's rise as the world's leading real-time payment system was not an accident. It is the result of years of planning and investment in digital infrastructure. India built a strong foundation that brought millions into the formal financial system, gave them secure digital identities and connected

them through affordable internet. This combination created the perfect environment for UPI to grow and succeed *(Press Information Bureau, 2025)*.

2. **Mobile Banking:** In the age of smartphones and their ability to onboard various applications, banks have channelled their facilities and services through institute applications, making the lives of consumers easier to access banking services. With the need to visit the bank almost becoming unnecessary, one can open accounts, transfer funds though IMPS, NEFT, RTGS, UPI, MMID etc., manage their accounts like generating statement, Interest certificate, provisional certificate for Loan accounts, plan investments in Govt Schemes like PPF, SSA, KVP, SGB etc as well as in private entities like Mutual fund and Life Insurance. One can pay bills, Recharge their phones, DTH etc.

   Mobile banking is very convenient and accessible. It is the on-the-go banking process when financial transactions are made from mobile devices that include smartphones, tablets etc. This allows one to bank anytime from any place. One can send and receive funds both within the country and abroad, make instant payments at merchant counters, and pay bills seamlessly, through secure banking apps. To make it more secured and reliable for the people, banks have applied layers of security to protect the interest of users, and if banking instructions are followed diligently, there is a rare chance of being misguided.

   All one requires is an internet connection and one can bank from anywhere at any time, round the clock. It enables faster transactions as most of the services provided by mobile is instant and covers almost all the services which minimizes the requirement to visit the bank. It has also enhanced security as the application helps to track and monitor transactions. It fast-tracks fraudulent transactions and informs the bank for immediate action. It is also cost saving as value-added services, such as payment of bills, investments, taxes and opening new accounts, can be channelled through the app and all these services are performed at a minimal cost *(Bank of Baroda, 2024)*

3. **Internet Banking:** In this day of technology, where the country is close to becoming a cashless economy, internet banking plays a pivotal role in shaping the consumer's banking habits. With this evolution in banking technology, financial freedom is just a click away and has emerged as a comprehensive solution for all banking needs.

   The internet has transformed modern banking into a seamless reality with the help of online banking, often referred to as e-banking. This technology has enabled the customers to complete their financial transactions through bank websites and apps. By accessing these secured digital facilities through electronic devices and mobile phones, users can utilize virtually all banking services, without having to visit the bank physically.

   Unlike traditional banking systems, which encompasses visiting banks and ATMs for personal banking transactions and restricts backing to stipulated banking hours, internet banking is available anytime, anywhere and 24/7 through a smartphone or electronic device. The traditional banking system's operating cost is very high as well as the security is conventional in it, whereas in internet banking the customer need not visit the bank physically, which reduces the costs and offers technology sourced layers of high security. Applications for cheque books, checking accounts updates and many such facilities are also available in internet banking *(Bank of Baroda, 2024)*

4. **Debit Cards:** The economy is going cashless and thus, the importance of cashless instruments has increased. Thus, Debit Cards have become an important part of our daily lives. They not only allow us to withdraw cash seamlessly from our bank account but also make online transactions easily.

   A Debit Card is a card issued by the bank where we have our bank account. This card allows us to make transactions in our bank account. It allows us to withdraw cash, make online as well as contactless transactions and even deposit cash through machines in our bank account. Each debit card has a unique number printed on it which represents the card held by us. The debit card number consists of two parts:

- The first 6 digits of the Debit Card number constitute the Issuer Identification Number, also known as the Bank Identification Number. This number helps determine the name of the company i.e., Visa, Master Card etc.
- The remaining 8 digits represent our bank account details i.e., the name of the card issuing bank, type of card issued and other identifiers that are specific to our bank account *(Team Axis Bank, 2024).*

When we're issued a debit card, it doesn't come with a spending limit the same way a credit card does. This is because a debit card is linked to our checking account. In most cases, the amount of money we've deposited into the checking account is our spending limit. When we use our debit card to make a purchase, we may have to enter a personal identification number (PIN) or sign for the purchase. Then, the merchant's payment system pulls the funds directly from our checking account. So, if we go over the amount of money in our account, we could be charged an overdraft fee. Since debit cards strictly allow us to access our own money, we don't have to make minimum payments, nor are we charged interest. People who are trying to budget might find debit cards help them stick to a financial plan.

There are also some restrictions with debit cards. Our bank might have daily purchase limits we can't exceed, and we might be limited in the ATMs we can use. For instance, one might be charged an out-of-network fee for withdrawing cash from an ATM that isn't affiliated with their bank or credit union *(Gibson, 2026).*

5. **Credit Card:** A credit card is a financial tool that provides one with access to a line of credit, allowing him/her to make purchases and avail services. It typically comes in the form of a plastic card issued by a bank or credit lender. With a credit card, one can spend up to a certain credit limit determined by the issuer. The key feature of credit cards is the ability to defer payment, giving him/her the flexibility to make purchases now and repay the amount later. Credit cards often come with rewards programs, offering cashbacks or points that can be redeemed for various benefits.

   Conventional or unseeded credit cards operate like a loan, where one is granted a predetermined credit limit. When one makes a purchase using a credit card, the issuer pays the merchant on his behalf. At the end of each billing cycle, they are required to pay back at least a minimum amount of the total outstanding balance. If one chooses not to pay the full balance, interest will be charged on the remaining amount. Credit cards are of four types, they are Balance Transfer Credit Cards, Credit Builder Cards, Overseas Credit Cards and Purchase Cards *(ICICI Bank, n.d.).*
6. **QR Code payments:** QR code payment is a contactless payment method that allows customers to pay for goods and services by scanning a QR Code with their smartphone. A QR Code is a two-dimensional barcode that can store various information, such as URLs, contact details, and payment information. When scanned using a smartphone camera, the QR Code directs the user to the encoded data. In the context of payments, a QR Code contains the merchant's account details and the transaction amount. QR code payment leverages this technology to enable customers to make payments by simply scanning the merchant's QR Code using a mobile app. This eliminates the need for physical cash or credit/debit cards, making the payment process more efficient and hygienic. This innovative payment solution has gained immense popularity in recent years due to its speed, convenience, and security.

   For the QR code payment to work, the merchant creates a unique code that creates their payment details. This can be a static QR code with fixed information or a dynamic QR code where the payment amount can be specified for each transaction. Then using a smartphone camera or a QR code scanner app, the customer scans the QR code for payment displayed by the merchant at the point of sale or on a digital platform. The scanning app then decodes the QR code and extracts the merchant's payment details, such as their name, account number, and transaction amount. After that the customer verifies the merchant details and the payment amount. If it's a dynamic QR code, they may need to enter the

specific amount to be paid. The customer then authorises the payment by entering their PIN or using biometric authentication within the payment app. The payment is later processed instantly, and the specified amount is transferred from the customer's linked bank account or mobile wallet to the merchant's account. And finally, both the customer and the merchant receive a payment confirmation notification and a digital receipt for the transaction. The entire QR code payment process happens within seconds, making it a quick and convenient alternative to traditional cash or card transactions. QR Code payments are mainly of two types, one is static QR code and the other is dynamic QR code. QR code payments offer numerous benefits for both businesses and consumers like it is contactless and hygienic. It is speed convenient, cost effective and has enhanced increased security and accessibility while being widely applicable and eco-friendly *(Razorpay, 2025).*

BENEFITS OF CASHLESS ECONOMY AND FUTURE PROSPECTS

Digital payment certainly has a lot of advantages and benefits, some of them are discussed as follows:

1. **Financial inclusion and accessibility:** Digital payments have given millions of unbanked people access to safe, formal, and affordable financial services. This reaches underserved individuals primarily located in semi-urban and rural regions. Through enabling infrastructure like Jan Dhan Accounts (basic bank accounts) and Aadhaar-enabled Payment Systems (AePS), unbanked individuals can now transact digitally. By using biometric authentication like fingerprints or iris scans, this system eliminates traditional barriers, allowing people to make digital transactions without owning a smartphone or having internet connectivity *(NITI Aayog, 2021).*
2. **Convenience and efficiency:** Digital transactions eliminate the need to visit banks, stand in lines, or wait for manual cash processing. They lower the expenses related to printing, transporting, securing, and handling physical currency. Additionally, they remove the logistical burden of counting cash, managing physical registers, and making manual change. This saves individuals time, cost, and physical effort associated with traditional cash handling. Real-time systems like UPI offer 24/7/365 availability, meaning transactions can be completed at any time of the day or night, including weekends and public holidays. Instant money transfers settle directly from the sender's bank account to the receiver's account within seconds, removing waiting periods. This provides individuals with a seamless, fast, and secure way to pay for goods and services instantly. Furthermore, it allows merchants to optimize cash flow, automate bookkeeping, and speed up checkout processes, ultimately ensuring consumer convenience and business productivity *(NPCI, 2023).*
3. **Transparency and Reduced Corruption:** Digital payments help in building a more transparent economy by creating an electronic trail. This minimizes anonymous, cash-based dealings that go unrecorded. Because electronic transactions are tracked, it becomes much harder for individuals or businesses to hide income. Consequently, this leads to more accurate tax collection and minimizes leakages in Direct Benefit Transfer (DBT) schemes *(MeitY, 2022).*
4. **Economic Formalization:** Informal businesses usually operate with unrecorded cash, but digital payments create an automatic, official paper trail of sales. With digital payments, businesses register formally, contribute to the tax system, and follow official regulations, leading to economic formalization. Traditional banks often reject informal businesses due to a lack of proof of income. However, a digital transaction history acts as concrete proof of regular revenue, allowing micro-enterprises to secure formal bank loans and access insurance policies *(RBI, 2023).*
5. **Faster transactions in a cashless economy:** This mean money moves instantly from buyers to sellers via digital networks. This speed transforms how money moves by cutting out the manual steps required to handle paper notes and coins. Digital payments remove delays, as sellers skip counting stacks of bills and buyers never wait for exact change. This speed also streamlines business operations. Faster checkouts help stores serve more customers per hour and reduce long queues. Transactions log automatically into accounting systems, saving hours of daily administrative work.

Furthermore, businesses no longer need to spend time traveling to deposit cash bundles or withdraw physical float. Unlike physical cash, which requires face-to-face interaction or physical infrastructure like ATMs during set hours, digital transactions operate without boundaries. E-commerce platforms process payments instantly to trigger immediate shipping or digital downloads. Funds move securely at midnight, on weekends, or during public holidays without relying on bank branch hours *(Katrak, 2024)*.

CHALLENGES OF A CASHLESS ECONOMY

While having a cashless economy has a lot of benefits and advantages, it also has a lot of disadvantages or challenges which cannot be overlooked, such as:

1. **Cybersecurity and Fraud Risks:** High digital usage correlates directly with increased cyberattacks, phishing, and unauthorized transactions. Like physical hygiene, there are routine practices to ensure online safety. Financial frauds can occur without the account holder's consent, such as, identity theft leading to account takeovers and cloned cards or stolen digital wallet credentials. Many individuals still lack basic cyber hygiene knowledge despite existing regulations *(CERT-IN, 2023)*.
2. **Digital Divide:** Many rural residents do not know how to navigate smartphones or banking apps safely. They live in constant fear of online fraud or making mistakes, which keeps them from trying digital options. Furthermore, most financial applications are primarily designed in English or a few major languages. This lack of local dialect support creates a confusing barrier for regional populations. Additionally, remote areas often suffer from weak cellular signals, slow speeds and frequent network drops. Because digital transactions require a stable connection to process smoothly without failing midway, poor infrastructure acts as a major bottleneck *(NASSCOM, 2022)*.
3. **Technical Vulnerabilities and Financial Anxiety:** When technical vulnerabilities like transaction failures, app crashes, and delayed refunds happen frequently, payments get stuck mid-process. This causes immediate financial anxiety for users. Furthermore, unstable software disrupts the user experience, signalling poor security and a lack of professionalism. The days spent waiting to recover money from a failed transaction only create more friction and panic. Financial interactions require absolute certainty, as repeated technical errors make users feel their money is unsafe. Beginners, in particular, lack the confidence to know if an error is a temporary glitch or a permanent loss of funds. Ultimately, these negative early experiences cause users to abandon digital apps and return to cash *(RBI, 2022)*.
4. **Regulatory and Infrastructure Challenges:** Know Your Customer (KYC) processes are essential to prevent fraud and money laundering. However, making them smooth, digitized, and uniform across different platforms remains a challenge. Ensuring interoperability, which refers to the ability of different financial systems, banks and fintech applications to communicate and work together seamlessly, is critical. With the massive rise in digital transactions, safeguarding sensitive financial and personal user data against cyber threats and leaks is a top regulatory priority *(RBI, 2023; (Katrak, 2024)*.

SUGGESTIONS AND RECOMMENDATIONS

After going through all the scenarios of a cashless economy, some of the suggestions could be provided which could be utilized for a smoother implementation of digital transaction system. Some of them are discussed as follows:

1. Users should start setting up strong and unique passwords for their digital payment accounts so that it becomes relatively harder for one to guess the password who has an ill-intention. Users should also enrol themselves in multi-factor authentication (MFA) to make their accounts more secured.

2. Banks should update their software regularly to patch the security holes and bugs in their code. There are numerous deceptive messages designed to steal sensitive information, such as, fake e-mails mimicking banks, delivery services, or government agencies and the users must be beware of such fraudulent.
3. The telecom providers should start investing more in building better telecom infrastructure in remote areas so that transactions do not fail due to poor signals.
4. Both the banks and the users should start using biometric checks widely on apps to block the unauthorized users.
5. The banks, fintech infrastructure and the government should start scaling up on better device wallet tools so that people can pay without internet or mobile data.
6. Payment apps should also be available in local languages for those who are not very comfortable with English.

CONCLUSION

India has undergone a significantly long way moving from a heavily cash-based economy to a more digitally assisted payment system. With the increasing growth of platforms such as UPI, BHIM, Debit and Credit cards etc., payments have changed. Once, payments in India required a visit to bank, writing cheques, waiting in long queues or a visit to an ATM. Now these transactions can be carried out in seconds without wasting anyone's precious time. The government has put forward several initiatives such as Digital India, Pradhan Mantri Jan-Dhan Yojana and AePS to make the mass more comfortable with the new transformation in the field of transactions and expanding the access to formal financial services, particularly among the people who were previously less connected to the banking system.

The visible change in the digital payment scenario came after demonetisation in 2016 which later received another huge push in 2020 due to COVID-19 pandemic when contactless transactions was the only way. Apart from making payments easier, digital transactions have also resulted to greater transparency related to transactions, reduced cash-handling costs, financial inclusion and formalisation of economic activities.

While India today shifts towards a digital and cashless economy, it still faces a few major difficulties like cyber fraud, phishing, limited digital literacy, unreliable internet connectivity, transaction failures, the digital divide etc. and, concerns about the safety of personal and financial information can discourage people from using digital payment services. Therefore, simply increasing the number of digital payments is not sufficient, the users must also feel secured and confident while sharing their personal and sensitive information and access to such systems without any fear of their information being leaked or stolen.

In the coming years, greater attention will be needed towards improvement in the fields such as digital infrastructure, strengthening digital security, providing payment services in regional languages etc. The government, banks, fintech companies and telecom providers all have a role to play in it. If these challenges are addressed accordingly, digital and cashless India has a wider scope and a bright future down the road.

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--Chapter--

Financial Technology for Rural Transformation: Bridging the Financial Inclusion Divide

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Digital Payment Adoption among Traditional Manufacturing Industries: Evidence from the Bell Metal Industry of Sarthebari

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ABSTRACT

Over the past decade, India's payment ecosystem has undergone a profound transformation, driven by the rapid adoption of digital payment methods among businesses and consumers. This transformation has increasingly extended beyond modern enterprises to traditional industries and small- scale manufacturing clusters, enabling enterprises in less formalised settings to participate in the evolving digital economy. This study examines digital payment adoption in the traditional bell metal industry of Sarthebari, Assam, with particular emphasis on payment modes, business benefits and adoption-related challenges. The study is based on primary data collected from 100 wholesalers and retailers in Sarthebari town and its adjacent villages using convenience sampling. The data were analysed using descriptive statistical techniques. The findings reveal that digital payments have expanded the market reach and simplified financial transactions of bell metal businesses by enabling them to receive orders and payments from customers across India without actually visiting Sarthebari. Digital payments have also streamlined payments to suppliers and improved the recording and monitoring of business income and expenses. Faster receipt of customer payments further supports more efficient cash flow and working capital management. Despite these benefits, businesses continue to face certain challenges in using digital payment systems. Therefore, the study highlights how digital payments are gradually reshaping the way traditional businesses operate while improving their access to wider markets and more efficient financial practices.

Keywords: Digital payment adoption, Traditional Manufacturing Industries, Bell metal industry, Sarthebari, Assam

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INTRODUCTION

Digital technologies have transformed how businesses work around the world. The rapid development of digital payment systems has helped companies, including small-scale and cottage industries, manage customers and handle payments more easily. But not all businesses adopt these tools at the same pace.

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Many small and micro businesses struggle due to poor digital skills and weak infrastructure. In today's digital world, e-payment systems have changed how small businesses handle money (*Rahadi & Xena, 2019*). Moreover, the penetration of digital payment systems, particularly UPI, has profound implications for financial behaviour among diverse demographics. Studies have indicated that increased use of digital payment influences spending habits, savings patterns and overall financial literacy (*Arif et al., 2026*).

Traditional manufacturing industries also known as cottage industries play a key role in growth of local economy, especially in rural and informal areas. They provide employment, preserve traditional skills and contribute to the development of local economy. These small businesses occupy a distinctive position in global commerce: they operate with tight cash cycles, limited administrative capacity and high sensitivity to frictions in receiving payments, customer conversion and repeat purchasing decisions. Mobile and electronic payments are positioned as tools that compress time-to-cash, widen customer reach and formalize transaction records that can inform pricing, inventory decisions and credit access. From an international significance perspective, the diffusion of digital payments intersects with cross border trade, platform economies, tourism flows and operational realities of the businesses (*Amin & Ahmed, 2022*). Thus, understanding digital payment adoption in traditional industries is important for examining how technology change is being adopted by the age-old local industries.

As India continues to embrace digital transformation, understanding the dynamics between digital payment systems and economic behaviour becomes crucial for policymakers, financial institutions and stakeholders striving for a more inclusive future (*Arif et al., 2026*). Existing studies have examined digital payment adoption among consumers, small businesses and micro enterprises but limited attention has been given to traditional manufacturing industries.

Therefore, the bell metal industry of Sarthebari, Assam can provide a valuable insight for examining digital payment adoption. The chapter examines digital payment adoption among enterprises, the purpose for which they are used, the benefits experienced by the industry and challenges associated with their adoption. The study shall contribute to the broader discussion on digital transformation within India's traditional manufacturing industries.

DIGITAL PAYMENT

Digital payment refers to the transfer of monetary value between a payer and payee through digital or electronic modes. It is commonly defined as monetary value transfers executed through electronic channels and governed by interoperable rules, authentication, and settlement infrastructures that replace or augment cash and paper- based instruments (*Amin & Ahmed, 2022*). The Framework on Alternative Authentication Mechanisms for Digital Payment Transactions given by RBI in 2024 states that Digital Payment Transactions shall have the same meaning as "Electronic Funds Transfer" as defined in the Payment and Settlement Systems Act, 2007. As per the definition, "Electronic Funds Transfer" means any transfer of funds which is initiated by a person by way of instruction, authorisation or order to a bank to debit or credit an account maintained with that bank through electronic means and includes point of sale transfers, automated teller machine transactions, direct deposits or withdrawal of funds, transfers initiated by telephone, internet and card payment.

1. **Evolution of Digital Payment Systems in India:** The evolution of digital payment systems in India represents a transformative journey that has redefined the nation's financial landscape. The development has been categorized into 4 distinct phases. The phases are explained below:
   - **Pre-2010: Foundational Infrastructure and Early digital channels:** India's financial journey has evolved over centuries from barter systems and cowrie shells to coins, paper currency and cheques. Cash remained the dominant mode of transaction while cheques and demand drafts were part of formal payments. The early 2000s marked the beginning of digital transformation in payments. The RBI introduced systems like Real- Time Gross Settlement (RTGS) in 2004,

National Electronic Fund Transfer (NEFT) in 2005. These systems laid the groundwork for secure electronic fund movement (*Katrak, 2024*).

- **2010-2016: Emergence of Mobile Banking and wallets:** The period from 2010- 2016 saw the introduction and steady growth of mobile banking and digital wallets. Players like Paytm, Mobikwik and Freecharge gained popularity among the young consumers. The RBI introduced guidelines for prepaid payment instruments (PPIs). However, adoption remained moderate due to trust issues, limited awareness and limited internet infrastructure in rural areas (*Katrak, 2024*).
- **2016-2020: Acceleration post-demonetization and rise of UPI:** In November 2016, the announcement of demonetization, marked a significant turning point in the digital payment landscape of the country. This period witnessed an extreme rise in the use of digital payment tools, particularly the Unified Payment Interface (UPI), launched in 2016 by the National Payments Corporation of India (NPCI). UPI enabled seamless peer-to -peer and person-to-merchant payments via mobile apps with real -time settlement (*Katrak, 2024*).
- **2020-2024: Digital acceleration amid COVID-19 and innovation expansion:** The COVID-19 pandemic created a renewed push toward contactless transactions, further enhancing the role of digital payments in daily life. Consumers increasingly adopted QR-based payments, UPI, and mobile banking to minimize physical contact. By 2021, UPI crossed 22 billion transactions (*Katrak, 2024*).

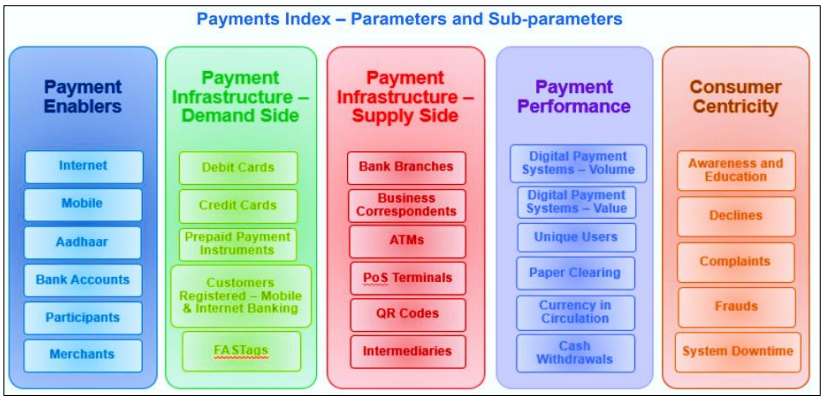
The future of digital payments in India looks promising as the UPI seems to expand globally, introduction of Central Bank Digital Currency, Blockchain and Cryptocurrency. The convergence of government policies, technological advancements, and changing consumer behaviours has created a robust digital payment ecosystem.

2. **Digital Modes of Payments in India:** Currently in India, 10 or more different cashless digital modes of payments are being widely used. Some these cashless modes of payment are:
   - **Banking Cards:** These are basically credit, debit, and pre-paid cards. These cards offer two levels of security: secure PIN and OTP. These are a secure, convenient cashless mode of payment, which gives more control to users than any other payment method (*Trivedi, 2024*).
   - **Unstructured Supplementary Service Data (USSD):** Providing banking service to every common man in the nation was the goal of the *99# or USSD. It is a distinctive interoperable direct-to -consumer service. Customers can use this service by dialling *99# on their mobile phone and can make purchase from an interactive menu that appears on their phone's screen. It is a service designed for feature phones without internet access (*Trivedi, 2024*).
   - **PoS Terminals:** The most common type of PoS machine is for debit and credit cards. The customers can easily swipe their cards, enter the preset PIN and the money gets deducted instantly. With increasing popularity of other online payment methods, a contactless reader of a PoS machine has emerged which can debit any amount up to Rs 2000 by auto-authenticating it without needing a PIN (*Trivedi, 2024*).
   - **Unified Payments Interface (UPI):** UPI has become one of India's most- used digital payment modes. It has recorded 24,162 transactions worth Rs 314 lakh crores in 2026 (*PIB).* UPI is the system of Scan and Pay without the need to type in the card or bank details. It brings numerous bank accounts into a single application, allowing money transfers between parties irrespective the bank types (*Trivedi, 2024*).
   - **Aadhar Enable Payment Service (AePS):** This model is powered by banks. It enables online interoperable financial inclusion transactions at PoS employing the Business Correspondent of any bank. For using AePS, a customer's IIN, Aadhar number and fingerprint taken upon enrolment are the only inputs needed to complete a transaction (*Trivedi, 2024*).

- **Net Banking:** It is an electronic payment system that allows customers of banks or any other financial institution to carry out several kinds of transactions via the website, eliminating the need for physically visiting the bank to get bank service (*Trivedi, 2024*).
- **Mobile Wallet:** This are type of wallet where cash can be carried in digital format. Customers can link their bank account to their wallets or also can add money to the mobile wallet and use the balance to transfer money. Some popularly used are Paytm, Freecharge, SBI Buddy, Axis Bank Lime, ICICI Pockets and others (*Trivedi, 2024*).

3. **Digital Payment Index**

The Reserve Bank of India (RBI) has constructed a composite Digital Payment Index (DPI) to measure the extent of digitisation of payment across the country. The RBI-DPI has been constructed with March 2018 as the base period i.e., 100. It comprises of 5 broad parameters that enable measurement of deepening and penetration of digital payments in the country over different time periods. These parameters are further divided into sub- parameters which consist of various indicators. The major parameters are displayed below with elaboration:



Source: RBI Portal

- **Payment Enablers-25%:** Payment Enablers refer to the basic conditions that support the adoption and use of digital payments. This includes the factors such as access to bank accounts, availability of mobile phones and internet connectivity that enable individuals and businesses to participate in digital payment systems. This parameter reflects whether the necessary conditions for using digital payments are available to users.
- **Payment Infrastructure-Demand side-10%:** This parameter focuses on the infrastructure and facilities available from the users' and customers' side for making digital payments. It covers the availability and accessibility of payment instruments and acceptance points through which users can make digital transactions such as the availability of QR codes, PoS terminals and other payment acceptance facilities.
- **Payment Infrastructure- Supply side-15%:** This relates to the infrastructure provided by banks and payment service providers to facilitate digital transactions. It considers the availability and functioning of banking and payment infrastructure that enables transactions to be processed efficiently.

- **Payment Performance-45%:** It is the largest weighted parameter of the DPI. It reflects the actual use of digital payment systems in the economy. It considers indicators related to the volume and value of digital transactions across different payment channels.
- **Consumer Centricity-5%:** It focuses on the user experience and protection associated with digital payments. It includes aspects such as consumer awareness, convenience, security and mechanisms for addressing grievances. This parameter recognizes the development of digital payments is not only about infrastructure and transaction volumes but also whether users can use these systems safely.

TRADITIONAL MANUFACTURING INDUSTRIES

Traditional Manufacturing Industry refer to those industries whose manufacturing practices are predominantly based on indigenous skills, passed on from generations to generations, manual labour, locally available raw materials and traditional knowledge system (*Koga, 1968*). There is no official definition of Traditional Manufacturing Industry. These industries are generally community-based, functioning through family enterprises or cooperative systems and produce goods that reflect regional art, culture and lifestyle. Traditional Manufacturing Industry refers to the services provided by traditional manufacturers who produce goods according to customer requirements using their own machinery (*Koga,1968*). It is defined by characteristics like labour intensive nature, small-scale operations, traditional skills passed on from generations and cultural significance.

1. **Role in Rural Development:** Rural industrialisation is an important component in rural transformation. Traditional manufacturing industries are primarily labour- intensive and skill based. Therefore, their contribution in the process of rural development is wide. Their major contributions are discussed below:
   - **Employment Generation and livelihood creation:** Traditional Manufacturing Industries like the handicrafts, handloom, pottery, metalwork and other cottage industries provide employment opportunities because of the nature of these industries is household based, small- scale industry which has been carried on for generations. Therefore, this reduces the dependence of rural people on agriculture only for their livelihood *(Keshari,2026).*
   - **Income generation and poverty reduction:** By generating opportunities for household-based production, traditional industries can supplement rural household incomes. Although not a huge amount of money can be earned at the initial stage but if product diversification and innovation is infused, the business can turn out to be successful which will further lead to poverty reduction *(Keshari, 2026).*
   - **Preservation of traditional skills and cultural heritage:** Traditional manufacturing industries help in preserving indigenous skills, knowledge, designs, and production practices that are transmitted across generations. It helps maintaining cultural heritage of rural communities *(Keshari, 2026).*
   - **Reduction of rural -urban migration pressure:** Traditional industries can play a significant role in reducing urban migration problem. Rural youths can be employed in these industries which will not only solve the rising unemployment problem but also strengthening traditional manufacturing industries can contribute to retain productive labour within rural communities which will help promoting development of local economy *(Keshari, 2026).*
   - **Promotion of entrepreneurship and self- employment:** Since the industry is often small-household enterprises and micro-enterprises, this can create opportunities for individuals to become self- employed and develop entrepreneurial activities without investing large capital. The new generation can utilise modern techniques to promote their products and increase the sales as compared to the previous generations who mostly lacked market knowledge *(Keshari,2026).*

BELL METAL INDUSTRY OF ASSAM

History says, this industry originated during 7th century A.D., as Kannauj king; Harshavardhan was gifted bell metal product of Sarthebari by Kamrupa king; Bhaskar Verma. The Bell Metal industry of Sarthebari was first carried out under the patronage of the wealthy and affluent merchants or traders, also called 'Mahajans'. These Mahajans were dominating in nature and did not provide proper wages to the rural artisans. Therefore, Mr. Kohiram Das, a visionary gentleman started a Co-Operative Society in the year 1933 to succour and provide assistance to bell metal workers. The Co-Operative society was formed in the name of "Assam Co- Operative Bell Metal Utensils Manufacturing Society Ltd." to help the skilled artisans. This enabled the workers to earn their proportionate share in earnings, remuneration and added benefits for their hard-earned works for which they were not paid earlier. The first secretary of the establishment was Mr. Kohiram Das. Later on, the Co-Operative Society was registered under the Co-Operative Society Act 1939. The products manufactured from bell metal were distributed through 11 Co-Operative Society namely in Sarthebari New Market, Fancy Bazar, Dispur, Paltan Bazar, Ganesh Guri Chariali, Jorhat, Sibsagar, Tezpur, Golaghat, Pathshala and North Lakhimpur (*Bharali et. al, 2023*).

1. **Economic and cultural significance:** Bell Metal craftsmanship in Assam represents a valuable traditional occupation that has been sustained across generations. Over the decades, numerous products of this craft have acquired socio-cultural and religious significance in Assamese society. The art of bell metal craftsmanship is deeply connected with Assamese culture, as its utensils and other products hold an important place in various social and religious practices. These products are significant during marriage ceremonies, where bell metal utensils are traditionally presented as symbols of cultural identity and hospitality. They are also widely used in religious rituals, including those associated with Vaishnavite tradition propagated by Srimanta Sankardeva. Despite the growing influence of modern lifestyles, these traditional practices have retained their position in the Assamese households. In fact, with the rising earning capacity of the people there is more demand for these products. Thus, bell metal industry are not merely household articles; they represent an undivided part of Assamese cultural heritage (*Deka, A.K., 2022*). Beyond the cultural significance, bell metal industry also provides income sources to the rural artisans, manufactures and traders. Therefore, the industry also serves as an important component of the local traditional economy of Sarthebari.
2. **Market and Business Characteristics:** The bell metal industry represents a traditional artisan- based economic activity that has gradually developed into an important local business cluster. From a business perspective, the industry is largely characterised by small -scale production units, skill-intensive manufacturing and competition among local producers. *Saloi and Barman (2020*), using Porter's Five Forces model and responses from 180 entrepreneurs in Sarthebari, found out several characteristics of the industry which are discussed below.
   - **Threat of Entry:** The Bell metal industry of Sarthebari has high threat of entry from new players. The approximate amount of capital required to set up a manufacturing unit of bell metal products is Rs.1 lakh but one should have expertise skill and knowledge regarding manufacturing of bell metal products. Moreover, there is no formality imposed by government except for registration with District Industries and Commerce Centre. But it can be concluded that the industry is attractive for the prospective entrepreneurs.
   - **Bargaining Power of Suppliers:** The bargaining power of supplier is less. There are no large number of suppliers of raw materials, equipments and tools. The raw materials are purchased from Guwahati city but whenever there is need of large number of raw materials, it is purchased from other countries like Bangladesh. Moreover, suppliers cannot increase the price of raw materials frequently and lower the quality of materials.
   - **Bargaining power of buyers:** The bargaining power of the buyers of bell metal is high. The purchaser can seek to reduce the price as there is no uniform price of the products. Full

information of the product is provided to the buyers. Also, there is the tendency among the purchaser to switch other manufacturer if they get better discounts.

- **Threat of substitutes:** The Bell metal industry has a high threat from substitute products like decorative items made of glass, clay, steel, plastic, et. Therefore, the demand of traditional bell metal products is decreasing. Also, the industry is facing serious challenge from the imitation products in the market.
- **Existing Rivalry among competitors:** The industry faces high competition among existing firms but limited to only Sarthebari area. The competitors use various strategies to attract customers like by producing unique designs and giving discounts. Also, there is involvement of middlemen which help competitors to connect international market.

INDUSTRY LEVEL INSIGHT: EVIDENCE FROM THE BELL METAL INDUSTRY OF SARTHEBARI

According to the *Commissionerate of Industries and Commerce (2025*), the Bell Metal Industry of Sarthebari provides employment to approximately 1,507 artisans reflecting its importance as a traditional source of livelihood in the region. The total number of bell metal firms operating in Sarthebari range between 280 and 350, which constitutes the population of the study. From this population, a sample of 100 firms was selected from Sarthebari and its adjoining villages including Tamulsuba, Karakuchi, Boniakuchi. For the purpose of analysis, the firms were classified into two strata namely wholesalers and retailers. Out of the 100 firms surveyed, the number of wholesalers was 30 and retailers were 70. Within each stratum, the firms were selected based on accessibility and willingness to participate in the study. Through this approach, the study captures the perspective of different categories of market participants within the bell metal industry. This classification provides a basis for examining the adoption and use of digital payment practices across different segments of the industry's business structure.

1. **Digital Payment adoption among the firms:** The field survey indicates that digital payment has become a widely accepted component of business transactions within the bell metal industry of Sarthebari. The firms reported that digital payment has made business convenient and flexible. During the survey it was observed that customers from different parts of Assam, as well as outside the state, make payments through digital modes while purchasing bell metal products from these firms. Therefore, digital payment adoption by these firms has facilitated transactions with customers irrespective of their geographical location and has extended the market for the products. As a result, the demand and sales of the products have increased. During the field survey, it was found that all the surveyed business firms has adopted digital payment and have an active QR code.
2. **Common digital payment modes:** During the field survey, the firms reported that UPI and bank transfers are the two major digital payment modes used by bell metal enterprises in Sarthebari. UPI emerged as the most commonly used mode for daily business transactions. Bank transfers were also commonly used for receiving as well as making payment for large-value transactions. It was observed that more than 95% of the enterprises use UPI applications such as PhonePe and Google Pay, while a few enterprises also use mobile banking applications such as Axis bank and SBI YONO.
3. **Purpose of using digital payments:** According to the survey conducted among the bell metal enterprises, digital payment is used by the bell metal enterprises for both business-related and household transactions. In business, digital payment is used for making payments to raw material suppliers as well as for receiving payments from customers. The survey also found that some enterprises use digital payment for paying their household expenses from their business income. These digital transactions provide a transaction trail that helps the owners keep track of their expenses and identify where their income has been spent. This further assists them in monitoring cash outflows

and maintaining clear understanding of their income and expenses, which help in assessing the profitability of their business.

4. **Benefits experienced by enterprises:** The adoption of digital payments has provided several benefits to the bell metal enterprises. One of the major benefits reported by the enterprises is greater convenience in conducting business transactions. Digital payments facilitated quick receipt of payments from customers and enabled enterprises to make payments to raw material suppliers which has contributed to smoother business relationships. The enterprises reported repeated purchases from loyal customers, indicating that convenient payment facilities may contribute to customer retention. The availability of digital transaction records further helps firms to keep track of their receipts and payments.

   Another benefit observed during the field survey was the accessibility to digital financial services. Some enterprises reported obtaining credit through digital platforms such as PhonePe, which provided them with short-term financial support. During the field survey, it was also reported that digital payment system has made it easier for some business owners to access online investment services, including mutual fund investments and the purchase of shares of different companies. Therefore, the findings reveal that the adoption of digital payment has extended beyond daily business transactions and has facilitated better customer engagements, financial record keeping, access to digital credit and participation in online investment activities among the surveyed enterprises.

CHALLENGES FACED BY ENTERPRISES

Despite the fact that digital payment adoption has brought great convenience in business transactions of bell metal enterprises and because of these benefits they have widely accepted digital payment system but their use is not entirely free from challenges. The enterprises reported certain difficulties associated with the use of digital payment, particularly in relation to transaction failures, internet connectivity and limited knowledge of digital payment systems. The major challenges reported by the enterprises include:

1. **Lack of digital knowledge:** Although the findings indicate that some enterprise owners have adopted digital platforms beyond daily payment transactions, such as for digital investments, a considerable number of enterprises appears to have limited knowledge of digital payment system. Many owners primarily rely on the sound notification generated by the QR code device to confirm that a payment has been received, other than independently verifying the transaction details. In some cases, they may also face difficulty in differentiating between a genuine payment confirmation and a false payment screenshot. Moreover, it is reported that it becomes difficult for some enterprises to verify whether a payment has actually been credited to their particular UPI ID. In such cases, they have to depend on someone from the family or friends who have knowledge of digital payment.
2. **Cybersecurity concerns:** Cybersecurity is another important challenge among the enterprises using digital payment platforms. The respondents reported receiving fake calls and messages related to digital payments, and some had experienced financial losses after becoming victim of such fraudulent activities. These experiences have created a sense of insecurity among the firm owners regarding the safety of digital transactions. The fear of fraud and potential loss of hard-earned money had made some enterprises cautious about relying heavily on digital payment platforms.
3. **Network connectivity issues:** Network connectivity has become another major concern for the business firms particularly those located in the villages adjoining Sarthebari. The respondents reported frequent problems with internet connectivity, which hinders the smooth processing and verification of digital payments. In some instances, customers make the payment successfully, but the owners are unable to verify in real time whether the amount has actually been credited to their

accounts due to poor network. As a result, they have to wait until the network is restored or travel towards Sarthebari town, where network connectivity is relatively better.

4. **Preference for cash transactions:** Some of the older business owners were found to have a clear preference for cash transactions. They are comfortable with cash as a result of limited familiarity with digital payment processes. Although many of them have kept QR codes at their shops due to the growing demand for digital payments, they often hesitate to use them regularly. They mainly accept digital payments when customers from outside the Sarthebari area place orders. Thus, it can be concluded that simply having a QR code does not mean that an enterprise has fully shifted towards digital payments.
5. **Limited awareness of advanced digital financial services:** Although some owners were found to use digital platforms for investing in shares and mutual funds, awareness of other advanced digital financial services remains limited among many enterprises. Many owners are familiar with basic digital payment facilities such as UPI and bank transfers but have limited knowledge of services such as digital insurance, online credit facilities and other financial services.

RECOMMENDATIONS

The findings highlight that digital payment system has become an increasingly important part of the bell metal industry and are widely adopted by the firm owners. However, when the difficulties faced by the enterprises are also addressed then the benefits of digitalisation can be more realised. The following measures may help in promoting the effective and wider use of digital payments among the enterprises.

1. **Digital literacy and awareness programmes on cybersecurity**: The study highlights an important challenge of limited digital literacy. Proper measures such as short-term practical training programs shall be undertaken for the owners and other related stakeholders where the focus should not be only on making payments but also on checking transaction status, verifying recipient or UPI ID, identifying fake payment screenshots, handling failed transactions and recognising fraud calls or messages. Demonstrations would be more useful rather than providing general information about cybersecurity.
2. **Improving network connectivity in adjoining villages:** The network problems reported by enterprises in villages surrounding Sarthebari need attention. Improving internet connectivity is important for ensuring the smooth use of digital payment systems. The network- related difficulties faced by enterprises make it difficult for them to verify whether payments have been received in their accounts. Better and more reliable internet connectivity would enable owners to reduce delays and uncertainty in business transactions.
3. **Strengthening transaction verification and record- keeping:** The owners should be encouraged to develop habit of verifying digital payments through their bank account, UPI application or transaction history instead of relying only on QR-code sound notification. This can help them confirm whether the amount has actually been credited to their account and reduce the possibility of accepting false or incomplete payment claims. Also, maintaining proper records of digital transactions can help enterprises keep track of their sales and receipts and make it easier to reconcile their business transactions.
4. **Integrating digitalisation with the traditional business ecosystems:** The bell metal industry should not be limited to the adoption of digital payment systems alone. The enterprises shall make use of digital tools in other areas of the business, such as maintaining records, communicating with customers, receiving orders and promoting their products through online platforms. This integration can help the enterprise respond to changing customer preference and expand the market while preserving their traditional methods of production and business practices.

CONCLUSION

The study presents a descriptive assessment of the digital payment adoption in traditional manufacturing industries, with specific focus on Bell Metal Industry of Sarthebari. The industry has both economic and cultural significance for the people of Assam. The study shows that the bell metal enterprises are increasingly using the digital modes for receiving and making payments. It has not only provided them with convenience but also helped in building better business relations with various stakeholders. Although, the usefulness is not limited to business transactions, as some enterprises use it for household expenses and for investment in shares and mutual funds. This indicates that digital financial practices are gradually becoming a part of everyday financial activities of enterprise owners.

From the study it appears that digitalisation appears to be creating opportunities for a traditional industry to respond to changing patterns of commerce without changing their traditional production processes. The main value for these enterprise lies in improving the way its financial and commercial activities are connected with a wider market. Therefore, the future potential of digital payment in the bell metal industry depends more on improving the quality and depth of adoption. By taking necessary measures to overcome its challenges such as reliable connectivity, digital and financial literacy, cybersecurity awareness, the industry can move to meaningful digital financial participation.

Therefore, it can be concluded that a gradual and supportive approach to digitalisation can help the bell -metal enterprises to benefit from changing financial and market practices while retaining to its root of traditional skills.

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--Chapter--

Financial Technology for Rural Transformation: Bridging the Financial Inclusion Divide

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Digital Transformation and FinTech Adoption for Enhancing Financial Inclusion and Sustainable Growth in the Handloom Industry of Manipur

Sushmita Konjengbam[1], Dr. Rishi Chakravarty[2]

ABSTRACT

The largest among different cottage industries in Manipur is handloom, which is used by 2.5 to 3 lakhs of weavers (mainly women) of Imphal East, Imphal West, Thoubal and Bishnupur. In spite of its cultural richness the sector is cash led and market-led, with minimal institutional credit facilities and/or markets and only three Geographical Indications (GI) related textiles - Shaphee Lanphee, Wangkhei Phee and Moirang Phee. The aim of this paper is to discuss the role of digital transformation and financial technology (fintech) in improving financial inclusion and sustainable development in the Manipur handloom sector. It is a conceptual cum analytical study and secondary data has been collected from government reports, publications of Reserve Bank of India (RBI) and peer-reviewed literature. It builds an ecosystem of digital infrastructure and financial instruments such as Unified Payments Interface (UPI), Mobile Banking, Digital Micro Credit, E-commerce marketplaces, and Block Chain for traceability linking to Financial Inclusion and Sustainable Livelihoods outcomes of the weavers. The paper reviews the schemes and policies namely Pradhan Mantri Jan-Dhan Yojana, Weaver MUDRA scheme and National Handloom Development programme along with their problems to enhance market access. The analysis suggests that using fintech, cluster-based digital skills development and public-private cooperation will lower transaction costs, increase formal financial access and enhance direct-to-consumer market access.

Keywords: Digital Transformation; Women Empowerment; Handloom Industry; Sustainable Livelihoods

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INTRODUCTION

Handloom weaving is one of the most ancient and prevalent livelihood activities of the rural segment. It holds a special status in Manipur economy and Indian population and occupies a large chunk in Manipur identity. Handloom, the largest cottage industry in Manipur, is also the second largest source of

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livelihood, after agriculture, in the state *(Northeast Now, 2021)*. There are estimated to be 2.5 to 3 lakh persons engaged in weaving in Manipur and the state has always been in the top ten of the lists of handloom producing states of the country in terms of number of looms in the state and the weavers per thousand population *(IBEF, 2025; Fibre2Fashion, 2016)*. India in the past few years has been experiencing a transformation in terms of digital and financial inclusion based on the popularly known JAM trinity - Jan-Dhan bank accounts, Aadhaar digital identity and mobile connectivity - along with the Unified Payments Interface (UPI) and a growing financial technology (fintech) industry providing digital payments and micro-lending, insurance and wealth-management solutions. Along with this, parallel evolution of telephony and Aadhaar has been taking place. Fintech is particularly significant for a geographically distant state such as Manipur. Manipur, a conflict prone state in recent years, was the place where the incident occurred. It provides a viable route to reduce the reliance of the Educate the weavers on relying on the informal intermediaries and formalise their financial relationship and tie them with their context. On the other hand, the handloom industry in Manipur has faced various problems ranging from scattered hills to post harvest losses and it is challenging the sector. Low financial or digital literacy, lack of speedy internet access amongst older women handloom. Both the speed and penetration of weavers, and occasional banking and internet service interruptions, limit the speed and penetration of the adoption of fintech. This paper thus asks: What are the strategic opportunities to strengthen the financial inclusion and promoting sustainable and inclusive growth in the handloom sector of Manipur through the digital transformation and adoption of fintech and what are the challenges that need to be overcome?

REVIEW OF LITERATURE

Generally speaking, the term "fintech" refers to a technologically driven financial innovation that leads to new business models, applications, processes or products, that have had and will have a material impact on financial markets, institutions and the delivery of financial services *(Schueffel, 2016)*. Digital finance is an integration of financial services and various technologies, which includes applications like mobile platforms, data analysis and automated decision-making, and cover digital payments, digital financing, digital investment and digital insurance *(Gomber et al., 2017)*. *Ozili (2018)* believes that digital finance can help increase financial inclusion when it comes to reducing the cost of delivery of financial services, particularly to the poor and remote, but warns that the poorest and least technologically literate may not be able to get included in digital finance unless this is taken care of along with the financial infrastructure.

1. **Measurement and determinants of financial inclusion**
   Sarma translates financial inclusion into three areas: banking penetration (access), availability of banking service and utilisation of the banking service, a framework which was later adopted in the subsequent RBI policy documents *(Sarma, 2012)*. The National Strategy for Financial Inclusion 2019-24 by the Reserve Bank of India (RBI) continues this trend and suggests that accessibility, usage and quality of financial services should be the three pillars to measure progress *(RBI, 2021; IMPRI, 2024)*. The World Bank's Global Findex Database 2021 highlights India's substantial improvement in account ownership over the last ten years, largely thanks to mobile money and digital payment accounts, particularly due to the launch of PMJDY and UPI in the country *(Demirgüç-Kunt et al., 2022)*.
2. **Entrepreneurship Skills and Knowledge among MSMEs and Artisan Enterprises**
   The empirical study of Indian micro, small and medium enterprises (MSMEs) on the factors influencing fintech adoption indicates that the perceived usefulness, perceived ease of use, trust, prior digital experiences and government support are significant determinants of the adoption of fintech while the age and gender of the MSMEs have been found to moderate the intensity of fintech

adoption, which confirms the Technology Acceptance Model (TAM) and the Diffusion of Innovation (DoI) theory *(Gupta et al., 2022)*. A detailed study of the rural financial ecosystem in India reveals that nothing can bridge the financial divide between rural and urban areas as effectively as the combination of regulatory support, agent banking networks and digital financial literacy - either by keeping or re-creating the financial exclusion in the digital sphere *(Farukh et al., 2025)*

There is little and increasing research on artisan and heritage-craft enterprises. A recently conducted structured survey of handloom weavers engaged in cotton and silk handloom weaving in Tamil Nadu revealed, statistically, positive correlation between the use of digital tools and financial-inclusion parameters and also found that income of the households and market access were improved with the use of digital tools, while unstable income, poor access to formal credit and distance to markets were observed to be recurring constraints on handloom weaving as a heritage-based entrepreneurship *(Solaipriya et al., 2025)*. A study of women weavers in other parts of India also reveals that the schemes of credit for the women weavers like the Weaver MUDRA Scheme, along with the handloom financial-assistance scheme at the state-level, need to be more purposefully targeted at women artisans for them to make a difference in providing independent access to credit, rather than credit through male relatives or traders *(PIB, 2021)*.

3. Manipur Handloom Context

There is scant literature regarding the handloom sector in Manipur that addresses digital or fintech aspects. State specific literature has been largely limited to aspects of production characteristics, marketisation constraints and welfare measures, and not much regarding digital or fintech aspects. A market study on the marketing of handloom products of Manipur has revealed that more than two lakh weavers and allied workers are engaged in the handloom sector that has been facing several difficulties in terms of constraints on market linkages and value addition, which negatively affect the income of the weavers *(Banik & Longjam, 2023).* The administrative data at district level reveals very uneven distribution and concentration of loa and cluster-development coverage in the valley districts of Imphal East, Imphal West, Bishnupur and Thoubal, while the cluster-development coverage is limited in several hill districts compared to the other districts *(NEDFi Databank, 2024 - 25).*

Overall, the literature shows that digital technologies are becoming very important in livelihood sectors but it also shows that gender gaps, poor infrastructure and weak institutions still exist. Even though studies have looked at adoption, empowerment and sustainability separately there is still not enough work that mixes these topics and looks at the real life of women weavers, in Manipur. This missing piece is why the present study was started.

RESEARCH GAP

There has been a significant body of literature on (i) fintech adoption by MSMEs in India, (ii) financial inclusion and financial inclusion framework and measurement, and (iii) the production and marketing problems of handloom industry in the state of Manipur, but not much scholarship available that merges all these three aspects specifically for the state of Manipur. Up to now, no study has explicitly connected the three dimensions of financial inclusion (access, usage, quality) and sustainable livelihood outcomes with the digital-infrastructure readiness and adoption of fintech-instruments for a GI recognised handloom economy, dominated by women, affected by conflict as in Manipur. This paper fills this void.

RESEARCH OBJECTIVES

1. To investigate the organization, socio-economic status and financial aspect of handloom industry in Manipur State.

2. To draw a digital transformation and fintech landscape that is relevant to weaver's households and handloom micro-enterprise in the state.
3. To create a conceptual framework on the linkage of digital transformation and fintech adoption with financial inclusion and sustainable growth of the handloom sector.
4. To map out key factors - infrastructural, financial, behavioural and socio-political that hinder the adoption of FinTech by the weavers in Manipur.

METHODOLOGY

This paper employs a conceptual-cum-analytical research design with a 100% secondary data used approach, which is very common in literature of the financial inclusion and digitalisation of MSMEs in the policy-oriented and review-oriented research literature. The secondary sources of data and evidence were classified into four categories: (i) official government and administrative publications like reports of the Department of Commerce and Industries, Government of Manipur, the India Brand Equity Foundation (IBEF), the Press Information Bureau (PIB) and the Reserve Bank of India (RBI); (ii) Academic and peer-reviewed literature on fintech, financial inclusion and handloom/artisan economy, through journal databases and preprint repositories; (iii) Sectoral databases like North East Data Bank (NEDFi) and Indiastat and (iv) Scheme documents related to Pradhan Mantri Jan-Dhan Yojana, the National Handloom Development Programme (NHDP) and the Weaver MUDRA Scheme.

THE HANDLOOM INDUSTRY OF MANIPUR

Handloom weaving in Manipur is a livelihood, an institution and, at the same time, an asset of the economy of creativity. The number of weavers in Manipur is estimated as 2.5-3 lakh, the highest in comparison to the population density of the Indian states and one of the highest density of looms per household in the country *(IBEF, 2025; Northeast Now, 2021)*. There were approximately 2.04 lakh Handloom workers and 1.90 lakh Handloom workers are already in the state as per census of Handloom Census, 2009-10 and other administrative estimates make it to several lakh of persons who are directly or indirectly dependent on the Handloom sector including allied or preparatory workers *(Fashion Network India, 2016; Northeast Now, 2021)*. The sector is strong in the Imphal valley districts (Imphal East, Imphal West, Thoubal, Bishnupur and Kakching), but looms and weaver households are also spread out, in the hill districts like Senapati, Kangpokpi, Churachandpur and Ukhrul *(NEDFi Databank, 2024–25)*.

Shaphee Lanphee (GI No. 371), Wangkhei Phee (GI No. 372) and Moirang Phee (GI No. 373) are all registered in 2013-14 and all are traditionally woven by the Meitei women, with unique motifs and techniques *(MyGov, 2022)*. While GI recognition serves to protect the products from being copied, it can create a premium-market positioning that can help individual weavers achieve profits or income gains, but it is important that these supply chains are traceable, verifiable, and that the weavers have direct access to markets - which digital tools and fintech-enabled e-commerce can help to create in a structural way.

The sector, though large, has features similar to those of most of the unorganised handloom sector in India: most weavers are outside co-operative societies and have to finance production and or get raw materials and credit from private traders, production is carried out by one loom at a time, and the final retail price is often negotiated by the traders *(Banik & Longjam, 2023)*. Though there are various government interventions like the Deen Dayal Hathkargha Protsahan Yojana, the Integrated Handloom Development Scheme and in recent years, the National Handloom Development Programme (NHDP) Block Level Cluster scheme and loom-distribution component, very few looms and weavers have benefitted from direct financial assistance, working-capital support and skill upgradation, and the coverage is uneven across looms and weavers, with disparities in the number of looms distributed in

2023-24 between various districts, ranging from Imphal East with over 2300 looms to no distribution in some hill districts *(NEDFi Databank, 2024 -25)*.

Table 1: Weaver Livelihood Profile at a Glance

Indicators	Estimate/ Status	Source
Estimated weavers in Manipur	≈2.5–3.0 lakh persons, overwhelmingly women	*IBEF (2025); Northeast Now (2021)*
Position of handloom in state employment	Largest cottage industry; 2nd-largest livelihood sector after agriculture	*Northeast Now (2021)*
GI-tagged products	Shaphee Lanphee, Wangkhei Phee, Moirang Phee (registered 2013–14)	*MyGov (2022); Wikipedia (2016)*
Predominant financing mode	Self-financed / trader (mahajani) credit; limited co-operative and bank credit	*Govt. of Manipur (n.d.)*
Geographic concentration	Imphal East/West, Thoubal, Bishnupur, Kakching (valley); thinner coverage in hill districts	*NEDFi Databank (2024-25)*
Primary market channel	Local haat/exhibition sales and trader-intermediated wholesale; limited direct e-commerce	*Banik & Longjam (2023)*

Sources: Compiled by researchers

CONCEPTUAL FRAMEWORK

This paper builds on Sarma's tri-dimensional categorisation of financial inclusion and existing literature on digital-finance to propose an integrated framework comprising four layers *(Sarma, 2012; Gomber et al., 2017; Ozili, 2018).*

1. **Layer 1 - Digital Infrastructure Readiness:** This layer includes mobile connectivity, Internet connectivity, electricity connectivity, penetration of smartphones, Aadhaar-based digital identity and physical or digital connectivity of the banking correspondents/agents in weaving clusters. It is the enabling layer, the basic structure on which the next generation of fintech will be built – if there's no identity infrastructure and connectivity to enable it, then no one will want to adopt it anyway.
2. **Layer 2 - Adoption of fintech instruments**: These include: (a) Apps for UPI/mobile banking which facilitate receipt of proceeds from handloom sale and payment of bills; (b) savings/overdraft accounts linked to PMJDY accounts or having a RuPay linkage; (c) fintech/lending-platform products and micro-credit using UPI with alternative data facilitated through digital transaction history or collateral-light micro-credit, as these options are available with MUDRA also; (d) micro-insurance products (including accident/life insurance bundled with PMJDY accounts); (e) e-commerce/social commerce marketplaces (including government platforms such as GeM and state emporia going digital) for direct-to-consumer sale of handloom products; and (f) emerging blockchain-based/electronic traceability tools, that can help authenticate GI-registered products and communicate the provenance to the buyers.
3. **Layer 3 - Financial Inclusion Outcomes:** The adoption at Layer 2 is expected to bring about three outcomes - Access (adoption of a transaction/savings account and a digital payment instrument), Usage (frequency of use and depth of use - regular use of digital payment instruments, mobilisation of savings, credit drawdown and repayment) and Quality (the extent to which financial products are appropriately priced, matched to the irregular income cycles of artisans and delivered with adequate consumer protection and grievance redress) *(RBI, 2021)*.
4. **Layer 4 - Sustainable Growth Outcomes:** The outcomes that capture the economic, social and environmental dimensions of sustainable development in a craft-based livelihood sector are: economic (better and more stable incomes for weavers, less reliance on exploitative trader credit, formalised savings for old-age and emergency resilience); social (women's economic agency, and

intra-household bargaining power, as the sector is predominantly female); and environmental/cultural (the handloom weaving process, as a natural, hand-powered production method, is preserved and sustainable, rather than being replaced by unsustainable mechanisation, and digital tools for provenance can maintain the authenticity and cultural-heritage value of weaving-made goods, when they are GI-tagged).

THE BUSINESS OPPORTUNITIES AND CHALLENGES OF DIGITAL TRANSFORMATION AND FINTECH IN MANIPUR HANDLOOM SECTOR

Pradhan Mantri Jan-Dhan Yojana has already facilitated the formal banking system to engage more than 50 crore people who were out of banks and nearly half of the accounts were opened by women and about two-thirds by residents of rural and semi-urban areas, a profile that closely mirrors that of the weavers in Manipur *(PIB, 2024; PIB, 2023)*. All PMJDY accounts come with a RuPay debit card, zero-balance and accident and life-insurance cover, effectively reducing the barriers to formal financing for low-income artisan households *(Digital India Gov, 2024)*. Keeping this in mind, UPI has emerged as the preferred digital-payment rail in India and is being exploited by a larger number of micro-merchants, such as craft producers, to receive payments directly from customers, without involving cash handlers or intermediaries *(Zameer & Khan, 2024)*.

The Weaver MUDRA Scheme's good news is that in principle it provides loan facility for individual weavers at a concessional interest to women who are unable to get a loan from a trader, with margin money and interest subvention in addition to the regular loan, the literature points out that there is a lack of targeted effort to reach women weavers, which is necessary to make them avail the scheme without relying on men as intermediaries *(PIB, 2021).* On the MSME level, overall, India's fintech lending ecosystem has evolved to provide lending where transaction history or GST data or digital payment records are used for collateral instead of traditional collateral *(Chand & Kansal, 2025).*

From the market-access side, e-commerce and social-commerce channels like marketplace platforms, direct selling through social media platforms and state-run digital emporia enable the sell-out of GI-tagged Manipuri textiles to the consumers outside Manipur. The digital traceability tools, present a way of validating the authenticity of the GI tagged product, linking the weaver story to the end consumer, and thereby enabling premium pricing for authentic, ethically sourced handloom products.

Table 2: Mapping Fintech Tools to Financial Inclusion Dimension

Fintech Instrument	Primary Function for weaver	Financial Inclusion Dimension Served
PMJDY savings account + RuPay card	Formal savings, digital receipt of income, accident/life cover	Access
UPI / mobile banking apps	Direct, low-cost digital payment from buyers	Usage
Weaver MUDRA / fintech micro-credit	Collateral-light working-capital and loom-upgrade finance	Usage, Quality
Micro-insurance (crop/accident/life bundles)	Risk protection against income shocks and health emergencies	Quality
E-commerce / GeM / social commerce	Direct-to-consumer and institutional market access	Usage (indirect income formalisation)
QR/blockchain traceability tools	Authentication of GI-tagged products; provenance storytelling	Quality (trust, fair pricing)
SHG/Producer-company digital ledgers	Group savings, internal lending, transparent accounting	Access, Usage, Quality

Sources: Compiled by researchers

DISCUSSION: FINTECH ADOPTION TO FINANCIAL INCLUSION AND SUSTAINABLE GROWTH

The evidence presented above indicates that the handloom industry in Manipur is at a teachable moment regarding digital-financial transformation, both in terms of its potential and the conflicts that it encounters. On the potential side, the sector's very fuzziness - its dependence on trader credit, cash transactions and "undocumented savings" - is the very reason fintech instruments have been proven to yield the greatest gains in other areas of Indian economic activity; the digitisation of payments and credit histories makes economic activity visible in the bank and, thus, financeable *(Ozili, 2018; (Solaipriya et al., 2025)*.

The hypothesis that such similar benefits could be realised for Manipur, with the right enabling conditions (connectivity, digital literacy and trust) is supported indirectly by evidence from the heritage handloom clusters in Tamil Nadu, where structured survey data reveal that for these clusters there are statistically significant positive correlations between adoption of the digital tools and measures of financial inclusion and income and market access *(Solaipriya et al., 2025)*. First, the sector's products with GIs offer a unique opportunity - premium, traceable, story-based e-commerce positioning - for market-access tools that integrate proven and authentic features into the digital sales channel. Second, the history of ethnic conflict and periodic Internet shutdowns in Manipur brings in a structural fragility in any value chain of fintech: digital payment rails, e-commerce logistics, even basic mobile banking access, can be suddenly and permanently cut off. Resilient approaches to financial-inclusion strategies for the weavers of Manipur, then, should focus on resilience, including dual-channel savings (formal account plus group savings through SHG) and ensuring that livelihoods are not reliant on the presence of digital channels at all times. Third, the sector is highly reliant on trader-based (mahajani) credit and this is not just a market failure that can be replaced with fintech lending, but also an informal risk-sharing and relationship-based function that fintech lending based on algorithms cannot easily substitute. Policy design should thus aim to build on and not replace existing informal financial arrangements, and connect with the existing layer of intermediary institutions like SHG and weaver-producer-company.

CONCLUSION

The handloom industry is a big livelihood activity of Manipur, which is a cultural activity and mainly a women dominated industry, even in financial terms it is still in the middle grounds and dependent on intermediaries. The Indian government's digital and fintech revolution, based on PMJDY, Aadhaar, UPI and the maturing digital lending and ecommerce sector, has already proven significant financial-inclusion benefits in the more demographically similar regions of the country. In this paper, a conscious, clustered approach towards investment in digital-infrastructure, designing the fintech-products locally, and enabling market access for the weavers through a GI system, followed by adoption through a producer-organisations based mechanism offers a plausible pathway to extend those gains to the weavers of Manipur, and transform their informal, trader-dependent livelihoods into a more resilient, formally financed and digitally connected creative economy. Policy and institutional design to achieve this potential should, however, take into account the unique constraints that exist in Manipur, including differences in infrastructure between hill and valley, periodic disruptions to connectivity resulting from civil unrest, gender-related infrastructure access issues, and the risk-sharing role currently played by informal trader credit. The socio-technical nature of digital transformation and the adoption of fintech means that it must be mutually reinforcing and sustainable with current community institutions, self-help groups, weaving co-operatives and producer companies, to be inclusive. Considering the primary-data validation that has been identified as an area of future work, the framework and recommendations put forth here can be used as a basis for digital-financial policy work by the state authorities, financial

institutions, fintech providers and weaver organisations to address the unique challenges of the handloom sector in Manipur.

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17

--Chapter--

Financial Technology for Rural Transformation: Bridging the Financial Inclusion Divide

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Financial Inclusion and Rural Economic Development in North East India: Evidence from State-Level Data

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ABSTRACT

Financial inclusion is expected to support rural development. This study examines the link between financial inclusion and economic outcomes in the eight North Eastern states of India. It uses state-level data on per capita income, multidimensional poverty, Pradhan Mantri Jan Dhan Yojana (PMJDY) accounts and bank branches in 2009. The methods are descriptive statistics, dispersion measures, convergence regression and Spearman rank correlation with exact permutation tests, diagnostic tests check normality, heteroscedasticity, specification, influence and serial correlation. PMJDY penetration is highly uneven, and Assam holds 84.8 per cent of all accounts. Account penetration shows no significant link with income or poverty. Branch density in 2009 is positively linked with present income (rho = 0.74), but the link is fragile. The study recommends a shift from account opening to account use.

Keywords: Financial inclusion, PMJDY, North East India, Poverty, Convergence, Rank correlation

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INTRODUCTION

Financial inclusion means access to useful and affordable formal financial services. These include savings accounts, payments, credit and insurance. Rural households face seasonal income and frequent shocks. Formal finance helps them save safely, smooth consumption and invest in health, education and small enterprises *(Beck et al., 2007; Demirgüç-Kunt et al., 2018). Sen (1999)* view development as the expansion of real freedoms, and exclusion from finance narrows those freedoms.

India has pursued inclusion through many policies. These include bank nationalisation, social banking, self-help group linkage and no-frills accounts *(Burgess & Pande, 2005; RBI, 2008)*. The Pradhan Mantri Jan Dhan Yojana (PMJDY), launched in August 2014, aimed to give every household a basic account. By 23 September 2026, the scheme reported about 594 million accounts.

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North East India has eight states: Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura. The region has hilly terrain, scattered settlements and long distances to bank branches. Customary land tenure in many areas limits the use of land as collateral. The states also differ widely. Sikkim and Mizoram are richer and less poor, while Assam holds about two-thirds of the regional population.

Evidence on finance and development is mixed. Cross-country studies find that finance raises growth and reduces poverty *(King & Levine, 1993; Beck et al., 2007)*. Field experiments find small average effects from basic accounts and credit *(Banerjee et al., 2015; Dupas et al., 2018)*. Few studies compare the eight North Eastern states on inclusion, growth and poverty together. The PMJDY period has received little sub-national evaluation using methods suited to small samples. Studies also seldom report how far results depend on one or two states. This study fills these gaps with a transparent state-level dataset, exact small-sample tests and diagnostic checks.

Against this gap, the study has two objectives. The first is to describe the level and distribution of financial inclusion, income growth and multidimensional poverty across the eight states. The second is to test whether financial inclusion is associated with income and poverty outcomes.

The paper has five sections. Section 2 reviews the literature, section 3 describes material and methodology, section 4 presents results and findings, and section 5 gives the conclusion and recommendation. Limitations follow at the end.

REVIEW OF LITERATURE

1. Finance and economic growth

The finance and growth literature is large. *King and Levine (1993)* show that financial depth predicts later growth across countries. *Levine (2005)* reviews the theory and finds that finance eases information and transaction costs. *Beck et al. (2000)* find that the effect works mainly through productivity growth. *Rajan and Zingales (1998)* show that industries needing external finance grow faster where financial markets are developed. *Arcand et al. (2015)* find that the benefit weakens at very high levels of finance. These studies focus on the depth of finance, not on the breadth of account ownership.

2. Finance, inequality and poverty

Theory links credit constraints to inequality. *Stiglitz and Weiss (1981)* show that lenders ration credit when information is imperfect. Poor borrowers without collateral suffer most. *Banerjee and Newman (1993)* show that such constraints keep poor households from profitable investment. *Galor and Zeira (1993)* reach a similar result for human capital. Wealth inequality then persists. Greenwood and Jovanovic (1990) argue that finance first benefits the better-off and later reaches the poor.

Empirical work is broadly supportive. *Beck et al. (2007)* find that financial development raises the incomes of the poorest fifth faster than average. *Clarke et al. (2006)* find that finance is linked with lower income inequality. These results come mainly from cross-country data, and they do not show how inclusion works inside a single region.

3. Evidence from field experiments

Field experiments give more cautious evidence. *Banerjee et al. (2015)* find that microcredit raised business investment but not average consumption. *Dupas and Robinson (2013)* find that a simple savings account raised productive investment among women traders in Kenya. *Prina (2015)* finds that savings accounts helped poor households in Nepal build assets. *Dupas et al. (2018)* find small average effects from basic accounts in three countries. *Suri and Jack (2016)* find that mobile money reduced poverty in Kenya, mainly among female-headed households. *Jack and Suri (2014)* show that mobile money improved risk sharing among Kenyan households after income shocks. Effects therefore depend on the product, the user and the context.

4. Financial inclusion in India

Indian evidence begins with social banking. *Burgess and Pande (2005)* find that rural branch expansion in unbanked locations reduced rural poverty. *Cole (2009)* finds that public-sector bank lending followed election cycles and did not raise output. *Kochar (2011)* finds that the benefits of branch expansion were uneven across households. The Committee on Financial Inclusion set a national strategy for universal access *(RBI, 2008)*. *Dev (2006)* argues that exclusion remained large among small farmers and the poor.

PMJDY later shifted policy towards account opening. *Muralidharan et al. (2016)* show that better payment systems improved the reliability of public transfers in Andhra Pradesh. Accounts can therefore matter even when balances are small. However, the programme has received little sub-national evaluation, and the North Eastern states are rarely examined as a group. Later reports stressed digital payments as a route to wider access *(RBI, 2019)*. Such channels may suit hill areas with few branches. Their success depends on mobile networks, electricity and user skills. These conditions are weak in many parts of the North East.

5. Measuring inclusion and poverty

Inclusion is multidimensional, so researchers use composite measures. *Sarma and Pais (2011)* combine banking penetration, availability and usage in one index. *Chakravarty and Pal (2013)* offer an axiomatic index for India. *Demirgüç-Kunt and Klapper (2012)* provide survey-based measures of ownership and use. *Allen et al. (2016)* show that use depends on distance, cost, documentation and trust. *Lusardi and Mitchell (2014)* show that financial literacy supports saving and planning. Poverty is measured by the Alkire–Foster method *(Alkire & Foster, 2011)*. India's national index includes bank account ownership as one indicator (NITI Aayog, 2021, 2023). This overlap matters when interpreting results, because opening an account can lower measured deprivation directly.

6. Regional convergence

Convergence studies ask whether poorer regions grow faster. *Barro and Sala-i-Martin (1992)* define absolute and conditional beta-convergence. *Mankiw et al. (1992)* test conditional convergence using savings and human capital. *Sala-i-Martin (1996)* separates beta from sigma convergence. *Quah (1993)* warns that the two can differ. Indian studies find widening gaps among states after liberalisation *(Ahluwalia, 2000; Bhattacharya & Sakthivel, 2004)*.

Evidence for the North Eastern states alone is thin. The Vision 2020 document names weak connectivity and infrastructure as regional constraints *(Ministry of Development of North Eastern Region [DoNER] & North Eastern Council, 2008)*.

7. Summary and conceptual framework

Three points emerge from the literature. First, finance supports growth, but effects depend on depth, use and context. Second, evidence on basic accounts is modest. Third, little work compares the North Eastern states. Figure 1 summarises the framework used here. Access leads to uptake, uptake to use, and use to outcomes, while context shapes every link. Because the data are cross-sectional, this study tests association only. The review also shows that most evidence rests on large samples or single experiments. Small, comparable regional studies are rare. Transparent methods are therefore needed to avoid overstating weak patterns.

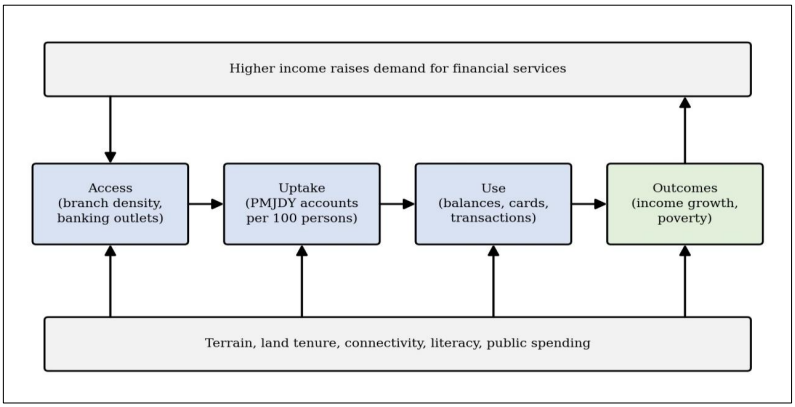


Figure 1. Conceptual framework linking financial inclusion and outcomes

MATERIAL AND METHODOLOGY

This study uses a cross-sectional design with secondary data for the eight North Eastern states. The data were compiled on 8 October 2026 from public sources. Table 1 lists the variables and sources.

Table 1. Variables and data sources

Variable	Definition	Justification
X1: Account penetration	PMJDY accounts per 100 persons (Census 2011 population)	Allen et al., 2016
X2: Branch density	Scheduled commercial bank branches per lakh population, March 2009	Allen et al., 2016
Y1: Income growth	Compound annual growth of per capita NSDP, 2011-12 to 2023-24	Muralidharan et al., 2016
Y2: Income level	Per capita NSDP in 2023-24 (Rs, current prices)	Muralidharan et al., 2016
Y3: Poverty level	MPI headcount ratio, NFHS-5 (per cent)	Alkire & Foster, 2011
Y4: Poverty change	Change in headcount ratio, NFHS-4 to NFHS-5 (percentage points)	NITI Aayog ,2023

Source: Compiled by researcher

Four data features need care. First, PMJDY ratios use Census 2011 population, so they overstate present coverage. They are used only to compare states. Second, income is at current prices, so growth includes inflation. Third, Assam's PMJDY count has not been cross-checked with state banking data. Fourth, the national poverty index includes bank account ownership, so part of any link with inclusion is mechanical.

Rank methods suit small samples with outliers. Exact tests avoid reliance on large-sample theory. All results are labelled associational, not causal.

Descriptive statistics summarise each indicator. Income dispersion is measured by the coefficient of variation, the standard deviation of logarithms, the Gini coefficient and the Theil (1967) index. Absolute beta-convergence is tested by regressing income growth on log initial income *(Barro & Sala-i-Martin, 1992).*

Association is measured by *Spearman's (1904)* rank correlation and *Kendall's (1938)* tau. With eight states, p-values come from exact permutation tests. All 40,320 pairings are enumerated, so no distribution is assumed. Bootstrap intervals use 10,000 resamples *(Efron, 1979)*. Leave-one-out estimates

show the effect of each state. *The Holm (1979)* procedure adjusts the six main tests. A log-log regression of income on branch density uses HC3 robust standard errors *(Long & Ervin, 2000)*.

Diagnostic tests check the assumptions behind these methods. Table 5 gives each test, the reason for using it and the result. All calculations used Python with SciPy and statsmodels *(Seabold & Perktold, 2010; Virtanen et al., 2020).*

RESULTS AND FINDINGS

Table 2 gives the main state indicators. The region has 30.7 million PMJDY accounts for 45.8 million residents, or 67.0 accounts per 100 persons. The national figure is 49.0. This high regional value comes from Assam, which has 83.3 accounts per 100 persons. The other seven states together have 31.9. Assam holds 84.8 per cent of regional accounts but has 68.2 per cent of the population. Nagaland (20.7) and Sikkim (18.2) have the lowest penetration. Balances are small. The regional average balance is Rs 3,237 per account, against Rs 5,357 nationally. Figures 2 and 3 show the penetration and its concentration.

Table 2. Financial inclusion, income and poverty by state

State	Accounts per 100 persons	Branches per lakh, 2009	NSDP per capita, 2023-24 (Rs)	Income growth (% a year)	MPI headcount, NFHS-5 (%)	Change in headcount (pp)
Arunachal Pradesh	34.14	6.25	217,325	9.45	13.76	-10.47
Assam	83.34	4.55	143,852	10.99	19.35	-13.30
Manipur	38.39	3.03	119,938	9.64	8.10	-8.86
Meghalaya	31.30	7.69	141,195	7.42	27.79	-4.75
Mizoram	41.19	9.09	234,996	12.42	5.30	-4.48
Nagaland	20.73	3.85	154,828	9.34	15.43	-9.73
Sikkim	18.21	12.50	587,743	11.53	2.60	-1.22
Tripura	32.11	5.88	172,299	11.40	13.11	-3.51
Mean	37.43	6.60	221,522	10.28	13.18	-7.04

Source: Compiled by author from various secondary sources including PMJDY, NITI Aayog.

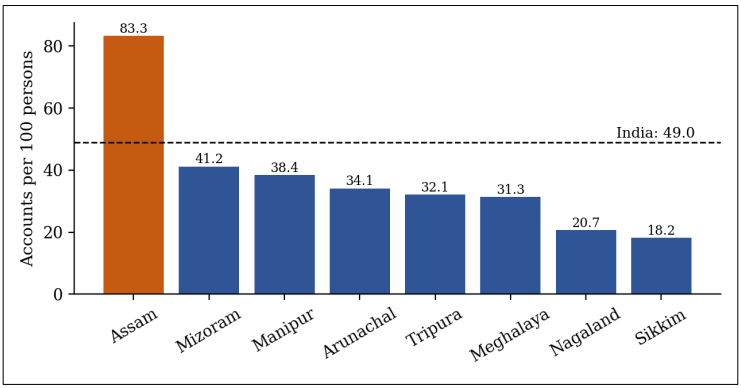


Figure 2: PMJDY accounts per 100 persons statewise

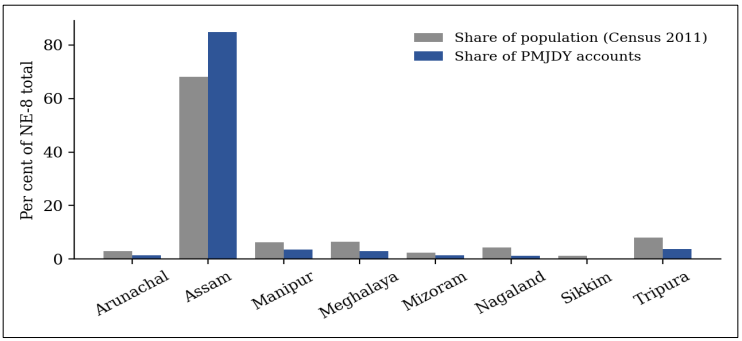


Figure 3. Shares of population and PMJDY accounts in the eight states

Nominal per capita income at the regional mean rose from Rs 66,341 in 2011-12 to Rs 221,522 in 2023-24. This is growth of 10.6 per cent a year. Mizoram grew fastest (12.4 per cent) and Meghalaya slowest (7.4 per cent). Income fell in seven states in 2020-21, by 3.5 per cent on average. Growth then rebounded, and Assam grew fastest between 2020-21 and 2023-24 (18.3 per cent a year). Recent years have been revised in the source, so these later rates need care.

Table 3 shows that inequality among states rose until 2020-21 and fell afterwards. The standard deviation of logarithms rose from 0.414 to 0.516 and then fell to 0.470. It stayed above its 2011-12 level. Sigma-convergence is therefore not supported. Without Sikkim, the rising trend is small and not significant (p = .23). Figure 4 plots the trend.

Table 3. Dispersion of per capita income across the eight states

Year	Coefficient of variation	SD of logarithms	Gini	Theil
2011-12	0.548	0.414	0.244	0.120
2014-15	0.531	0.439	0.259	0.119
2017-18	0.639	0.488	0.293	0.162
2019-20	0.632	0.508	0.301	0.163
2020-21	0.658	0.516	0.307	0.174
2023-24	0.646	0.470	0.281	0.161

Source: Author's own calculation

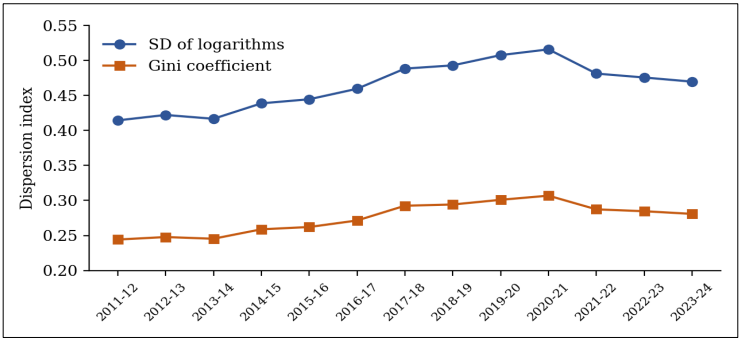


Figure 4. Dispersion of per capita income across states, 2011-12 to 2023-24

The convergence regression gives a slope of 0.006 (p = .70, R-squared = 0.03). Without Sikkim the slope is -0.020 (p = .56). Thus, there is no evidence of absolute convergence. Poverty fell in every state. The mean headcount ratio fell from 20.2 to 13.2 per cent. Assam recorded the largest fall (13.3 points). Meghalaya fell by only 4.8 points and now has the highest headcount (27.8 per cent). Sikkim (2.6) and Mizoram (5.3) have the lowest. Figure 5 compares the two survey rounds.

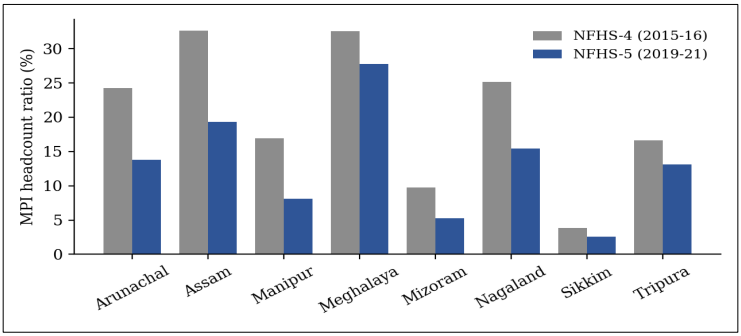


Figure 5. Multidimensional poverty headcount in NFHS-4 and NFHS-5

Table 4 reports the rank correlations. PMJDY penetration has no significant link with income growth, income level or poverty. All exact p-values are above .20. The link with poverty change is negative (rho = -0.50). This suggests larger poverty falls where penetration is higher, but it is not significant and halves without Assam. Branch density in 2009 is positively linked with 2023-24 income (rho = 0.74, p = .046). Its link with poverty has the expected sign (rho = -0.36) but is not significant. After Holm adjustment, the income link has p = .275.

Table 4. Rank correlations between financial inclusion and outcomes

Pair	Rho	Exact p	Holm p	Rho without Assam (p)	Leave-one-out range
Accounts and income growth	0.262	.536	1.000	0.321 (.498)	0.00 to 0.68
Accounts and income level	-0.262	.536	1.000	-0.143 (.783)	-0.50 to 0.11
Accounts and poverty level	0.095	.840	1.000	-0.179 (.713)	-0.36 to 0.32
Accounts and poverty change	-0.500	.216	1.000	-0.250 (.595)	-0.68 to -0.25
Branches 2009 and income level	0.738	.046	.275	0.786 (.048)	0.61 to 0.96
Branches 2009 and poverty level	-0.357	.389	1.000	-0.393 (.396)	-0.57 to -0.04

Source: Author's own calculation. Note: Exact p-values are two-sided. A negative rho for poverty change means a larger fall in poverty.

The branch and income result is fragile. A log-log regression gives a slope of 0.88 (R-squared = 0.66). The OLS p-value is .014, but the HC3 p-value is .059. Sikkim is highly influential, with a Cook's distance of 1.95. Without Sikkim the slope falls to 0.45 (p = .07). Using the lower income estimate for Assam (Rs 135,787) raises the rank correlation to 0.81. Figures 6 and 7 plot the two main associations. PMJDY

penetration and 2009 branch density are weakly and negatively related (rho = -0.29, p = .50). This agrees with targeting of less-banked states.

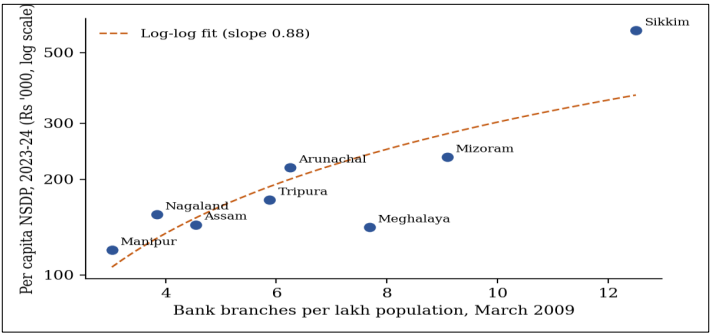


Figure 6. Branch density in 2009 and per capita income in 2023-24

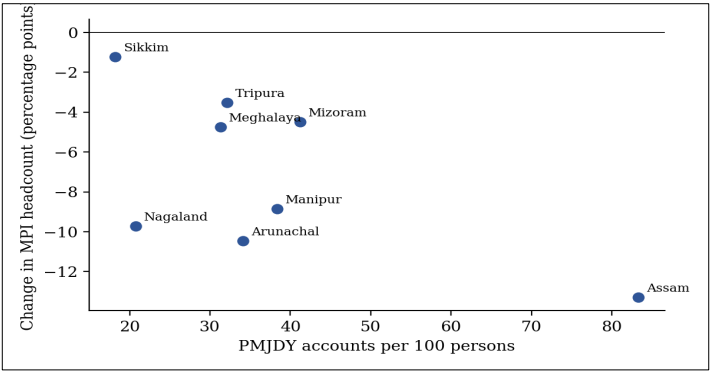


Figure 7. PMJDY penetration and change in poverty headcount

Statistical power is low. With eight states, the test detects a true correlation of 0.5 only 19 per cent of the time. Non-significant results are therefore inconclusive. They do not prove that no association exists. Table 5 presents the diagnostic tests.

Table 5. Diagnostic tests, reasons and results

No.	Test	Reason for the test	Result and implication for this study
1	Shapiro–Wilk test on indicators (Shapiro & Wilk, 1965)	To choose between parametric and rank methods	Accounts per 100 (W = 0.78, p = .019) and income level (W = 0.65, p < .001) are non-normal. Rank correlation is justified.
2	Tie check on ranks	Spearman formula assumes no tied ranks	No ties exist in any variable, so exact tests are valid.
3	Shapiro–Wilk test on regression residuals	To check normality of errors for t-tests	Branch model W = 0.97 (p = .89). Convergence model W = 0.96 (p = .84). Errors are normal.

4	Breusch–Pagan test (Breusch & Pagan, 1979)	To detect unequal error variance	Branch model p = .088. Convergence model p = .89. No clear heteroscedasticity, but HC3 errors are reported.
5	White test (White, 1980)	General check of heteroscedasticity	Branch model p = .195. Variance is not significantly unequal.
6	Ramsey RESET test (Ramsey, 1969)	To check functional form	F = 3.93, p = .104. The log-log form is acceptable, though power is low.
7	Cook's distance, leverage and studentised residuals (Cook, 1977)	To identify influential states	Sikkim: Cook's D = 1.95 and studentised residual = 3.49. Results are also reported without Sikkim.
8	Variance inflation factor (Belsley et al., 1980)	To check multicollinearity	Each model has one regressor, so VIF = 1. Multicollinearity is not a concern.
9	Durbin–Watson test (Durbin & Watson, 1951) and Breusch–Godfrey test (Godfrey, 1978)	To check serial correlation in the dispersion trend	DW = 0.56 and Breusch–Godfrey p = .009. Errors are correlated, so trend p-values are descriptive only.
10	Leave-one-out and bootstrap estimates (Efron, 1979)	To test stability to single states	The branch and income link stays positive (0.61 to 0.96). Account links change sign. Only the branch result is stable in direction.
11	Holm correction (Holm, 1979)	To control false positives across six tests	The branch and income p-value rises from .046 to .275. No result is significant after correction.
12	Power simulation	To judge the ability to detect effects	Power is 19 per cent for rho = 0.5 and 40 per cent for rho = 0.7. Non-significant results are inconclusive.
13	Data consistency checks	To confirm data reliability	Published MPI equals H times A within rounding. Rural plus urban accounts equal total accounts. Source revisions after 2021-22 are noted.

Source: Author's own calculation

Three findings emerge from the analysis. First, PMJDY penetration is highly concentrated in Assam, and the regional average hides low penetration elsewhere. Second, account penetration shows no reliable link with income or poverty. This agrees with studies that find modest effects from opening accounts alone *(Dupas et al., 2018; Prina, 2015)*. Compensatory targeting and the short time since 2014 may also explain it. Third, early branch density is linked with present income. This is consistent with the lasting role of access infrastructure *(Burgess & Pande, 2005)*. However, reverse causation and the influence of Sikkim prevent a causal reading.

Meghalaya is a useful case. It had above-average branch density in 2009 and a balance per account similar to Sikkim. Yet it has the slowest income growth and the highest poverty headcount. Access alone is therefore not sufficient. Land tenure, connectivity and the quality of public services may matter, but the data cannot test them. The finding also supports the call for district-level study in the region.

CONCLUSION AND RECOMMENDATION

This paper examined the relationship between financial inclusion, income and poverty across the eight North Eastern states. The evidence shows that Pradhan Mantri Jan Dhan Yojana (PMJDY) accounts are

heavily concentrated in Assam, and that income inequality among the states widened until 2020-21. There is no evidence of absolute convergence, although poverty declined in every state over the period. Account penetration shows no reliable association with either income or poverty, while branch density in 2009 is positively linked with present income, though this result is fragile. Account counts alone are therefore a weak guide to development outcomes.

Several recommendations follow from these findings. Policymakers should shift monitoring from the number of accounts opened to indicators of actual use, such as active accounts, transaction volumes, deposits and credit, since these better reflect whether inclusion is meaningful. Priority should be given to Nagaland and Meghalaya, where penetration or poverty outcomes remain weakest. Physical and digital access should be expanded together, through business correspondents and improved mobile connectivity, particularly in hill areas where branch networks are costly to sustain. Financial literacy programmes delivered in local languages would further help households convert account ownership into regular use. Because Assam's account figures appear unusually high, they should be verified, and state-level time series should be published to support independent research. Finally, the impact of PMJDY should not be judged by the national multidimensional poverty index alone, as that index itself incorporates account ownership and may therefore overstate the programme's effect on welfare.

LIMITATIONS

This study has limits. Only eight states and one PMJDY snapshot were available, so causal claims are not possible. Income is nominal, and PMJDY ratios use the 2011 population. Account counts do not show unique holders or actual use. Data on credit, deposits, digital payments and control variables were unavailable. Future work should build a state-year panel and use district data.

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18

--Chapter--

Financial Technology for Rural Transformation: Bridging the Financial Inclusion Divide

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Digital finance and Agriculture Development in the Northeastern States of India: A comprehensive Study on Government Initiatives, Agri-Tech and Digital Public Infrastructure

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ABSTRACT

The Northeastern states of India have a unique agricultural economy known for its high biodiversity and a large group of small-scale farmers. Although there are potential, physical remoteness and low financial inclusion have historically affected local development. This chapter provides a comprehensive analysis of the digital transformation currently reshaping the region's agricultural sector, the integration of India's Digital Public Infrastructure (DPI) centered on the JAM trinity (Jan Dhan, Aadhaar, and Mobile) and the Unified Payments Interface (UPI) as a foundation for financial inclusion. The research evaluates the impact of the Direct Benefit Transfer (DBT) framework through flagship schemes like PM-KISAN, which provides essential liquidity, and PM-Fasal Bima Yojana, which utilizes remote sensing for rapid risk mitigation. Furthermore, the chapter details the role of the Digital Agriculture Mission (FY24-FY26) specifically the creation of AgriStack and Farmer IDs to streamline resource delivery. The growth of AgriTech ecosystem is explored through farming tools like drones and blockchain tracking for organic produce is helping local farmers' access wider markets. There is significant progress, but the study identifies common struggle; key challenges such as low digital literacy and a visible gender gap in smartphone ownership, expanding rural internet infrastructure and offering localized digital training remains essential steps toward making modern farming accessible to all in the region. The chapter concludes with strategic recommendations to enhance rural connectivity and localized training, ensuring a resilient and inclusive digital agrarian future of the Northeast.

Keywords: Northeastern India, Digital finance, Digital public infrastructure, AgriTech, Financial inclusion, Direct benefit transfer

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INTRODUCTION

Northeast India plays an important and distinctive role in the India's agricultural terrain *(Sood,n.d.)*. Consisting of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, and Tripura, the region is known for its ecological diversity, unique agricultural products, and a large population dependent on farming and related activities. For a large section of the rural population, agriculture is a

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way of life; it remains closely connected to household security, employment, culture, and local development *(IICA, 2005)*.

Regardless of its considerable potential, agricultural development in the region has been affected by long term, rigid limitations like slow rate of infrastructure development, geographic isolation and other factors. Mountainous terrain and remote communities often make transportation and service expensive *(Taylor,2016)*. Small and low scale agricultural land can limit economies of scale, while inadequate storage, market infrastructure, and financial access may result in farmers getting the full value of their produce. These challenges are most common for small scale farmers, who often operate with limited capital and continue to be at risk to fluctuations in prices and weather conditions.

Long standing geographical isolation has limited the access to formal finance. In many rural communities, individuals have to face many problems while visiting a bank like travel, time, and cost. In result, farmers have often depended on informal credit facility or intermediaries to meet urgent financial requirements. While such informal credit may provide immediate assistance, they can also restrict farmers' financial option and increase their dependence on local networks.

With India's growing digital infrastructure has opened new possibilities for addressing some of these barriers faced by the Northeast India. Widespread adoption of bank accounts, digital identity systems, mobile technology, and instant payment platforms has changed the way individuals engaging with financial institutions and government services *(Demirguc-Kunt et al., 2022)*. These technologies can play an important role in rural areas to reduce the need for physical presences. A farmer who previously needed to travel to access a financial service will be able to receive payments, verify identity, obtain information, or interact with a service provider through a digital network.

The impact of this evolution goes beyond the replacement of cash with digital payments. Digital finance can potentially be able to reshape the wider agricultural ecosystem. With the help of reliable data systems and agricultural technologies, it can improve the delivery of subsidies, facilitate access to formal credit, strengthen crop insurance, provide market information, and connect farmers with new buyers. The growth of Digital Public Infrastructure (DPI) has therefore created an opportunity to integrate financial inclusion with agricultural development *(World Economic Forum, 2024)*.

This chapter therefore studies about: to what extent digital finance and agricultural technology help overcome the long-standing barriers to agricultural development in Northeast India, and what is essential to ensure such transformation?

REVIEW OF LITERATURE

We observed that the e-NAM's market efficiency is more of positive and supported evidence is found. *Reddy and Mehjabeen (2019)* and *Swain et al. (2022)* found that e-NAM's online auction system significantly improves price discovery by allowing farmers to see real-time buyer demand. *Pawar and Walke (2023)* highlights that e-NAM reduces the influence of unnecessary intermediaries, allowing farmers to retain a larger share of the final sale price, *Chauhan and Rathore (2025)* found that the platform expedited payments and made it harder for traders to manipulate prices. These gains are not free of obstacles. *Bisen and Kumar (2018)* identified critical hurdles, including "weak rural internet connectivity", inadequate mandi infrastructure, and the need for state-level legal reforms (APMC Acts).

Research found that digital financial services improve household level welfare primarily by reducing transaction cost and enhancing efficiency. *Suri and Jack (2016)* found that mobile money services (like M-Pesa in Kenya) improved household resilience by lowering transaction costs, a trend now being observed in India. *Klapper, El-Zoghbi, and Hess (2016)* emphasized that digital platforms bridge the gap for excluded populations by increasing transparency in credit and insurance. *Arora and Rathi (2019)* analyzed how digital platforms facilitate "timely credit delivery" and reduce dependence on informal moneylenders. In India, *Nair and Kumar (2021)* found that mobile apps improved access to crop insurance and weather-based risk management tools. *Ghosh (2018)* noted that while the *Pradhan Mantri Jan Dhan*

Yojana (PMJDY) expanded bank account access, it was the addition of FinTech solutions that truly enhanced usability for rural communities.

Gulati and Banerjee (2015) estimated that one-third of subsidized urea never reached farmers' fields due to industrial diversion and smuggling. *Sharma and Thaker (2010)* observed inclusion errors of 25-30% in traditional seed subsidy programs. The *JAM trinity* (Jan Dhan, Aadhaar, Mobile) created a transparent digital spine. *Singh et al. (2021)* found these schemes successfully coaxed 470 million people into the formal banking network. *PM-KISAN* now provides essential liquidity to over nine crore farmers, acting as a safety net against indebtedness.

While *PMJDY* closed the gap in account ownership (89% of women now have accounts), *Patwardhan (2018)* and *Duvendack et al. (2023)* found that "43% of these accounts remain inactive. *Doss et al. (2020)* argue that a woman's relative wealth and asset ownership within the household are better predictors of formal savings than absolute assets. *Perrin and Hyland (2023)* found that stronger legal equality correlates with better financial access, yet *Acemoglu and Jackson (2017)* noted that social norms often undermine formal legal rights.

Recent study explored the discussion to frontier technologies. *Dhivya et al. (2024)* discuss blockchain's ability to provide "farm-to-fork" transparency", certifying organic or fair-trade products and opening premium global markets for farmers. Blockchain-based smart contracts are noted for automating payments and reducing disputes among stakeholders. OECD (2022) reports that AI-driven credit scoring is reducing lender risks for smallholder financing globally.

OBJECTIVES OF THE STUDY

1. To study the role of digital finance, Digital Public Infrastructure, and AgriTech in boosting agricultural development and financial inclusion in the Northeastern states of India.
2. To identify the existing challenges affecting agricultural development and financial access in Northeast India.
3. To assess the contribution of Direct Benefit Transfer mechanisms and major agricultural schemes, such as PM-KISAN and PM-Fasal Bima Yojana, to improving the access to financial support and risk protection.
4. To evaluate the potential of the Digital Agriculture Mission, AgriStack, Farmer IDs, and other data-driven agricultural initiatives.
5. To identify the major challenges to digital adoption in the region.

THE FOUNDATION: DIGITAL PUBLIC INFRASTRUCTURE AND MOBILE CONNECTIVITY

India's digital transformation has been significantly supported by the JAM trinity, comprising Jan Dhan bank accounts, Aadhaar-based digital identification, and mobile connectivity *(Ravi, 2018)*. Together, these three components have built an important foundation for expanding financial inclusion and improving access to public services.

In the Northeast India, the physical bank branches are located far from remote villages and transportation is difficult, digital infrastructure can provide an alternative way to financial services. Mobile-based banking, biometric authentication, and digital payments have the potential to reduce geographical isolation and bring essential financial services closer to rural house areas.

1. **UPI and AEPS: Emerging Payment Systems:** The Unified Payments Interface (UPI) has emerged as one of India's most widely used digital payment systems and is growingly gaining acceptance in rural and semi-urban areas. Recent reports suggest that approximately 38% of rural and semi-urban Indians prefer UPI as a mode of payment *(EY India, 2024)*. The growing adoption of digital transactions among younger populations is particularly significant, as individuals between the ages

of 18 and 35 have a relatively higher preference for digital financial services. Complementing UPI is the Aadhaar-enabled Payment System (AEPS), which enables individuals to withdraw cash and conduct basic banking transactions through biometric authentication at local Business Correspondent points. This system is especially valuable in remote areas where access physical bank branches remain limited. Together, these services play an important role into the digital financial ecosystem. By reducing transaction costs and improving convenience, they can with time increase familiarity with mobile-based financial services and encourage greater participation in the formal financial system.

2. **Savings and Investment Potential:** Conflicting to the assumption that rural households are unwilling to participate in formal financial activities, recent reports indicate a strong inclination among rural Indians to save and invest, with approximately 96% expressing an interest in savings and investment opportunities *(EY India, 2024)*. This creates significant potential for financial institutions and FinTech companies to develop products suited to the specific needs of farmers and rural households in the diverse agro-climatic zones of Northeast India. However, increased access does not automatically translate into complete trust in digital systems. Reports indicate that many rural and semi-urban account holders still prefer visiting physical bank branches for financial transactions. This shows the importance of building confidence, improving digital literacy, and maintaining a combination of physical and digital financial services during the transition towards a more digitally integrated rural economy.

DIRECT BENEFIT TRANSFER: BUILDING A TRANSPARENT DIGITAL SPINE

The Direct Benefit Transfer (DBT) framework represents one of the most significant transformations in India's welfare and subsidy delivery system. By transferring benefits directly from the government to beneficiaries' bank accounts, DBT has the potential to help the people in the remote area and the authority to reduce leakages, minimize the role of intermediaries, lower administrative costs, and improve the timeliness of financial assistance *(Singh, I., 2025)*. For farmers in Northeast India, timely access to financial support is particularly important because agricultural incomes are often seasonal and vulnerable to weather-related disruptions.

1. **PM-KISHAN: Income Support and Financial Security:** The Pradhan Mantri Kisan Samman Nidhi (PM-KISAN) scheme provides eligible landholding farmers with annual income support of ₹6,000, distributed in three installments *(Ministry of Agriculture and Farmers Welfare, Government of India,n.d.)*. In the Northeastern region, where a substantial proportion of agricultural holdings are small or marginal, such support can serve as an important supplementary source of income. The funds provided to the farmers can help them meet immediate agricultural expenses, including the purchase of seeds, fertilizers, and other essential inputs. It may also reduce dependence on informal moneylenders and high-cost credit sources. Although the amount may not be sufficient to meet all agricultural investment requirements, it can provide basic financial assistance to the farmers.
2. **Fertilizer Subsidy and Digital Delivery:** The digitalization of fertilizer subsidy delivery has helped to address long-standing inefficiencies within the agricultural input distribution system. Under the DBT framework, the use of digital records and biometric authentication at points of sale can improve transparency and strengthen the monitoring of subsidized fertilizer distribution. The widespread adoption of neem-coated urea has also contributed to efforts in improving the efficiency of nitrogen use and reducing diversion for non-agricultural purposes. Such measures are best suited in the environmentally sensitive ecosystems of Northeast India, where sustainable agricultural practices are essential for protecting soil, water, and biodiversity.
3. **PM-Fasal Bima Yojana: Technology-Based Risk Mitigation:** Agriculture in the Northeast is highly affected due to climatic uncertainties, including excessive rainfall, floods, landslides, and other weather-related events. The Pradhan Mantri Fasal Bima Yojana (PM-FBY) seeks to provide farmers with financial protection against crop losses *(Ministry of Agriculture and Farmers Welfare,*

Government of India,n.d.). The increasing use of technologies such as remote sensing, drones, satellite data, and smartphone-based assessment tools has the potential to improve crop-loss assessment and accelerate the settlement of insurance claims *(Saha, 2018)*. Faster claim processing is particularly important for small scale farmers because delayed compensation can affect their ability to finance the next agricultural season. The scheme has also provided substantial financial support to insured farmers, with reports indicating that farmers have received considerably more in claims than the premiums contributed by them. Continued improvements in technology-based assessment could further help strengthen agricultural resilience in disaster-prone regions.

THE DIGITAL AGRICULTURE MISSION AND AGRISTACK

To boost the modernization of Indian agriculture, the Government of India approved the Digital Agriculture Mission for FY 2024–26, with an outlay of ₹2,817 crore *(PIB,2024)*. The mission aims to develop a comprehensive digital ecosystem for agriculture and improve the delivery of services to farmers. Its major components include AgriStack and the Krishi Decision Support System (DSS), which are aimed to support data-driven decision-making and more efficient agricultural service availability.

1. **AgriStack and Farmer IDs:** AgriStack is envisioned as a farmer-centric Digital Public Infrastructure designed to integrate agricultural information and streamline access to government services. One of its key features is the development of a Farmer ID, which can serve as a trusted digital identity within the agricultural ecosystem. By integrating relevant information relating to land records, crops, livestock, and other agricultural activities, the system could enable more efficient access to government schemes, agricultural credit, insurance, and customized advisories. The mission aims to create digital identities for a large number of farmers, with a target of approximately 11 crore Farmer IDs by 2027 *(Ministry of Agriculture and Farmers Welfare, Government of India,n.d.)*. For the Northeast, the effective implementation of such a system could help overcome fragmented service delivery and improve the targeting of agricultural programmes. However, strong safeguards relating to data privacy, consent, and cyber security will be essential to ensure that digitalization remains farmer-centric and inclusive.
2. **Precision Agriculture and Namo Drone Didi:** The Namo Drone Didi initiative seeks to promote the use of agricultural drones through women-led Self-Help Groups (SHGs), with an allocation of ₹1,261 crore and a target of supporting 15,000 SHGs *(Ministry of Agriculture and Farmers Welfare, Government of India,n.d.)*. Drone technology can be useful with activities such as crop monitoring, spraying, mapping, and precision application of agricultural inputs. In geographically isolated areas, these technologies may reduce physical labour requirements and improve the efficiency of farm operations. The success of drone-based agriculture, however, will depend on appropriate training, maintenance facilities, regulatory compliance, and affordability. Partnerships involving government agencies, farmer groups, SHGs, and private AgriTech companies can play an important role in ensuring that such technologies reach small and marginal farmers rather than remaining concentrated among larger producers.

THE AGRITECH STARTUP ECOSYSTEM

With India's AgriTech ecosystem growing rapidly in recent years, moving beyond experimentation towards the development of integrated solutions across the agricultural value chain. The sector includes innovations in agricultural inputs, farm mechanization, agricultural finance, resource management, productivity enhancement, storage, supply chains, and digital commerce. The growth of AgriTech is particularly relevant for Northeast India, where technological platforms can potentially connect geographically isolated producers with information, finance, logistics, and wider markets *(Singh, N., 2026)*.

1. **Leading Innovators:** Several Indian companies have developed innovative models that address different stages of the agricultural value chain *(Singh, N., 2026)*:
   - ❖ DeHaat provides an integrated platform offering agricultural inputs, advisory services, financial support, and market linkages to farmers across multiple states.
   - ❖ Ninjacart focuses on the fresh produce supply chain and uses technology and demand forecasting to connect farmers with retailers while seeking to reduce wastage.
   - ❖ Arya.ag operates in agricultural storage and warehouse-based financing, enabling farmers and agricultural businesses to access financial services against stored commodities.
   - ❖ Samunnati focuses on agricultural finance and supports Farmer Producer Organizations (FPOs) and other agricultural enterprises in addressing credit and market-related challenges.

   The expansion of such models into the Northeastern region could help address long-standing gaps in market access and agricultural finance. However, solutions must be adapted to local conditions rather than simply replicating models developed for other parts of India.

2. **Blockchain and Agricultural Traceability:** Blockchain technology has emerged as a potential tool for improving transparency and traceability within agricultural supply chains. By creating secure and verifiable records of transactions and product movement, blockchain-based systems can support "farm-to-fork" traceability *(Croft, 2021)*. This technology may be particularly valuable for the Northeast's distinctive agricultural products, including *kaji nemu*, *joha rice organic ginger*, *specialty tea*, *black rice*, and other region-specific commodities. Digital traceability can help verify claims relating to origin, organic production, and sustainable farming practices. More transparency can strengthen consumer confidence, reduce fraudulent labeling, and in result in improved access to premium domestic and international markets. Nevertheless, the effectiveness of blockchain will depend on the reliability of data entered into the system and the ability of small producers to participate in digital supply chains.

ENHANCING MARKET LINKAGES: E-NAM AND DIGITAL COMMERCE

The National Agriculture Market (e-NAM) was launched to integrate agricultural markets and create a more unified digital platform for the trading of agricultural commodities. For farmers in geographically isolated areas, digital marketplaces have the potential to expand access to buyers and improve awareness of prevailing market prices.

1. **Improving Price Discovery:** Research shows a positive relationship between the adoption of e-NAM and improved market access. Digital auction mechanisms can help in increasing transparency and can also help the farmers for better understanding. Increasing the number of potential buyers beyond local markets, e-NAM can potentially improve competition and support better price discovery. By 2024, more than 1,260 agricultural markets had reportedly been integrated with the platform, facilitating wider inter-state trade and digital market participation.
2. **Supply Chain and Market Efficiency:** Digital platforms can reduce farmers' dependence on traditional intermediaries by providing improved access to market information and potential buyers. However, the benefits of digital marketplaces are dependent on adequate physical infrastructure. In Northeast India, uneven “bozaar or bazzar” integration, inadequate quality testing and assaying facilities, limited storage capacity, and logistical challenges are still the key factor that challenge the effectiveness of digital agricultural markets. Therefore, digital platforms must be supported by investments in roads, warehouses, cold chains, grading facilities, and reliable transportation systems.

CLOSING THE GENDER GAP IN FINANCIAL INCLUSION

Despite the rapid growth of digital financial services, the gender inequality continues to exist in access to technology and financial decision-making. Financial inclusion should not be measured solely by the

number of bank accounts opened; and also, be based on meaningful inclusion that requires regular usage, financial literacy, and independent control over financial resources.

1. **The Access and Usage Gap:** Government initiatives such as the Pradhan Mantri Jan Dhan Yojana (PMJDY**)** have noticeably expanded bank account ownership among women. However, the existence of an account does not necessarily guarantee active participation in the formal financial system, and a considerable number of accounts remain inactive. The gender gap in access to mobile technology is another important concern. In remote areas, women are less likely than men to own personal mobile phones and smartphones, which limit their ability to independently access digital payments, financial information, and online agricultural services. These inequalities can be highly consequential in rural areas, where social norms, limited digital literacy, and unequal control over household resources may further restrict women's participation in the digital economy.
2. **Strategies for Meaningful Inclusion:** Financial inclusion strategies in Northeast India should move beyond account ownership and focus on empowering women to actively use and control financial services. The appointment of female banking correspondents who are called “sakhi”, targeted digital literacy programs, and the development of user-friendly technologies can help increase confidence and participation. Digital platforms should also be designed in a way that it can coexist with local communities in mind. Voice-enabled services and interfaces in regional languages including languages relevant to the Northeastern state could make financial and agricultural technologies more accessible to users with limited literacy or technological experience.

CHALLENGES AND CONSTRAINTS IN THE NORTHEASTERN REGION

Although digital finance and AgriTech offer significant opportunities, several barriers continue to limit their full potential in Northeast India.

1. **Digital literacy:** Although there is an increase in the ownership of smart phone in rural parts of India, but digital literacy among farmers remains uneven. Many individuals are still not able to accesses the financial services due to their limited experience with online transactions.
2. **Connectivit**y: Reliable internet connectivity remains a key challenge in remote and hilly regions of the Northeastern parts of India. Weak network infrastructure can interrupt digital payments, access to agricultural information, and participation in online marketplaces. With time Northeast India are now being upgraded through optical fiber expansion under BharatNet and the setup of localized digital access point
3. **Trust and Cybersecurity:** Concerns regarding fraud, cybercrime, data privacy, and financial security can discourage farmers from adopting digital financial services. Building trust through awareness programmes and effective grievance-redressal systems is therefore essential.
4. **Physical Infrastructure:** Digital agriculture cannot function effectively without adequate physical infrastructure. Inadequate storage facilities, cold chains, transportation networks, and grading and assaying equipment continue to limit the ability of farmers to fully benefit from digital marketplaces and supply-chain technologies.

CONCLUSION

Digital finance, Digital Public Infrastructure, and AgriTech are playing an important role in reshaping India's agricultural economy and helps in the development in the agricultural sector of the Northeastern states. By providing better access to banking, government benefits, agricultural information, insurance, and markets, digital technologies can help reduce some of the structural disadvantages faced by small scale farmers.

On the other hand, technology alone cannot transform agriculture of a region. Digital systems must be supported by reliable infrastructure, localized training, strong institutions, and policies specially

designed according to the needs of small and marginal farmers. Inclusion must remain as the main focus of this transformation, particularly for women, remote communities, and individuals with limited digital literacy.

In conclusion, the convergence of Digital Public Infrastructure, digital finance, and AgriTech has the potential to create an impact that is more productive, resilient, and inclusive agricultural economy in Northeast India. The next phase of agricultural transformation should not be defined only by the adoption of advanced technologies, but by how effectively those technologies are being adopted by the farmers and helping empower individual farmers and rural communities. If implemented inclusively and are supported by appropriate infrastructure and institutional capacity, this digital transformation can help ensure that the benefits of India's evolving agricultural economy reach even the most geographically remote cultivators.

POLICY RECOMMENDATIONS

To maximize the benefits of digital transformation, the following policy interventions are recommended:

1. **Strengthen Rural Digital Infrastructure:** High-speed and reliable internet connectivity should be prioritized in remote areas through initiatives such as *BharatNet* for better access to digital financial and agricultural services to function effectively with dependable network access.
2. **Promote Localized, Farmer Centric Training:** Digital literacy programmes should be implemented through Krishi Vigyan Kendras (KVKs**)**, Farmer Producer Organizations, Self-Help Groups, and local institutions. Training should use regional languages, demonstrations, and simple video-based learning tools to improve both technical skills and trust.
3. **Build Trust Trough Transparency and Security:** Governments and financial service providers should strengthen grievance-redressal mechanisms and improve transparency in digital credit, insurance, and benefit delivery for greater awareness of cybersecurity and prevention of fraud is also essential.
4. **Encourage inclusion Technology Design:** FinTech and AgriTech platforms should be designed around the practical challenges of small-scale farmers. Offline access, voice-enabled services, regional language interfaces, and simplified user experiences can help overcome literacy and connectivity barriers.
5. **Upgrade Agricultural Market Infrastructure:** Investment in grading, assaying, warehousing, cold-chain facilities, and transportation is essential for farmers to fully benefit from platforms such as e-NAM. Digital marketplaces must be supported by strong physical infrastructure.

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--Chapter--

Financial Technology for Rural Transformation: Bridging the Financial Inclusion Divide

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An Empirical Analysis of Animal Feed Industry at Industrial and Rural Level Assessment within the Purview of Nalbari District

Kakuli Kalita[1]

ABSTRACT

The animal feed industry has the potential to generate employment, boost livestock production, and contribute to rural development. Animal feed production is an important part of livestock development, job creation, and rural livelihoods. This study assesses the impact of the animal feed industry in Nalbari district towards employment generation and meat production between the period 2019–2021 (COVID-19 era) and 2025–2026 (Present era). A quantitative cross-sectional study with a primary data collection method, using a structured questionnaire, was used for collecting data from the industry and rural households in the villages surrounding Mega Food Park, Tihu. The results show significant improvements in feed production, employment, and livestock production in the post-COVID period. In the main feed industries, broiler feed production and jobs grew tremendously, and in the commercial feed adoption, livestock productivity and rural income improved significantly. In conclusion, the study shows that the animal feed industry is a key player in industrial growth, provides jobs, food security, and sustainable rural development. The results give policy makers and stakeholders useful information to build the livestock sector's resilience and development.

Keywords: Animal feed industry, Employment generation, Livestock production, Rural economy, Commercial feed

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INTRODUCTION

The animal feed industry is a critical link in the livestock production system, supplying nutritionally balanced feed for healthy growth and productivity of poultry, cattle, goats, pigs, and fish *(Ndudzo et al., 2023)*. It is an important bridge between agriculture and animal husbandry, which will promote feed efficiency, boost meat, milk, and egg production, and promote livestock health. The animal feed industry is one of the fastest growing industries that plays a crucial role in food security and rural development with increased population, urbanization, change in eating habits and rising demand for animal protein in the food chain.

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Livestock production is not only a way to enhance livestock productivity, but also to create jobs and stimulate economic growth within the animal feed industry *(Yami, 2013)*. It is a source of direct jobs in feed production, quality control, packaging, transportation, marketing and distribution and an indirect source of jobs in livelihoods, veterinary and allied services, machine maintenance etc. of livestock production. Good quality feed in rural areas allows for commercial livestock activities, improves household income and livelihoods *(Pica-Ciamarra et al., 2019)*. Therefore, the sector is a very important contributor to the improvement of the industrial development and rural employment.

COVID-19 pandemic in 2020 posed serious challenges to the animal feed industry *(Hafez & Attia, 2020)*. Feed production and distribution was disrupted by lockdowns, transportation restrictions, labour shortages, disruptions in raw material supply and market uncertainties. These disruptions affected livestock productivity, employment opportunities and production of meat. The industry slowly bounced back after making use of improved supply chains, technology and improvements in health and safety, but the pandemic showed the need to research its longer-term effects on the industry.

The technology, market demand, raw material availability, government policies, labour supply, workplace safety, industrial hygiene, quality of animal feed are also affecting factors of animal feed industry. They impact on the efficiency of production, creation of jobs and livestock output. Knowing how they affect the sector is crucial for designing policies which will facilitate sustainable industrial development and increase the resilience of the livestock sector.

With this backdrop, the present study looks at the employment generation and meat production effects of the animal feed industry in the pre- and post-COVID-19 periods. The study covers both the industrial and the rural area so that it may be known how the production of feed has affected the employment opportunities and the productivity of livestock. The results are likely to contribute to the development of sustainable livestock development strategies, rural livelihoods and food security improvement by the policy-makers, industry and researchers. The study will assess the role played by the industry in employment, meat production, and will contribute to evidence-based long-term planning for the livestock industry.

REVIEW OF LITERATURE

Previous research has confirmed the significance of the livestock and animal feed value chains for agricultural development, rural livelihoods and employment creation. Vinod et al. (2012) noted that the production of integrated crop–livestock systems are beneficial for resource utilization, income generation and environmental sustainability. Khan et al. (2013) discussed the role of livestock in food security, employment and rural development, and Ghose (2014) spoke about the need of food processors and value addition to enhance the agricultural growth.

The livestock and poultry industries are experiencing rapid growth in India and *Chatterjee et al. (2015), Irshad et al. (2015) and Islam et al. (2016)* have highlighted that quality animal feed, better breeding and modern production systems have contributed to the production of meat, milk and egg. Singh (2019) also highlighted India's robust livestock production position in the world and mentioned the disease outbreak, productivity, and infrastructure issues.

Demissie (2020) found in his international studies that feed quality, raw material availability, and technical support are important factors that affect livestock productivity. *Chaudhary (2021)* pointed out that technological innovations, precision nutrition and sustainable feed resources are important players in achieving better feed efficiency and profitability. *Hatab et al., (2021), Singh (2021) and Patnaik (2022)* studied the impact of COVID-19 and reported that the impact of the COVID-19 on livestock output, employment and labour disruption in the supply chains and transportation was negative.

Recent studies by *Arna et al. (2023), Ihor Petik et al. (2023) and Verma et al. (2023)* highlighted the following points regarding industrial safety, sustainable feed production, alternative feed resources,

and resilient supply chains. *Naldo (2025)* also emphasized that in the future, the animal feed sector will have to rely on the principles of environment protection, efficient use of resources and precision feeding. In general, the literature shows that the animal feed industry plays an important role in livestock productivity, job creation, food security and rural development. But market dynamics, technological progress and the post-COVID recovery still impact on industry performance.

RESEARCH GAP

While several studies focused on the quality of feed, productivity of livestock, technological innovations or environmental sustainability, few have evaluated the employment effect, on the one hand, and the output of meat, on the other, of the animal feed industry. The majority of studies tend to be concentrated on industrial production or livestock systems in rural areas and do not pay attention to the interrelationship of the two. Moreover, there is limited empirical evidence to compare the pre-COVID-19 and post-COVID-19 periods, especially at the regional level. There are very few studies that combine industrial and rural views and take into account employment, feed quality, production efficiency and technological development. So, the present study aims to fill this gap and examine the impact of animal feed industry on employment generation and meat production in Nalbari district, Assam, before and after the advent of COVID-19 as evidence for the policy formulation and sustainable livestock development.

OBJECTIVES OF STUDY

1. To assess the impact of the animal feed industry on industrial employment and meat production before and after COVID – 19.
2. To assess the impact of the animal feed industry on rural employment and meat production before and after COVID -19.

RESEARCH METHODOLOGY

The study has used a quantitative cross-sectional research design to explore the effects of the animal feed industry in employment generation and meat production both at industrial and rural levels before and after COVID-19 pandemic in Nalbari district Assam. The primary data was gathered from two animal feed industries, Sona Gold and Suguna that are situated in the Mega Food Park, Tihu, and rural households from villages under their influence zone. Data were collected using two structured questionnaires: one for industry respondents which was about employment, meat production and operational problems, and another for rural households which was about employment, livestock activities and meat production. The sample size is 150 households that were picked randomly from 10 villages, purposive sampling method was used. The study compared the COVID-19 period (2019–2021) with the post-COVID-19 period (2025–2026). Collected data were coded, classified and analysed through the descriptive statistical techniques which include percentages, tables, bar diagrams and pie charts to compare the two periods and for the assessment of contribution of the animal feed industry to the generation of employment and meat production.

RESULTS AND DISCUSSION

Table 1: Comparative Production and Employment Levels of Animal Feed Industries during COVID-19 and the Current Period

Industry unit	Type of feed/ production	Production (Million Tons) OVID-19 Period (2019–2021)	Production (Million Tons) Period 2025 - 2026	Employment (%) COVID-19 Period (2019–2021)	Employment (%) Current Period (2025–2026)
Industry unit 1- Sona Gold	Broiler Feed	1,000	2,500	15%	30%
	Layer Feed	750	1,200	10%	20%
	Cattle Feed	600	1,000	10%	20%
	Goat Feed	700	150	15%	10%
	Fish Feed	100	450	10%	10%
	Pig Feed	300	1,000	15%	10%
Industry unit 2- Suguna	Broiler Feed	1,000	2,500	45%	55%
	Broiler Hatchery	517	1,500	35%	45%

Source: Field Survey, 2025

The table 1, shows that there was a considerable increase in production and employment in the animal feed industries selected after the COVID-19 period. Feeds for broilers increased from 1,000 to 2,500 million tons, for layers – 750 to 1,200 million tons and for cattle – 600 to 1,000 million tons of feeds. There were also significant increases for fish feed and pig feed. There was an increase in employment in broiler, layer and cattle feed from 15%, 10% and 10% respectively to 30%, 20% and 20% respectively. The production of goat feed dropped significantly, from 700 to 150 million tons, and the employment dropped from 15% to 10% while the employment of fish-feed remained unchanged (10%). The employment in broiler feed production increased from 45% to 55% and hatchery production increased from 35% to 45% in Suguna because of the increase in the production volume of broiler feed and hatchery. In general, these results indicate a robust recovery from COVID-19, a boost in production capacity and employment creation, with some differences in the performance by feed categories.

Table 2: Village-wise Production, Commercialized Feed Use and Employment Engagement (2025-2026)

Name of Village	Major Animal Husbandry	Production Level (In terms of %)	Uses of Commercialized Feed (In terms of %)	Types of Employment Engagement
Jamunattry	Cattle	80%	50%	Partially
Helashapara	Goat	75%	40%	Partially
Napara	Pig	93%	60%	Moderate
New Baniakuchi	Broiler	60%	95%	High
Nakhara	Cattle	75%	55%	Partially
Lachima	Broiler	85%	90%	High
Nathkuchi	Fish	90%	30%	Partially
Nannattry	Cattle	80%	50%	Partially
Makhibaha	Goat	75%	40%	Partially
Haribhanga	Pig	93%	60%	Moderate
Jalkhana	Broiler	60%	95%	High
Kathalmura	Cattle	75%	55%	Partially
Mkrapar	Broiler	85%	90%	High
Bali	Fish	90%	30%	Partially
Sialmari	Fish	90%	30%	Partially

Source: Field Survey, 2025

From the table 2, it is visible that animal husbandry is an important livelihood activity in the villages surveyed, and production levels vary from 60% to 93%. The use of commercialized feed is higher in broiler farming (90–95%) than in fish and goat farming. Higher or moderate use of commercialized feed corresponds to high or moderate employment engagement, while lower feed use is generally associated with partial employment. Overall, the findings indicate a positive relationship between the use of commercial feeds, production, and employment opportunities in the surveyed villages. One important finding of the study is that the rate of commercialized feed utilization varies considerably among the sampled villages and is closely associated with the intensity of livestock rearing and labour participation. The highest commercial feed use (90–95%) and high employment engagement are observed in broiler-producing villages, whereas comparatively lower feed use and mostly partial employment are observed in fish- and goat-based villages. This suggests that greater use of commercial feed may contribute to improved production efficiency and increased employment opportunities in rural animal husbandry.

Table 3: Combined Village-wise Status of Animal Husbandry During COVID-19 (2019-2021)

Name of Village	Major Animal Husbandry	Production Level (In terms of %)	Uses of Commercialized Feed (In terms of %)	Types of Employment Engagement
Jamunattry	Cattle	75%	15%	High
Helashapara	Goat	60%	10%	High
Napara	Pig	70%	20%	High
New Baniakuchi	Broiler	20%	20%	Low
Nakhara	Cattle	70%	10%	High
Lachima	Broiler	25%	10%	Low
Nathkuchi	Fish	40%	10%	High
Nannattry	Cattle	60%	15%	Moderate
Makhibaha	Goat	65%	10%	Moderate
Haribhanga	Pig	55%	20%	Moderate
Jalkhana	Broiler	20%	20%	Low
Kathalmura	Cattle	60%	15%	High
Mkrapar	Broiler	25%	10%	Low
Bali	Fish	40%	15%	Moderate
Sialmari	Fish	40%	10%	High

Source: Field Survey, 2025

There is great diversity in animal husbandry among the villages surveyed shown in table 3, Only 10% to 20% of the commercialized feeds are fed, and 20% to 75% of production. There is a positive correlation between production level and employment engagement in the villages, especially in the cattle, pig and fish farming sectors. The relationship, however, is not the same in all the villages and employment is also dependent upon the nature and size of animal husbandry. One important conclusion is that the major animal husbandry practices in the survey villages are cattle, broiler, fish, goat and pig rearing. The production level in the broiler producing villages is relatively low during the COVID-19 period while that of the cattle and pig-based villages is comparatively high. Furthermore, employment engagement is high or moderate in cattle, pig and fish-based activity whereas in broiler-based villages, the engagement is comparatively low, pointing to varying labour dynamics across different livestock sectors during economic disruptions.

MAJOR FINDINGS

Crossed Industry Units, the vast majority of sectors moved from low levels of production during the COVID-19 period (2019-2021) to much higher volumes in the current period (2025-2026).

1. **Broiler Feed Production Growth is dominated:** Production of Broiler Feed has increased by the same figure in both Sona Gold as well as the Suguna, from 1000mt to 2500mt, which is the highest in volume. At Sona Gold, the production of Pig Feed increased by over three times to 1,000 million tons from 300 million tons and the Fish Feed production grew by more than four times to 450 million tons from 100 million tons.
2. **Steady Growth in Layer Feed and Cattle Feed Production:** Sona Gold's Layer Feed production was increased from 750 to 1,200 million tons; and Cattle Feed production was increased from 600 to 1,000 million tons. Sona Gold's Goat Feed (GF) production is sharply down from 700 million tons during the pandemic to 150 million tons now, bucking an overall growth trend. The employment drives of Broiler Feed proved its dominance of producing the feed, with the employment increased by double at Sona Gold from 15% to 30% and at Suguna the employment was increased from 45% to 55%.
3. **Doubled Employment Shares:** At Sona Gold, Employment Percentages of both Layer Feed and Cattle Feed were doubled from 10% to 20% to meet the higher outputs.
4. **Sectors with a very low level of employment:** Sona Gold's Fish Feed employment stayed flat at 10%, and the employment shares of both the Goat Feed and Pig Feed decreased from 15% to 10%.
5. **Tripled Hatchery Production at Suguna:** Suguna's dedicated Broiler Hatchery segment has witnessed a tremendous production increase, going from 517 million tons in the COVID-19 period to 1,500 million tons now.
6. **Balanced Workforce Expansion at Suguna:** In addition to its increased production, Suguna also successfully scaled up its Broiler Hatchery workforce allocation from 35% to 45%.

The main activity in broiler farming is being distributed across the villages with a large number of people involved in this activity in the villages of New Baniakuchi, Lachima, Jalkhana and Mkrapar in the villages surveyed.

1. **Bovine and Fisheries Footprints:** In 4 villages (Jamunattry, Nannattry, Nakhara and Kathalmura), cattle rearing is the major economic activity, whereas fish farming is the main economic activity in 3 clusters of villages (Nathkuchi, Bali and Sialmari).
2. **Goat farming (Helashapara and Makhibaha) and pig rearing (Napara and Haribhanga)**: Both are small-scale activities in only 2 villages of the surveyed ones. Highest production output (relative) was obtained in the village of Jamunattry (75%) followed by the pig and cattle dominant villages Napara and Nakhara at 70% each.
3. **Uniform Mid-Tier Production Clusters:** All the dedicated fish farming cluster villages (Nathkuchi, Bali and Sialmari) recorded a perfectly uniform production output level of 40%. The lowest village production values are confined to the broiler dominated localities with the lowest value of 20% recorded in New Baniakuchi and Jalkhana.
4. **Commercial Feed:** Commercial feed has been introduced in all 15 villages studied, but it is only being used in a low intensity manner, with a maximum adoption rate of 20% in 4 villages.
5. **Baseline Commercial Feed Adoption:** Most of the region heavily leans on traditional methods with 7 out of 15 villages having a relatively low commercial feed baseline of only 10%.
6. **High Workforce Engagement Areas:** Workforce engagement in the study zone is strong at high levels and is already in place in almost half the study area in 7 villages, such as Jamunattry, Helashapara and Napara.
7. **Production and Employment Correlation:** There is a clear socio-economic linkage between the villages with the lowest production outputs and the employment engagement levels (New Baniakuchi, Jalkhana, Lachima and Mkrapar villages are coinciding with the "Low" engagement level).

CONCLUSION

Even considering the impact of the COVID-19 pandemic, the study reveals that the animal feed industry has played a significant role in creating employment opportunities, increasing the productivity of the animal industry, production of meat and food security, and development of rural areas in Nalbari district. The study suggests that Government's support through financial incentives, credit facilities, provision of infrastructure, provision of quality feed, better transportation, extension services, farmer training and enhanced market linkages can be provided to support sustainable livestock development and employment. Nevertheless, the study has limitations as it deals only with the two feed industries and selected villages, is cross-sectional, uses questionnaire information, has limited industry records, and policy changes, market variations, diseases, and climate change. Hence, future studies should address more regions, adopt a longitudinal and comparative study approach, and focus on the adoption of technology, profitability, environmental issues, value-chain development, digital technologies, precision feeding and production of climate-smart feed, to create sustainable growth strategies in the animal feed sector based on evidence.

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--Chapter--

Financial Technology for Rural Transformation: Bridging the Financial Inclusion Divide

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Food Processing Units and Rural Growth Engine: Evidence from the North East Mega Food Park, Tihu, Nalbari District

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ABSTRACT

Food processing is a critical bridge between agriculture and industry, offering rural economies pathway from primary production toward value-added, employment-generating activity. This paper examines the North East Mega Food Park (NEMFP) at Tihu, Nalbari district, Assam, evaluating both the internal functioning of its processing units and its wider effect on surrounding rural households. Using primary data from six food processing units and 125 households across twelve villages, the study combines descriptive statistical analysis with a Difference-in-Differences (DID) framework comparing "treatment" villages (within 10 km of the park) with "control" villages farther away. The units show high-capacity utilisation, rising production, and expanding market reach, though labour conditions remain mixed, with long working hours and limited training persisting alongside near-universal minimum-wage compliance. At the household level, the DID estimates show a net income gain of ₹2,000 per month and a net employment gain of 17.2 percentage points attributable to proximity to the park, alongside broader improvements in local business activity, market access, infrastructure, and agricultural marketing. These outcomes suggest that the Food Park has strengthened local economic linkages and supported rural transformation beyond direct industrial employment.

Keywords: Food Processing Units, Rural Economic Development, Labour Welfare, Employment Generation, Household Income, Difference-in-Differences (DID)

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INTRODUCTION

Agriculture remains the backbone of the Indian economy, yet the food processing sector serves as the critical bridge between agriculture and industrial growth. Although India is the second-largest producer of fruits and vegetables globally, only about 7% of its perishable produce is processed, resulting in post-harvest wastage of 25–30% (*ICRIER, 2015).* The food processing industry is recognised as a powerful catalyst for rural development, with a multiplier effect on employment nearly 2.5 times higher than

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other industrial sectors, generating an estimated 140 jobs for every Rs. 1 crore invested (*Report by ITV Agro & food technologies Pvt. Ltd. (2015)*). Against this backdrop, the North East Mega Food Park (NEMFP) at Nathkuchi, Tihu, in Nalbari district, Assam, was established under the Pradhan Mantri Kisan SAMPADA Yojana as one of the first Mega Food Parks approved by the Ministry of Food Processing Industries in the North East. With an estimated project cost of about ₹759.8 crore *(AIDC,2026)*, spread over 50 acres, the park integrates cold storage, standard design factories, testing laboratories, and common infrastructure facilities to link farm production with modern processing, aiming to reduce post-harvest losses and generate sustainable livelihoods, particularly for youth. Official projections estimate the park will create direct and indirect employment for around 6,000 people and benefit 25,000–30,000 farmers *(PIB,2015,)*, in its catchment area, positioning it as a key employment pathway for the youth of Nalbari, offering an alternative to subsistence farming and distress migration.

However, despite substantial investment and the presence of established units such as Salai Agro Products, Sona Gold Agro Chem, and Graintech Foods India, a considerable gap persists between the employment envisioned and the actual conditions experienced by youth. Local absorption remains constrained by skill gaps, limited awareness of opportunities, seasonal fluctuations in raw material supply leading to inconsistent employment cycles, and gendered disparities, with women largely confined to sorting and packaging roles rather than technical positions. Official employment figures remain largely project-level projections, with little publicly available evidence on how many jobs have actually materialised for educated rural youth.

This study therefore examines the functioning, employment pattern, and labour conditions of selected units within the NEMFP, and assesses the park's impact on income, employment, and local economic activity in surrounding villages. The study is significant as it provides empirical, micro-level evidence still scarce in Assam and the wider North East on the socio-economic outcomes of Mega Food Parks, offering insights for policymakers, planners, and development agencies to strengthen the scheme's effectiveness. The scope of the study is confined to twelve villages around the NEMFP in Nalbari district, using household surveys to assess the extent of employment generation, industrial linkages, labour participation, and livelihood enhancement attributable to the food park.

REVIEW OF LITERATURE

The reviewed literature situates the North East Mega Food Park (NEMFP) within broader debates on agro-industrialization, rural employment, and food processing development in India. *Rae (1999)* examined food consumption and nutrition in urban Java, finding that rising income and women's education drive diversification away from cereal-based diets, though education tends to increase fat intake without proportionally improving protein consumption, cautioning against assuming income and education automatically improve nutrition. *Chengappa (2004)*, using secondary data up to 2003, traced India's agro-processing growth, noting that fruit and vegetable processing capacity expanded from 2.7 to 21 lakh tonnes between 1980 and 2000, yet capacity utilization stayed low, with annual value losses of Rs. 50,000 crore; value addition from processing (e.g., wheat into bakery goods, mango into pickle) remained highly profitable, driven by urbanization and a youthful population open to new food products.

Viswanadham (2005) explored India's potential as a global food supplier, identifying fragmented supply chains and weak cold chain infrastructure causing roughly 20% food wastage worth Rs. 500 billion annually as key barriers, advocating integrated "food supply chain clusters." *Kumar et al. (2011)*, analyzing Annual Survey of Industries data, found "capital-biased technical progress" in the organized food sector post-1991, with high-value segments like fruits, vegetables, and dairy growing faster than traditional ones, though employment generation remained limited due to capital intensity

and infrastructural gaps. *Wedowati et al. (2014)* reviewed food production system characteristics perishability, seasonality, and regulatory complexity introducing "mass customization" strategies (e.g., postponement techniques) applicable across products like yoghurt, crisps, and puddings.

Rais et al. (2014) highlighted untapped potential in the North East region, showing simple value addition can raise farmer income by up to 42.8%, despite the sector remaining unorganized and 35% of NER households living below the poverty line. *Sarma and Devi (2016)*, studying Kokrajhar district, similarly found abundant raw materials (tomato, orange, pineapple) underutilized due to poor cold storage, though basic processing could still boost farmer income by 42.8% per kg, suggesting scope for youth-led micro-enterprises. *Bhattacharyya and Goswami (2016)* provided a foundational study of NEMFP itself, describing its network of a Central Processing Centre, six Primary Processing Centres, and nineteen Collection Centres, while noting fruit and vegetable processing levels in the region remained as low as 2.2% despite rich horticultural diversity, including eleven banana varieties.

Soni (2016) traced India's agricultural and food processing evolution from the 1950s to 2017, noting the sector's fifth-place global ranking, its 14% contribution to manufacturing GDP, USD 7.54 billion in FDI (2000–2017), and projected potential to generate 9 million jobs, while identifying structural challenges including inadequate infrastructure, inconsistent regulation, and skill shortages, with only about 3% of the workforce engaged in agro-processing. *Bharadwaj and Rajkonwar (2017)* studied skill financing in Dibrugarh district, finding nearly 50% of units self-financed, with weak institutional support and inaccessible government schemes constraining skill development. *Hazarika and Kalita (2018)* examined women-led home-based enterprises (mompreneurs) in Sonitpur, finding 88% started with personal funds and relied on manual methods, despite providing employment and income within household settings.

Mang Muan Lian Zou and Prasain (2019) argued that food processing, requiring lower investment than heavy manufacturing, offers rural youth a viable transition from farming to formal employment, though supply-side constraints like poor cold storage limit growth. *Koorella and Perumal (2019)*, focusing on Cipla's pharmaceutical plant, found that while working conditions and incentives improve loyalty, educated employees prioritize job security and career growth over salary. Prasad (2019) detailed food loss across India's supply chain, citing 18–25% losses overall and higher losses for fruits (34%) and vegetables (44.6%), showing scientific storage could reduce losses from 10% to 0.5%, saving up to USD 13 billion annually. *Samsher (2019)* emphasized value addition opportunities across commodities grains, oilseeds, dairy, meat, and fish noting India processes only about 10% of food compared to 80% in developed nations, despite being the world's largest milk producer.

Pote (2023) examined agriculture-industry linkages nationally, affirming that Mega Food Parks address inefficiencies and post-harvest losses while contributing to GDP and rural livelihoods, though capital requirements and weak infrastructure limit small-scale participation. Thomas and Tantri (2023), using three decades of ASI data, revealed regional imbalance, with ten states led by Maharashtra and Uttar Pradesh accounting for 82.5% of sectoral value addition, and noted the organized sector's employment elasticity rose from 0.04 to 0.08, suggesting clusters like NEMFP could better absorb labor over time despite rising capital intensity. *Meena and Sharma (2024)* linked demographic shifts half of India's population being under 25 to rising demand for processed foods, though India's processing levels for fruits (4%) and vegetables (3%) lag far behind countries like Italy and Thailand.

Choudhury and Ghosh (2025) documented MSME growth in Cachar district, noting a 636% rise in registered units between 2011 and 2020, dominated by cereal, bakery, and fish processing, with limited development in fruit and vegetable processing despite women's participation. *Gaibimei et al. (2025)* explored underutilized indigenous fruits across the Northeast, highlighting their economic, nutritional, and social potential, including reducing out-migration and empowering women. *Kumari and Kumari (2025)* examined Bihar's Muzaffarpur district, finding under 5% of produce processed and 35–40% post-harvest losses in litchi, though the upcoming Motipur Mega Food Park is expected to

create around 5,000 jobs. Finally, *Sakina (2026)* analyzed India's dualistic food processing structure, showing the unorganized sector still dominates (75% of the market), only 7% of perishable produce is processed compared to much higher rates abroad, and identified eleven major challenges, including cold storage shortfalls, skill deficits, and complex taxation, constraining sectoral growth despite the industry's faster-than-agriculture growth rate of 8.4%.

OBJECTIVES

1. To examine the functioning, employment pattern, and labour conditions of selected units in the Northeast Mega Food Park.
2. To assess the impact of the food park on income changes, employment changes, and local economic activities.

METHODOLOGY

This study pursues two objectives: assessing the internal functioning, employment, and labour conditions of selected units, and evaluating the park's impact on surrounding rural income, employment, and economic activity. It follows a descriptive-analytical design combining qualitative and quantitative data via two structured questionnaires.

The first objective uses descriptive statistics to analyse production, employment, and labour conditions across six purposively selected units, with input from guards, operators, labourers, and managers. The second objective applies a Difference-in-Differences (DID) framework, comparing treatment villages (within 10 km of the park) against control villages (beyond 10 km) before and after the park's establishment, using DID = (Treatment After − Treatment Before) − (Control After − Control Before) to isolate the park's net impact.

Primary data were collected through field surveys and face-to-face household interviews across twelve nearby villages, using simple random sampling for 125 respondents, alongside the six purposively chosen units. Secondary data were drawn from MoFPI reports, official Food Park documents, government records, and academic literature. Findings are presented through tables, figures, and discussion, offering an integrated micro-level (units) and household-level analysis of the Food Park's socio-economic impact on the surrounding rural economy.

RESULTS AND DISCUSSION

Table 1: Operational Performance of units

Units	Scale	Activity	Established Year	Owner Ship	Raw material source	Capacity utilization (%)	Production trend (in last 3yrs)	Market coverage
Graintech Foods India	Large	Consumer products	2019	Private Limited	National	90%	Increased	Regional & National
Sona Gold Agro Chem	Large	Animal feed	2019	Private Limited	Regional	80%	No changes	Regional & National
Hygen Beverages	Medium	Juice	2019	Private Limited	National	77%	Increased	Regional & National
Har Food & Beverages	Medium	Fruits & vegetables	2020	Partnership	Regional & National	75%	Increased	Regional & National
Suguna Foods	Medium	Animal feed	2022	Private Limited	Cooperatives	82%	Highly increased	National

Dhansiri Nutrient Foods	Medium	Grain& Rice Milling	2022	Partnership	Local & Regional	70%	No change	Regional

Source: Compiled from field survey, 2026

Interpretation: Operational Performance of Units of six food-processing units show a predominantly medium-to-large scale profile, with most established between 2019 and 2022 under private limited or partnership ownership structures. Capacity utilization is generally strong, ranging from 70% (Dhansiri Nutrient Foods) to 90% (Graintech Foods India), suggesting most units are operating close to their potential rather than sitting idle. Production trends are largely positive four of the six units report "increased" or "highly increased" output, while only two (Sona Gold Agro Chem and Dhansiri Nutrient Foods) report no change, and none show a decline. Market coverage has also expanded beyond purely local or regional boundaries, with most units now reaching regional-plus-national markets, indicating that raw material sourcing (a mix of national, regional, cooperative, and local supply chains) has supported this outward growth rather than constrained it.

Table 2: Employment Pattern and Labour conditions

Units	Gender	Employees	Employment Changes	Recruitment Source	Payments	Working hours	Benefits
Graintech Foods India	Mixed	>50	Increased	Local & National	< minimum wage	12 hours	No
Sona Gold Agro Chem	Mostly Male	26-50	Increased	Local & National	>minimum wage	8 hours	Yes
Hygen Beverages	Mixed	>50	Increased	Local & National	=minimum wage	12 hours	Yes
Har Har Food & Beverages	Mixed	26-50	Increased	Local & Regional	=minimum wage	11 hours	Yes
Suguna Foods	Mostly Male	>50	Increased	Local & Regional	=minimum wage	8 hours	Yes
Dhansiri Nutrient Foods	Mostly Male	26-50	Increased	Local & National	=minimum wage	10 hours	Yes

Source: Compiled from field survey, 2026

Interpretation: Employment Pattern and Labour Conditions represents employment across all six units has increased, reflecting the operational growth seen in the first table, with workforce sizes ranging from 26-50 to over 50 employees per unit. However, labour conditions vary noticeably: working hours are inconsistent, spanning from 8 hours (Sona Gold Agro Chem, Suguna Foods) to as high as 12 hours (Graintech Foods India, Hygen Beverages), which raises questions about labour welfare standards in the longer-hour units. Wage compliance is also mixed — Graintech Foods India pays below minimum wage and offers no benefits, standing out as an outlier, while the remaining five units pay at or above minimum wage and provide benefits. Gender representation skews toward mixed or mostly male workforces, and recruitment is drawn mainly from local, national, or regional sources, suggesting these units rely on accessible labour pools rather than specialized or distant hiring.

Table 3: Impact On Local Economic Activities

Business Activities	Responses	Market Access	Responses	Transport and infrastructure	Responses	Agricultural Marketing and Sales	Responses
Increased	68	Improved	83	Improved	69	Increased	74
No Changes	44	No changes	29	No changes	40	No changes	33
Decreased	13	Declined	13	Declined	16	Decreased	18
TOTAL							125

Source: Compiled from field survey, 2026

Interpretation: Impact on Local Economic Activities represents community perception of these units economic impact is broadly positive across all four dimensions surveyed. Market access received the strongest endorsement, with 83 out of 125 respondents (about 66%) reporting improvement, followed by agricultural marketing and sales (74 respondents, ~59%) and business activities (68 respondents, ~54%) reporting increases. Transport and infrastructure also improved for 69 respondents (~55%), though it had a comparatively higher "no changes" response (40) than the others. Across all categories, only a small minority (13–18 respondents) reported declines or worsening conditions, indicating that the presence of these units has generally been perceived as a net positive contributor to local economic activity, market linkages, and infrastructure development.

Table 4: Socio-economic Profile of Respondents

Age Group	No. of Respondents (out of 125)	Education category	No. of respondents (out of 125)	Occupation	No. of respondents (out of 125)
18-25	42	No formal	8	Agriculture	33
26-35	48	Primary	15	Wage labour	65
36-45	23	Secondary	37	Self employed	15
46-60	12	Higher Secondary	53	Service	5
		Graduate+	12	Business	7

Source: Compiled from field survey, 2026

Interpretation: Socio-economic Profile of Respondents shoes that the majority of the 125 respondents were younger to middle-aged, about 72% (90) were aged 18–35, suggesting a younger than average workforce. Educationally most had at least secondary level education with 53 respondents having Higher Secondary education and 8 respondents not having any education. Occupationally, wage labour was the dominant occupation, accounting for 65 respondents (52%), followed by agriculture with 33 respondents and smaller percentage were self-employed, and engaged in services along with business.

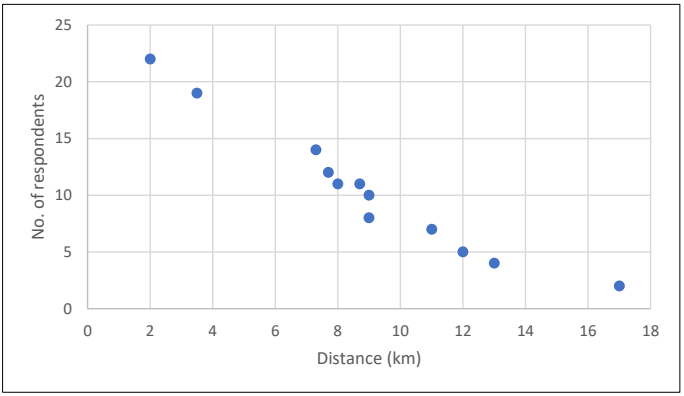
Table 5: Distance from the food park

Village	Distance(km)	No. of respondents
Nathkuchi	2	22
Bar-Bairagi	3.5	19
Chapra	7.3	14

Helochapara	7.7	12
Madhapur	8	11
Haramjar	8.7	11
Digheli	9	10
Jamunatari	9	8
Jalkhana	11	7
Haribhanga	12	5
Makhibaha	13	4
Kaithalkuchi	17	2

Source: Compiled from field survey, 2026

Figure (i): Distance from the food park



Source: *Compiled from table 5*

Interpretation: Table 5 and Figure (i) present the distribution of surveyed households according to the distance of their villages from the Northeast Mega Food Park. The findings indicate that the majority of respondents were concentrated in villages located closer to the Food Park. Nathkuchi, situated approximately 2 km from the Food Park, recorded the highest number of respondents (22 households), followed by Bar-Bairagi at 3.5 km with 19 respondents. Villages located within approximately 10 km of the Food Park collectively accounted for a larger share of the sample. Respondent numbers gradually declined with increasing distance from the Food Park. Villages such as Jalkhana (11 km), Haribhanga (12 km), Makhibaha (13 km), and Kaithalkuchi (17 km) recorded comparatively fewer respondents, with Kaithalkuchi having the lowest representation of only 2 households.

Figure (i) shows a downward pattern between distance and number of respondents, suggesting that the survey design focused more heavily on nearby villages that are expected to experience stronger direct effects from the Food Park. The inclusion of villages located farther away provides a comparison group for assessing variations in employment, income, and local economic activities.

Impact of food park on rural income and employment using DID Model

Difference-in-Differences Model

DID equation: $Yit=\beta0+\beta1\text{Post } t+\beta2\text{Treatment } i+ \delta (\text{Post } t\times\text{Treatment } i)+ \varepsilon it$

Where;

Yit is the outcome variable (here; monthly household income or employment status) for household i at time t.

β_0: The baseline average outcome for the control group prior to the Food Park's establishment.

Post t is a binary time indicator equal to 0 (before the Food Park) and 1 (after establishment).

Treatment i is a binary exposure indicator equal to 1 (if the household is < 10 km from the Food Park) and 0 (if the household is > 10 km away).

δ is the main coefficient of interest, it is the DID estimator representing the estimated causal impact of the Food Park.

εit is the error term

DID estimator(δ) = (Treatment After – Treatment Before) – (Control After – Control Before)

For estimating the impact of food park, household respondents were divided into treatment and control groups based on the proximity to the food park.

Table 6: Treatment and Control groups classification

Distance(km)	Group	Code (dummy variable)
<5	Treatment	1
5-10	Treatment	1
10-20	Control	0
>20	Control	0

Table 7: Distribution of the household respondents

Group	Village	Households	Percentage
Treatment	8	107	85.6
Control	4	18	14.4

Table 8: Average Household Income Before and After

Group	Before (₹)	After (₹)	Change [A-B] (₹)
Treatment	3500	12000	8500
Control	2500	9000	6500

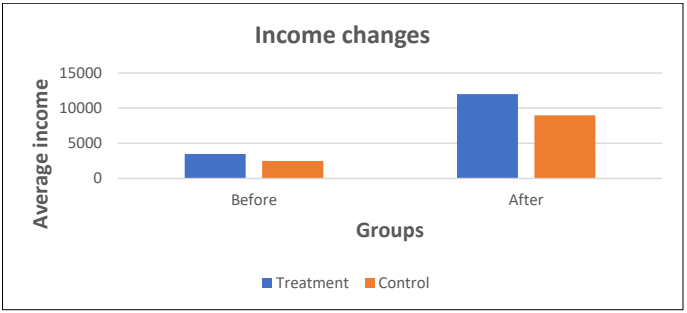
Difference-in-Differences Estimate: For Income

Formula: DID = (Treatment After – Treatment Before) – (Control After – Control Before)

= (12000-3500) – (9000-2500)

= 2000

Figure (ii): Income changes



Source: Compiled from table 8

The empirical study is performed within the framework of the Difference-in-Differences (DID) approach to assess the economic effects of the Food Park at local level. According to the classification in Table 6, respondents can be classified as treatment group (dummy =1; distance less10 km) and control group (dummy =0; distance more 10 km). As shown in Table 5.6, the treatment group has 107 households (85.6%) in 8 villages, and the control group has 18 households (14.4%) in 4 villages. Average Monthly Household Income before and after the facility's establishment are outlined in Table 8 and shown in Figure (ii) The baseline monthly incomes for the treatment and control groups, respectively, were ₹3,500 and ₹2,500. As shown in the visual trends of Figure (ii), both groups had increase in their income after the Food Park was established, with treatment group increasing by ₹8,500 and the control group increasing by ₹6,500. The DID estimator(δ) is the difference between the growth of the treatment group and that of the control group, giving a positive causal effect estimate of ₹2,000. This statistically isolates the net economic premium directly driven by the presence of the Food Park to show that distance has a significant effect on accelerating the income generation of households that is greater than ambient regional trends

Table 9: Employment Status Before and After

Group	Total Household	Unemployed Before	Unemployed After	Employed Before	Employed After
Treatment	107	98	38	9	69
Control	18	12	5	6	13

Table 10: Average Employment Rate by Group

Group	Before	After	Change=After-Before
Treatment	9/107= 0.084	69/107= 0.645	0.561
Control	6/18= 0.333	13/18= 0.722	0.389

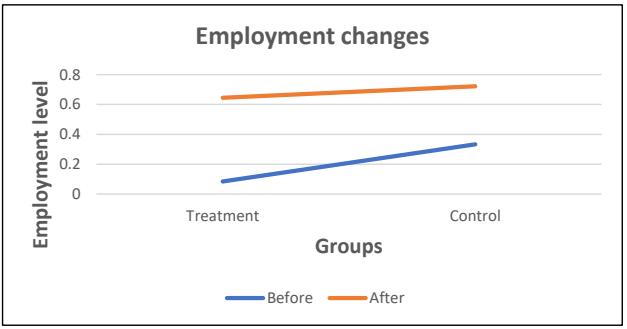
Difference-in-Differences Estimate: For Employment

Formula: DID = (Treatment After – Treatment Before) – (Control After – Control Before)

= (0.645-0.084) - (0.722-0.333)

= 0.172

Figure (iii): Employment changes



Source: Compiled from table 10

Empirical assessment of employment dynamics uses a Difference-in-Differences (DID) approach that enables the separation of the causal effect of the Food Park on the local labor force participation. The absolute frequencies of employment status are shown in Table 10, and show that there was a substantial change in the treatment group (107 households) from 98 unemployed to 38, and from 9 to 69 employed. The control group (18 households) experienced a smaller change, with a decrease in the number of households that were unemployed (from 12 to 5) and an increase in the number of households that were employed (from 6 to 13). The changes are translated into formal statistical rates in the average employment rates by group in Table 10 the employment rates for the treatment group were very low initially (8.4%) and increased by 56.1 percentage points after the establishment of the Food Park (64.5%). Meanwhile, the control group's employment rate grew from 33.3% (0.333) to 72.2% (0.722), marking an absolute change of 38.9 percentage points. This comparative trend is graphed in Figure (iii)The estimated causal impact is 17.2% (0.172), which is the difference between this increase and the baseline expansion that occurred in the control group. This shows that proximity to the Food Park has a significant effect on job creation in the local area.

CONCLUSION

The establishment of the Northeast Mega Food Park (NEMFP), Tihu, represents an important initiative linking industrial development with rural economic transformation in Nalbari district, Assam. The study finds that selected units within the park demonstrate satisfactory operational performance, reflected in relatively high-capacity utilisation, expanding production trends, moderate profitability, diversified business activities, and growing market outreach, with the predominance of medium-scale units and private investment indicating strengthened agro-based production systems. Labour conditions showed mixed outcomes: while most units complied with minimum wage standards and provided employee benefits, concerns around long working hours, inconsistent wage practices, limited training, and low participation of women in technical roles suggest that employment quality still requires improvement. Household-level analysis, using the Difference-in-Differences approach, further confirms that villages closer to the Food Park experienced greater improvements in income and employment than farther villages, alongside wider gains in business activity, market access, infrastructure, and agricultural marketing.

These findings carry important policy implications. Local employment generation should be strengthened through hiring incentives, employment exchanges, and community-industry linkage programmes, with attention not just to job quantity but job quality. Greater investment in skill development and workforce training covering processing technologies, machinery handling, packaging, quality control, and managerial skills through collaboration between government, educational institutions, and industry can build a skilled local labour pool. Labour welfare policies should ensure uniform fair wages, safe conditions, reasonable hours, and benefits across all units, while a regular monitoring and evaluation framework should be institutionalised to track socio-economic outcomes over time. Ultimately, policy should move beyond industrial infrastructure alone toward an integrated rural development model combining employment, income, local participation, labour welfare, and agricultural transformation.

The study is subject to certain limitations. Reliance on primary survey data makes findings susceptible to respondent bias, recall errors, and differing perceptions, while limited access to unit-level financial records restricted deeper firm-level analysis. Time constraints limited the study to a relatively short reference period, potentially understating long-term impacts, and although the DID approach was used, it could not fully isolate external influences such as broader economic conditions, government welfare schemes, inflation, migration, and post-pandemic recovery dynamics.

As a final takeaway, the study establishes that the NEMFP has meaningfully advanced rural economic development in Nalbari district, though realising its full potential requires sustained policy

attention to employment quality, skill building, and inclusive participation. Looking ahead, future research could expand this work through comparative studies across multiple Mega Food Parks in different states, longitudinal analysis to assess long-term sustainability of gains, and more advanced methods such as panel data or mixed-method approaches to better isolate industrial impact. Further studies could also explore environmental sustainability, technology adoption, supply chain efficiency, digitalisation, climate resilience, and the export potential of processed foods from the North-East, broadening the understanding of food processing-led rural development in the region.

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21

--Chapter--

Financial Technology for Rural Transformation: Bridging the Financial Inclusion Divide

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P – ISBN: 978-81-180547-8-8

Assessing the Financial Viability of a Tomato Paste Processing Unit with Aseptic Bag-in-Drum Packaging: Evidence from Anand, Gujarat

Yatinkumar Sharma[1], Dr. Urvi Amin[2]

ABSTRACT

India is one of the largest tomato-producing countries in the world, but it faces challenges such as post-harvest losses and limited processing infrastructure. The plant has an installed capacity of 3,750 MT per year, with production beginning at 70% utilization 2,625 MT per year tomato paste plant located at Anand, Gujarat, using aseptic bag-in-drum packaging. Based on machinery cost, construction cost, utilities, and other project costs, the total investment required is ₹15.47 crore. Financial analysis shows a net present value (NPV) of ₹6.47 crore, an internal rate of return (IRR) of 23.16%, and a discounted payback period of 3.71 years. The benefit-cost ratio of 1.42 and accounting rate of return of 41.23% indicate high profitability. The average DSCR of 3.42 confirms strong repayment capacity. Break-even analysis suggests costs will be covered early in the operating cycle, supported by healthy margins and cost control. Projections over five years show steady growth in revenue, profit, and cash flow, along with an improving balance sheet position. The study recommends establishing reliable procurement arrangements with tomato growers and suppliers in Gujarat, maintaining efficient utilization of processing capacity, adopting energy-efficient processing technology, implementing strict quality-control practices, and developing strong B2B and export marketing channels. Product diversification into tomato puree and other tomato-based products may also help reduce market risk and improve capacity utilization. Overall, the project has the potential to contribute to value addition in the tomato supply chain and reduce post-harvest losses while generating sustainable financial returns.

Keywords: Tomato Processing, Aseptic Packaging, Financial Feasibility, Capital Budgeting, Project Appraisal

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INTRODUCTION

India is one of the major producers of tomatoes and has a strong agricultural base that contributes to the development of the food processing industry. The country grows tomatoes in different agro-climatic

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zones, making them available throughout the year. Previous studies have highlighted the scope for greater tomato processing and value addition in India *(Kaundal et al., 2024; Subramanian, 2016)*. The supply chain in India starts with tomato farmers who sell their produce to processing firms, wholesalers, Farmer Producer Organizations (FPOs) or collection centers. These centers inspect tomatoes and reject diseased, damaged, and immature ones. This step is very important as raw tomato quality determines the yield, taste, color, and texture of tomato paste. Tomato processing involves sorting, washing, crushing, heat treatment, pulping, concentration and packaging.

Gujarat, and particularly the Anand region, offers good transportation and logistics connectivity, making it a suitable location for a tomato processing unit serving domestic B2B and export markets *(GAIC, n.d.)*. Aseptic bag-in-drum packaging is a technique that involves commercial sterilization of tomato paste and filling it in a multilayer aseptic plastic bag placed inside a steel drum. Unlike other packaging systems, aseptic packaging ensures that tomato paste can be stored at room temperature without refrigeration, which helps in saving storage and transport costs. This packaging system allows commercially sterile tomato paste to be stored and transported without refrigeration, which can reduce storage and transportation requirements *(Ranganna, 2005; Sanjana, 2019)*.

The current study focuses on financial viability of project for producing tomato paste with aseptic bag-in-drum packaging. The other research paper focuses on regarding the process, quality, and aseptic packaging of tomatoes. Some research is done combining these three aspects with the financial feasibility study of the particular project and particular geographical region. This paper attempts to fill this gap in literature by designing a five-year financial plan of a tomato production plant in Anand, Gujarat.

LITERATURE REVIEW

Kaundal, Sharma and Anand (2024) studied tomato processing, value addition, and post-harvest technologies from foreign and Indian Market. The authors explain the tomatoes are used to produce products like tomato paste, puree, ketchup. But they found India is produce large Quantity of tomato. But only a small share is processed, resulting in unnecessary losses, and suggested that improved processing facilities using new technology they help enhancing the quality and value of the products. *Eslami and Abdurrahman (2023)* reviewed the published research on the technologies of tomato processing, production and waste management. It was found that significant resources are consumed in stages such as washing, evaporation and sterilisation. Modern processing technologies can improve efficiency, reduce waste and increase sustainable production. The study also shows to the need for improved manufacturing practices to enhance product quality and their environmental performance.

Moresi and Liverotti (1982) built an economic model for the mid-size tomato paste plant was created and it was determined that raw materials are the biggest cost factor so efficient procurement and processing is essential to make business profitable. The researchers also pointed out that mechanization, automation, and processing efficiency can help decrease the cost of production. *Ranganna (2005) and Sanjana (2019)* examines the basic principles of aseptic packaging, explaining how product and package sterilization, aseptic filling, and they contribute to extending the shelf life without refrigeration, with bag-in-drum and bag-in-box systems being the preferred bulk packaging options for puree, pastes, and juice products.

Kuruba (2016) explored the economic feasibility study, which was done on the pilot tomato processing plant which included the whole process from raw material input to bottling, and was analyzed using fixed and working capital needs, cost of production, break-even point, benefit-cost ratio, and rate of return. *Iotti and Bonazzi (2014)* studied focus on financial management of Italian tomato process plant and pointed out that profits can provide a false measure of financial stability in a capital-intensive sector like this and they maintained that cash flow such as operating cash flow, unlevered free cash flow, and interest coverage ratio are used for better estimation of debt repayment ability and financial sustainability of the company.

IIFPT (2020), SMEDA (2018) and IMARC Group (2024) Each one prepared detailed feasibility project reports regarding tomato-processing unit, including considerations such as capacity, machinery, utilities, and costs of the project, and used techniques like NPV, IRR, payback period, and profitability ratios in order to assess commercial viability based on certain assumptions, thus showing that these are the benchmark criteria for judging a similar new project. *Sorathiya et al. (2025)* evaluated the financial viability of a cashew processing unit in India by analysing investment requirements, operating costs, profitability and financial indicators such as DSCR, break-even point, IRR and NPV. The study demonstrates the importance of systematic cost estimation and financial appraisal in determining the viability of food-processing investments. However, the study focuses on cashew processing, leaving scope for examining the financial feasibility of tomato processing and aseptic packaging technologies.

Chauhan et al. (2022) highlighted the increasing importance of horticulture in India's agricultural economy and emphasized its potential to generate income through market-oriented cultivation of fruits and vegetables. The growth of horticultural production creates opportunities for processing and value addition, thereby providing an economic rationale for investments in food-processing enterprises. *Amin (2025)* examined the economic and financial considerations influencing technology adoption in residential and commercial sectors. The study identified initial investment cost, expected financial savings, government support and awareness as important considerations affecting adoption. These factors are relevant to food-processing investments where entrepreneurs must evaluate the additional capital expenditure and economic benefits associated with modern technologies such as aseptic packaging.

RESEARCH GAP

The literature reviewed above indicates two main aspects. First, tomato processing and aseptic packaging are well understood at a technical level, with better quality parameters, sterilization methods, and resource efficiency. Second, capital budgeting concepts such as NPV, IRR, payback period, and DSCR are used to assess the feasibility of processing plants. Some project reports combine these two components in assessing the feasibility of food-processing projects (SMEDA, 2018; IIFPT, 2020; IMARC Group, 2024). However, these studies generally use national or broad cost estimates and do not provide a detailed location-specific assessment of land, construction, utilities, and other operating costs for Anand, Gujarat. There is also limited research combining raw material availability and logistics in Anand with five-year projected financial statements, a nine-year loan amortization schedule, and comprehensive financial ratio analysis for a tomato paste processing unit using aseptic bag-in-drum technology.

RATIONALE OF THE STUDY

The rationale for this study is to determine whether a tomato paste processing unit can be financially sustainable under the specific operating and cost conditions of Anand, Gujarat. Tomato is a highly perishable crop, and processing into paste offers significant potential for value addition and reduction of post-harvest losses. However, establishing such a unit requires substantial investment in plant and machinery, utilities, infrastructure, and working capital. Therefore, a location-specific financial assessment is essential to help project promoters, financial institutions, and other stakeholders understand the expected returns, debt repayment capacity, break-even requirements, and major financial risks before making an investment decision.

RESEARCH OBJECTIVES

1. To assess the profitability of the unit by analysing its financial statements.
2. To evaluate the future growth and development prospects of the unit.
3. To examine the financial viability of the unit using selected financial ratio analysis techniques.

4. To determine the overall financial sustainability of the proposed tomato-paste manufacturing unit in Anand.

RESEARCH QUESTIONS

1. What is the estimated total project cost, means of finance, and cost structure for establishing a tomato paste processing unit with aseptic bag-in-drum packaging in Anand, Gujarat?
2. Is the proposed tomato paste processing unit in Anand, Gujarat financially viable based on NPV, IRR, BCR, payback period, and ARR?
3. What is the debt servicing capacity and break-even level of the proposed unit during the five-year projected period?

RESEARCH METHODOLOGY

1. **Research Design:** The research follows the descriptive and analytical design based on secondary data. Secondary data has been gathered from industry reports, government documents, market research reports and machinery manufacturers. The capital budgeting methods used include Net Present Value (NPV), Internal Rate of Return (IRR), Payback Period, Breakeven analysis and Debt Service Coverage Ratio (DSCR).
2. **Nature of Research:** The research is primarily quantitative and project-based, with financial projections prepared using estimated technical, operational and financial assumptions.
3. **Sources of Data:** Data used in this study is secondary. Land cost, construction cost, plant & machinery cost, utility cost, laboratory cost, and office cost taken as per market rates, quotation of machinery given by suppliers and construction rates in Anand, Gujarat. Assumptions taken for operating cost related to cost of raw materials, labour, packaging cost, and selling price were derived from various industries, government sources, and market reports like the Ministry of Food Processing Industries, National Horticulture Board, APEDA, Food and Agriculture Organization, IMARC Group. No primary survey was conducted.
4. **Tool for Data Collection:** Structured Microsoft Excel sheets were used to enter and analyse cost data. Additional tools include costing templates, utility cost calculators, depreciation estimators.
5. **Data Analysis:** The analysis was presented through tables to effectively illustrate financial outcomes, along with descriptive statistics to interpret key variables and financial tools like NPV, IRR, Break-even Analysis (BEP), and Payback Period to evaluate the projected financial performance and feasibility for tomato paste processing unit in Anand.

DATA ANALYSIS AND INTERPRETATION

This part discusses from the financial model for tomato paste unit and analyses its results in accordance with the goals of the study. All the figures presented below are taken straight from the financial model of the project, which combines cost estimate of the project, its five-year forecast, capital budgeting calculations and ratios.

Table 1: Estimated Cost of Project and Means of Finance

Cost of Project	Amount (₹)	Means of Finance	Amount (₹)
Land Purchase	₹ 1,50,64,720.00	Promoter's Contribution	₹ 3,46,54,369.46
Civil Work of Building	₹ 4,05,86,100.00	Term Loan from Bank	₹ 12,00,00,000.00
Plant & Machinery	₹ 7,33,98,179.46		
Utilities	₹ 1,79,42,000.00		
Laboratory Equipment & Fixtures	₹ 7,68,770.00		
Office Furniture & Fixtures	₹ 6,84,400.00		
Electrical Installation	₹ 48,85,200.00		
Preliminary & Pre-operative Expenses	₹ 13,25,000.00		

Total Project Cost	₹ 15,46,54,369.46	Total Means of Finance	₹ 15,46,54,369.46

Source: Author's computation from the project financial model.

The investment needed for setting up tomato processing unit approximately ₹15.47 crore. The largest expense involved is plant and machinery (47.5%), and next civil works (26.2%) and utility expenses (11.6%). The project financing is done in the form of promoter's contribution (₹3.47 crore), which forms 22.4%, and bank loan (₹12 crore).

Projected Capacity Utilization and Sales Revenue

Table 2: Projected Capacity Utilisation and Sales Revenue (2027-2031)

Year	Capacity Utilisation	Output (MT)	Selling Price (₹/MT)	Sales Revenue (₹)
2027	70%	2,625	62,000	16,27,50,000
2028	80%	3,000	64,200	19,26,00,000
2029	90%	3,375	66,488	22,43,97,000
2030	100%	3,750	68,868	25,82,53,200
2031	100%	3,750	71,342	26,75,33,325

Source: Author's computation from the project financial model.

The production capacity starts at 70% and increases to 100% by the fourth year. The production volume increases from 2,625 MT to 3,750 MT. Sales revenue increases from ₹16.28 crore to ₹26.75 crore. This shows that the business plan is viable.

Cost Structure - Year 1 (2026-27)

Table 3: Cost Sheet Summary — Year 1 (Output: 2,625 MT)

Particulars	Amount (₹)	Amount per Unit (₹/MT)
Cost of Direct Material Consumed	7,03,41,428	26,796.73
Direct Labor Cost	98,42,000	3,749.33
Prime Cost	8,01,83,428	30,546.07
Total Factory Overheads	3,08,59,665	11,756.06
Total Factory Cost	11,10,43,093	42,302.13
Office & Administration Overheads	21,38,000	814.48
Cost of Production	11,31,81,093	43,116.61
Selling & Distribution Overheads	86,10,000	3,280.00
Total Cost of Sales	12,17,91,093	46,396.61
Total Sales	16,27,50,000	62,000.00
Profit	4,09,58,907	15,603.39

Source: Author's computation from the project financial model.

The cost sheet for the base year and explain how cost of sales has been distributed among prime cost, factory overheads, administrative overheads, Selling & Distribution Overheads. The prime cost includes direct materials raw tomatoes and aseptic bag in drum packing materials. This part discusses in previous paper raw tomato cost is important cost in tomato processing unit (Moresi & Liverotti, 1982). The factory costs include costs like depreciation, utility costs, and quality control cost. Factory overhead includes depreciation, utilities, and quality control cost. The total factory cost amount is ₹11,756 per ton of tomato paste, which means overall factory cost is ₹42,302 per ton. After adding selling and administrative expenses, the total cost of sales come ₹46,397 per ton. Compared with selling price ₹62,000 per ton, the project makes an operating profit of about 25.2% in Year 1.

Projected Income Statement (2027-2031)

Table 4: Projected Income Statement (₹)

Particulars	2027	2028	2029	2030	2031
Sales	16,27,50,000	19,26,00,000	22,43,97,000	25,82,53,200	26,75,33,325
Gross Profit	6,57,98,372	8,06,90,121	9,72,39,400	11,55,54,115	12,34,07,249
EBIT	4,09,58,907	5,58,88,867	7,23,12,266	9,03,50,453	9,90,68,411
Interest on Term Loan	1,16,10,073	1,07,02,920	97,00,775	85,93,692	73,70,684
Profit Before Tax	2,93,48,834	4,51,85,948	6,26,11,491	8,17,56,761	9,16,97,727
Tax @ 22%	64,56,743	99,40,909	1,37,74,528	1,79,86,487	2,01,73,500
Net Profit After Tax	2,28,92,090	3,52,45,039	4,88,36,963	6,37,70,274	7,15,24,227

Source: Author's computation from the project financial model.

The income statement for the period of five years shows that Earnings Before Interest and Tax (EBIT) increases from ₹4.10 crore to ₹9.91 crore in Year 5 due capacity utilization and increase in price, where interest cost decreases every year due to the repayment of loan. The net profit after tax (PAT) increases more than three times from ₹2.29 crore to ₹7.15 crore in Year 5.

Capital Budgeting Analysis

Table 5: Capital Budgeting Summary

Metric	Result
Net Present Value (NPV) @ 10%	₹6.47 crore
Internal Rate of Return (IRR)	23.16%
Modified IRR (MIRR)	18.74%
Benefit-Cost Ratio (BCR)	1.42
Payback Period	3.13 years
Discounted Payback Period	3.71 years
Accounting Rate of Return (ARR)	41.23%

Source: Author's computation from the project financial model.

The projected net cash flows (PAT + depreciation and amortization) were discounted at an assumed discount rate of 10% to calculate the NPV. The 10% rate is consistent with the assumed term-loan interest rate used in the financial model. The present value of total cash flow over the period of five years is ₹21.94 crore initial investment is ₹15.47 crore and NPV ₹6.47 crore. Is positive based on this project is accepted. The IRR of project is 23.16%; This is higher than the required 10% cost of capital. The MIRR is 18.74% it shows profitable investment. The Benefit-Cost Ratio is 1.42 show that the project generates ₹1.42 in present value for every ₹1 invested. The project takes 3.13 years to recover the investment without time value of money, while in consideration of the time value of money, the payback period would be 3.71 years. All of this include in nine-year loan period. ARR is 41.23%, and this show high accounting returns.

Debt Service Coverage Ratio

Table 6: Debt Service Coverage Ratio (2026-31)

Particulars	2026-27	2027-28	2028-29	2029-30	2030-31
Cash Available for Debt Service (₹)	4,83,28,629	5,83,91,777	6,97,37,174	8,24,43,459	8,79,66,455
Total Debt Service (₹)	2,02,73,308	2,02,73,308	2,02,73,308	2,02,73,308	2,02,73,308
DSCR (times)	2.38	2.88	3.44	4.07	4.34

Average DSCR: 3.42 times

Source: Author's computation from the project financial model.

The Debt Service Coverage Ratio (DSCR) show that capacity of project pays back its loan using operating

cash flows. The ratio increases from 2.38 times to 4.34 times in Year 5, which means that cash flows generated by the project are enough to cover debt repayment.

Break-Even Analysis

Table 7: Break-Even Point Analysis (2026-31)

Particulars	2026-27	2027-28	2028-29	2029-30	2030-31
Contribution (₹)	9,24,44,800	11,14,47,712	13,21,87,713	15,47,73,889	16,30,19,221
P/V Ratio	56.80%	57.86%	58.91%	59.93%	60.93%
BEP (Sales Value, ₹)	11,10,81,083	11,42,64,607	11,76,20,814	12,11,06,909	11,63,08,149
BEP (% of Capacity)	68.25%	59.33%	52.42%	46.89%	43.47%

Source: Author's computation from the project financial model.

The break-even point is rising every year in rupees, but in terms of percentage of capacity, it decreases from 68.25% to 43.47% in Year 5. The contribution margin increases from 56.8% to 60.9%. This indicates that the percentage of installed capacity required to cover total costs declines over the projected period, improving the project's margin of safety.

Financial Ratio Analysis

Solvency Ratios

Table 8: Solvency Ratios (2026-31)

Particular	2026-27	2027-28	2028-29	2029-30	2030-31
Debt-Equity Ratio	1.93 x	1.10 x	0.64 x	0.39 x	0.24 x
Total Debt to Total Assets Ratio	65.9%	52.3%	39.2%	27.9%	19.4%
Proprietary (Equity) Ratio	34.1%	47.7%	60.8%	72.1%	80.6%
Interest Coverage Ratio (times)	3.53 x	5.22 x	7.45 x	10.51 x	13.44 x

Source: Author's computation from the project financial model.

The solvency position of the company improves each year. The Debt-Equity Ratio decreased to 0.24 times from 1.93 times, which shows that the company depends less on borrowed funds. The Debt to Total Assets Ratio decreased from 65.9% to 19.4%, which shows that a lower proportion of assets is financed through debt. The Proprietary Ratio increased from 34.1% to 80.6%, which shows that the owner's contribution to financing increases. Furthermore, Interest Coverage Ratio increased from 3.53 to 13.44 times, showing that the company can easily cover its interest expenses.

Profitability Ratios

Table 9: Profitability Ratios (2026-31)

Particular	2026-27	2027-28	2028-29	2029-30	2030-31
Gross Profit Ratio	40.4%	41.9%	43.3%	44.7%	46.1%
Net Profit Ratio	14.1%	18.3%	21.8%	24.7%	26.7%
Return on Assets - ROA	13.6%	18.1%	21.0%	22.4%	20.8%
Return on Capital Employed - ROCE	24.3%	28.7%	31.1%	31.7%	28.8%

Source: Author's computation from the project financial model.

Profitability of the company improved over five years. Gross Profit Ratio has grown from 40.4% in 2026-27 to 46.1% in 2030-31. This show that the company earns more gross profit from sales. Net Profit Ratio is also growing from 14.1% to 26.7%. Its show that the company earn more profit after all expenses. ROA increases from 13.6% to 22.4% in 2029-30 and then decreases to 20.8% in 2030-31. ROCE grows from 24.3% to 31.7% in 2029-30 and then falls to 28.8% in 2030-31. Thus, it can be seen that the company

gets more profitable and efficient in asset management and use of capital, even though there is a small decrease in ROA and ROCE. Overall, profitability consistently improved, show efficient cost management and strong earnings growth.

Activity (Turnover) Ratios

Table 10: Activity (Turnover) Ratios

Particular	2026-27	2027-28	2028-29	2029-30	2030-31
Total Asset Turnover Ratio	0.96 x	0.99 x	0.96 x	0.91 x	0.78 x
Fixed Asset Turnover Ratio	1.17 x	1.52 x	1.94 x	2.44 x	2.77 x
Working Capital Turnover Ratio	5.75 x	2.89 x	1.93 x	1.44 x	1.08 x

Source: Author's computation from the project financial model.

The activity ratios show the efficiency with the company uses its assets to produce sales. The Total Asset Turnover Ratio is around 1 in the first years but falls from 0.96 to 0.78, which means that the total assets of the company generate fewer sales in the following years. But the Fixed Asset Turnover Ratio consistently rises from 1.17 to 2.77, that show that the company effectively utilizes fixed assets as the production and sales rise. The Working Capital Turnover Ratio declined from 5.75 times to 1.08 times, indicating lower working-capital turnover over the projected period.

Capital Market Ratios

Table 11: Investment and Return Ratios

Particular	2026-27	2027-28	2028-29	2029-30	2030-31
Return on Investment - ROI	14.8%	22.8%	31.6%	41.2%	46.2%
Earnings per ₹100 of Promoter's Capital Invested (₹)	₹ 66.06	₹101.70	₹140.93	₹184.02	₹206.39

Source: Author's computation from the project financial model.

The Investment and Return Ratios show that the company returns to the promoter are improve strong over the five-year period. The Return on Investment (ROI) increases from 14.8% in 2026–27 to 46.2% in 2030–31, show that the project is generating higher returns on the investment. Similarly, Earnings per ₹100 of Promoter's Capital Invested increases from ₹66.06 to ₹206.39. This means that for every ₹100 invested by the promoter, business generating ₹206.39 of earnings by 2030-31. Overall, these ratios indicate that the profitability and return to the promoter improve significantly over the projected period, making the investment more attractive.

FINDINGS

Total investment required is ₹15.47 crore, of which plant & machinery constitutes almost half (47.5%), which shows that the project is capital-intensive. The DSCR average is 3.42 times, which shows good loan repayment capacity. NPV of ₹6.47 crore and IRR of 23.16% show that the project is financially viable.

The project takes 3.13 years to recover the investment without time value of money, while in consideration of the time value of money, the payback period would be 3.71 years. All of this include in nine-year loan period The break-even point is rising every year in rupees, but in terms of percentage of capacity, it's decrease from 68.25% to 43.47% in Year 5.

Financial stability improves with time, as the debt-equity ratio has reduced from 1.93 to 0.24 while interest coverage has increased from 3.53 to 13.44. The profitability position has also improved with the net profit margin increasing from 14.1% to 26.7%.

SUGGESTIONS

To ensure continuous supply of tomatoes. Since tomatoes make up the largest expenses, it becomes vital to control their prices to maintain profitability. The firm should make an effort to utilize more than 70% of its production capacity in the first year in order to ensure that the plant This will help the plant cover its costs and maintain a good level of profit.

Invest in energy-efficient processing and utilities infrastructure, especially in evaporation and sterilization, because studies indicate that these are the most resource-intensive processes in tomato processing, and protect margins against increasing utility costs.

The firm can also add products such as tomato puree and ketchup in future. This will decrease the dependency on just tomato paste and allow the facility to operate even during low demand times. The firm needs to concentrate towards the market of tomato paste through B2B, domestic and export market channels for boosting sales.

After setting up its business, the firm must continually check the prices of tomatoes, electricity expenses, and selling prices. It should also assess how the changes in these expenses can impact profits.

CONCLUSION

Financial analysis suggested tomato paste processing unit at Anand, Gujarat, show that the project is profitable. This is based on the positive NPV, the high IRR, benefit-cost ratio of greater than 1, payback period, and a healthy DSCR. These parameters show that the project will make good returns and make time to time payments of the loan. Moreover, the consistent cash inflows, high liquidity, and impressive profitability ratios suggest that the business will maintain operational stability even under varying market conditions. The projections confirm that the enterprise has the ability to meet its financial obligations while also building long-term capital strength. Overall, this project showcases a well-structured model that aligns with strategic business goals and effective management, making it a worthy investment opportunity.

LIMITATION OF THE RESEARCH

1. This research is mainly dependent upon the use of secondary information as well as financial assumptions derived from reports, government publications, and quotations received from suppliers.
2. The changing prices of tomatoes, packaging materials, utilities, and market demands were not taken into account while calculating the financial projections.
3. Variations in government policies, taxes, interest rates, and economic environment have not been taken into consideration in the predicted financial figures.
4. These financial estimates are made keeping in mind the plant capacity suggested by us and hence might differ from practical situations.

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--Chapter--

Financial Technology for Rural Transformation: Bridging the Financial Inclusion Divide

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Relationship Between Credit Facilities and Industrial Production: Evidence from an Autoregressive Model

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ABSTRACT

In order to understand the rapid pace and dynamics of industrialization, it's crucial to understand how industrial output shifts over time. Through this research an attempt has been made to look into the changes in the industrial output in India within a span of 13 years. The study is based on understanding the correlation of industrial production with industrial credit. Secondary time series data like the Index of Industrial Production (IIP) published by the MoSPI, and industrial credit data from the Reserve Bank of India database have been considered for the studies. An autoregressive model has been used for the study where industrial output at current time is the dependent variable and lag industrial output and credit at current time are the predictors. The study makes an attempt to understand if industrial growth follows a stable path or experiences instability over different periods. The results show that past output has a strong effect on current industrial output. This means that growth in the industrial sector tends to continue over time. While credit and industrial output have a positive relation, their strength is not always stable or it does not always rise as time passes. Therefore, for industrial output to increase, measures besides credit must also be taken.

Keywords: Industrial Output, Autoregressive Model, Industrial Credit, Correlation

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INTRODUCTION

The industrial sector plays a vital role in economic development by generating employment and increasing productivity. Understanding its dynamic behaviour is important across all economies because industrial production is influenced by changes in policy, financial conditions, and broader macroeconomic shocks. Industrial output does not evolve in isolation; current performance is often shaped by past trends, which makes time-dependent analysis essential for capturing real growth patterns.

Over the last two decades, the Indian industrial sector has experienced periods of rapid expansion as well as phases of slowdown. Several policy reforms, including liberalization measures, expansion of

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financial markets, infrastructure development programs, and credit-oriented industrial policies, have influenced the trajectory of industrial production *(Nayyar & Nayyar, 2024)*. At the same time, industrial growth has also been affected by external shocks such as global financial instability, disruptions in international trade, fluctuations in commodity prices etc *(Patnaik, 2022; Mishra & Behera, 2024)*.

These fluctuations make it important to study industrial production not merely as a static variable but as a process that evolves continuously over time. Industrial firms generally make production decisions based on previous output levels, expected demand, access to finance, and existing production capacity. Because of this, present industrial output is often closely connected with past output. Dynamic modeling approaches therefore becomes useful for understanding. Among these, autoregressive model in particular, is useful, as it incorporates lagged values of output to explain present movements.

This paper applies an autoregressive model to study the dynamics of industrial output in India using monthly secondary data. The study demonstrates how standard time-series techniques can be utilized to better understand fluctuations in industrial growth. While previous studies have explored the relationship between credit and industrial output, the present study adds to the literature by providing additional insights on fluctuations in the short run and stability in the long run (*Balasubramanian, 2022*).

REVIEW OF LITERATURE

Studies on economic growth, particularly the neoclassical growth framework, have consistently emphasized capital formation and technological advancement as central forces behind output growth *(Solow, 1956; Swan, 1956)*. These models have provided the foundation for understanding how savings and investment, and productivity contribute to economic growth.

Autoregression models have been widely used in economic dynamics to analyse the pattern of change in discrete time settings *(Chiang & Wainwright, 2005)*. This model is especially suitable for industrial output analysis, as industrial data are typically observed at annual or quarterly intervals.

Various empirical studies have shown that industrial output often displays persistence, where past output levels significantly influence current production. Such results have been found in studies carried out using dynamic time-series models and autoregressive frameworks *(Romer, 2012; Nelson & Plosser, 1982).* The presence of output persistence implies that shocks to industrial production may have long-lasting effect.

The role of financial factors in industrial growth has been extensively examined in the literature. Access to credit affects firms' capacity to invest in capital, adopt new technologies, and expand production. Financial development theories suggest that well-functioning financial systems enhance economic growth by efficiently allocating resources to productive sectors *(King & Levine, 1993)*. Empirical evidence supports a positive relationship between industrial credit and manufacturing output growth, particularly in developing economies *(Rajan & Zingales, 1998).*

Despite the extensive literature on industrial growth and financial factors, there remains a need for simple and transparent mathematical frameworks that combine economic intuition with empirical relevance. This study contributes to the existing literature by employing a autoregressive model using secondary data to analyse industrial output growth dynamics in India.

RESEARCH OBJECTIVES

1. To examine the influence of bank credit on industrial output in India after accounting for past industrial output.
2. To analyse the pattern of relationship between industrial credit and industrial output across different time periods.

RESEARCH METHODOLOGY

To examine the impact of industrial credit on industrial output in India, this study adopts a quantitative research design. The study is carried out using secondary time-series data collected on a monthly basis. The study uses the following secondary data sources:

1. Industrial Output: Industrial output is measured using the Index of Industrial Production (IIP), published by the Ministry of Statistics and Programme Implementation (MOSPI). The IIP provides an annual measure of industrial performance and serves as a widely accepted proxy for industrial output.
2. Industrial Credit: Industrial credit data has been obtained from the Reserve Bank of India's database on Indian Economy (DBIE). Bank credit to the industrial sector is used as a proxy for financial support to manufacturing and industrial activities.

Both series are expressed at the monthly frequency, covering the period from April 2012 to November 2025 (sample period). The model was estimated using Ordinary Least Squares (OLS) regression in SPSS. The lagged dependent variable ln_IIP_{t-1} and the independent variable ln_Credit_t were included as predictors of ln_IIP_t.

The regression output was evaluated based on R-squared, F-statistics, individual coefficient significance (t-statistics and p-values), and diagnostic statistics to ensure the reliability and soundness of the model.

MODEL SPECIFICATION

Industrial output evolves over time and is influenced by both past performance and contemporaneous economic conditions. Since industrial data is typically observed at regular intervals, a difference equation model is appropriate for analyzing output dynamics.

The relationship is expressed as:

$$Y_t = \alpha + \beta Y_{t-1} + \gamma X_t + \varepsilon_t$$

where:

Y_t is industrial output at time t,
Y_{t-1} is lagged industrial output,
X_t is industrial credit,
α is a constant term,
β measures output persistence,
γ captures the impact of the industrial credit, and
ε_t is the error term.

For empirical estimation, the model is expressed in logarithmic form:

$$\ln Y_t = \alpha + \beta \ln Y_{t-1} + \gamma \ln X_t + \varepsilon_t$$

This transformation enables elasticity-based interpretation and improves statistical properties of the data. Since the model is estimated in logarithmic form, the coefficient β represents the elasticity of industrial output with respect to industrial credit. The choice of the log–log dynamic model is justified because it makes economic interpretation easy**.** Elasticities provide a clear indication of percentage response — for example, how much industrial output responds in percentage terms to a 1% change in credit. Thus, β captures the magnitude of the impact of lagged industrial output on current output in proportional terms and γ captures the magnitude of the impact of credit on industrial output in proportional terms.

RESULTS AND DISCUSSION

To examine the dynamic relationship between bank credit and industrial output, a log–log autoregressive model was estimated in which current industrial production depends on its own past level and current bank credit. The estimated model is:

$$\ln Y_t = \alpha + \beta \ln Y_{t-1} + \gamma \ln X_t + \varepsilon_t$$

where Y_t represents the Index of Industrial Production and X_t denotes total bank credit and Y_{t-1} denotes lagged Index of Industrial Production.

Table: 1

Model Summary[b]					
Model	R	R^2	Adjusted R^2	tandard. Error of the Estimate	Durbin-Watson
1	.814[a]	.662	.658	.08532	2.275
a. Predictors: (Constant), Lag_ln_IIP, Credit					
b. Dependent Variable: ln_IIP					

The regression results indicate a strong model fit. The coefficient of determination R^2=0.662 suggests that approximately 66.2% of the variation in industrial output is explained by past output and bank credit.

Table: 2

ANOVA[a]						
Model		Sum of Squares	df	Mean Square	F	Sig.
	Regression	2.286	2	1.143	157.027	.000[b]
	Residual	1.165	160	.007		
	Total	3.451	162			
a. Dependent Variable: ln_IIP						
b. Predictors: (Constant), Lag_ln_IIP, Credit						

The F-statistic (F = 157.027, p < 0.01) confirms that the model is jointly significant, meaning the explanatory variables together have a statistically significant effect on industrial output.
The Durbin–Watson statistic is 2.275, which is close to the ideal value 2. This indicates absence of serious autocorrelation in the residuals, suggesting that the regression estimates are reliable and not affected by serial correlation.

Coefficients[a]						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.589	.281		5.652	.000
	Credit	1.824E-8	.000	.208	3.501	.001
	Lag_ln_IIP	.666	.059	.666	11.236	.000
a. Dependent Variable: ln_IIP						
Table. 3						

The coefficient of lagged industrial output is 0.666 and is highly significant at the 1% level (p < 0.01). Since the model is in logarithmic form, this coefficient represents an elasticity. This implies that a 1% increase in industrial output in the previous month leads to a 0.67% increase in the current month's output, holding credit constant.

This strong and positive relationship indicates persistence in industrial production, which means that industrial activity tends to follow a gradual and continuous adjustment path rather than abrupt changes. Production capacity, investment commitments, and ongoing industrial processes contribute to this inertia.

The coefficient of bank credit is 0.208 and is statistically significant at the 1% level (p = 0.001). This represents elasticity. This means that a 1% increase in bank credit leads to a 0.21% increase in industrial output, other things being equal. Although the increase in output is smaller than the increase in credit, the relationship is still important because industrial growth depends on many other factors such as demand, technology, infrastructure, labour, and overall economic conditions. The results show that credit availability has a positive and significant contribution to industrial output. When firms have better access to more credit, they can better handle their day-to-day expenses. While past output captures the inherent continuity of production, bank credit acts as an enabling factor that supports expansion, working capital needs, and investment decisions. The results thus show that the financial sector plays a great role in supporting real economic growth. To see if the relationship between industrial credit and industrial output was stable over time, the study period was divided into four separate phases and then calculated correlation coefficients for each phase. The correlation was strong, reaching 0.74 in Period I (April 2012–August 2015). This means that there is correspondence between growth in credit and growth in industrial output. The strong relationship during Period I may be associated with efforts to revive industrial growth after the global financial slowdown, along with policy initiatives such as MSME credit expansion, priority sector lending support, and the launch of the Make in India programme in 2014, which aimed to encourage manufacturing activity and investment. This relationship is much weakened for Period II, September 2015–January 2019, to 0.36. It would imply that growth in credit during this period did not lead to the same increase in industrial production. The weaker relationship during Period II may partly reflect structural challenges in the banking and industrial sectors, including rising Non-Performing Assets (NPAs) and the NBFC liquidity stress that began emerging toward the later part of the period. Although several policy measures such as MUDRA Yojana, Stand-Up India, and bank recapitalization initiatives were introduced, industrial output growth remained relatively moderate.

The linkage further weakened in Period III: from February 2019 to June 2022. The correlation fell to a very low level of -0.11. The weakening of the relationship during Period III may partly reflect the economic disruptions caused by the COVID-19 pandemic. During this phase, industrial production was severely affected by lockdowns, disruptions in supply chains, labour shortages, and reduced consumer demand. Even though financial support measures were introduced, firms may not have immediately utilized credit for higher production because economic uncertainty remained high. However, in the most recent Period IV (July 2022–November 2025), the correlation again rose back to 0.76. The strengthening of the relationship during this phase may reflect the gradual recovery of industrial activity after the pandemic, supported by measures such as the expansion of Production Linked Incentive (PLI) schemes, continued MSME financing support, infrastructure-led investment, and improvements in credit flow.

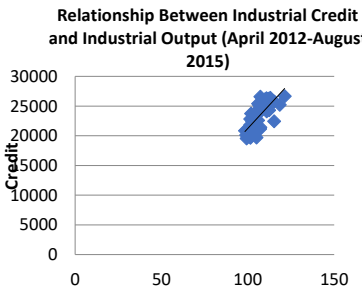


Fig.1

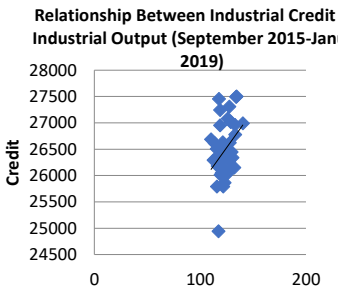


Fig. 2

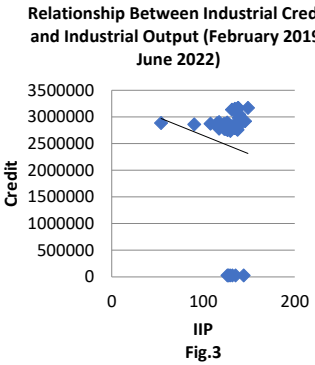


Fig.3

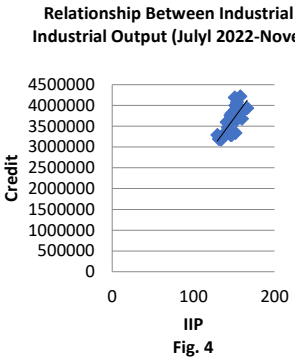


Fig. 4

These correlations do not necessarily show causal impact, rather it indicates association. These correlations help illustrate how the strength of co-movement changes across periods.

The regression results show that industrial credit has a positive and significant effect on industrial output. However, when the study period is divided into equal phases to see whether this relationship stays the same over time, the correlation results show a different picture. The short-term relationship between credit and output does not remain the same in every phase. In most phases, the relationship is positive. But in one phase, the correlation turns negative.

This does not go against the regression result. Instead, it shows that in the short run, the way credit affects production can change. There may be delays in how credit is used. Sometimes firms may take loans but may not increase production immediately. Economic slowdowns or weak demand can also affect this link. This reflects short-term changes or shifting economic conditions but overall stability in the long run.

RECOMMENDATION

The results reveal that only increasing the amount of credit does not necessarily lead to steady industrial growth. Bank credit and industrial output do move in the same direction, but this link is not equally strong all the time. This means credit works better in some periods than in others. Its impact does not depend only on how much money is available, but also on the overall economic situation in which firms operate.

1. **Ensuring productive utilization of credit:** It should also be made sure that borrowed money is used for productive investment. Sometimes firms use loans just for short- term survival or to repay old debts. This does not help production grow. Because of this, banks and financial institutions need to monitor how credit is used. Lending decisions should match the firm's real production capacity and long-term plans. When this happens, credit has a stronger and more stable effect on industrial output.
2. **Improving credit allocation:** Credit can be allocated more effectively by assessing the productivity of each sector separately. Instead of relying solely on collateral-based lending, banks can incorporate indicators such as past productivity performance, employment generation capacity, and value-added contribution of different sectors while making lending decisions. This is because collateral-based lending is not always effective as it focuses mainly on the value of assets rather than the actual productive potential of the borrower. Many small and medium enterprises may have good business ideas and high productivity potential but lack sufficient assets to offer as security, which limits their access to credit. As a result, credit may not reach the most productive sectors, and funds may remain

underutilized. Asset-based lending is also not very effective because firms may sometimes overstate or misrepresent the value of their assets to obtain more credit. In such cases, the lending decision becomes less reliable.

3. **To strengthen industrial demand:** The study further shows that wider economic conditions matter a lot. When the economy is slow and demand is weak, firms are less willing to invest. Even if loans are easy to get, businesses may still hold back. In such situations, government support becomes important. Public investment can help increase overall demand. Policies that promote exports can create new market opportunities. These steps can encourage firms to produce more. As demand improves, the link between financial support and actual production becomes stronger.
4. **Productivity oriented credit distribution:** Another important implication is the allocation of credit across sectors and firms. Rather than expanding credit uniformly, financial resources should be directed toward industries and enterprises with strong productivity potential, particularly manufacturing units and MSMEs. In addition, data-sharing mechanisms between financial institutions and industrial monitoring agencies can improve the efficiency of credit allocation.

CONCLUSION

This study highlights that the relationship between industrial credit and output is dynamic rather than fixed. While credit supports industrial activity, its impact varies over time depending on the broader economic environment and the capacity of firms to use financial resources productively. Understanding this variability is important for understanding industrial growth patterns and for framing policies that aim to achieve stable and sustained development. From a policy perspective, these results imply that credit policies must be adaptive rather than uniform.

APPENDIX

Intertemporal: It describes situations where current values of a variable are influenced by its past values or where decisions and outcomes are connected over time.

Logarithmic Form: All variables in the model are expressed in natural logarithms. It allows the estimated coefficients to be interpreted as elasticities, meaning they show percentage changes rather than absolute changes.

R-squared (R^2): R-squared measures how well the independent variables in the model explain variations in the dependent variable. It ranges from zero to one. A higher value of R^2 indicates that a larger proportion of changes in dependent variable (industrial output) is explained by the independent variables (industrial credit at current time and lagged industrial output) included in the model.

Durbin–Watson Statistic: The Durbin–Watson statistic is used to detect the existence of autocorrelation in the residuals of a regression model. It has a value between 0 to 4. When the Durbin-Watson statistic is near zero, there is no autocorrelation; when it is below two, there is positive autocorrelation; and when it is above two, there is negative autocorrelation.

Autocorrelation: When the error terms, or residuals, in a regression model exhibit a long-term correlation with one another, this is known as autocorrelation. This means that in time-series data, factors that have an inexplicable impact on industrial output in one period might still have an impact on it in later periods.

P- value: The probability that a coefficient in the population is equal to zero is indicated by the p-value.The variable has a statistically significant impact on the dependent variable when the p-value is small (typically less than 0.05), indicating that the observed relationship is unlikely to be the result of chance.

Unstandardized Coefficients: In model units, unstandardized coefficients display the true estimated impact of an independent variable on the dependent variable. These coefficients show the percentage

change in the dependent variable that results from a one percent change in the explanatory variable in a logarithmic model.

Correlation coefficient: The degree and direction of a linear relationship between two variables are measured by the correlation coefficient. Its value falls between -1 and +1. A strong positive relationship is indicated by a value near +1, a strong negative relationship by a value near -1, and a weak or nonexistent linear relationship by a value near zero.

Residuals: Residuals are the differences between the actual observed values and the values predicted by the regression model. They represent the unexplained portion of the model.

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--Chapter--

AI-Enabled Sustainable Banking Services: Customer Awareness, Evaluation, and Satisfaction among Bank Customers in Guwahati City

Juliet N Tuolor[1]

ABSTRACT

Artificial Intelligence (AI) is transforming the banking sector by facilitating efficient, customer-oriented, and resource-efficient financial services. This study examines customers' awareness of AI-enabled sustainable banking services, their evaluation of these services, and their overall satisfaction among bank customers in Guwahati City. Primary data were collected from 110 bank customers using a structured questionnaire and convenience sampling. Descriptive statistics, including frequency, percentage, mean, and standard deviation, were used to assess customer awareness, evaluation, and overall satisfaction. One-way Analysis of Variance (ANOVA) was employed to examine whether awareness and overall satisfaction differed across age groups. The findings indicate a relatively high level of awareness of AI-enabled sustainable banking services among respondents, with the highest mean score recorded for familiarity with green digital banking services ($M = 3.91$, $SD = 0.71$). Customers also evaluated AI-enabled banking services positively, particularly in terms of time-saving ($M = 4.14$, $SD = 0.93$), convenience ($M = 4.02$, $SD = 1.13$), and reduction of paper-based transactions ($M = 4.00$, $SD = 1.13$). The direct measure of overall customer satisfaction recorded a mean score of 3.16 ($SD = 1.05$), indicating a moderately positive level of satisfaction. Significant differences were observed in awareness across age groups, $F(4, 105) = 75.518$, $p < 0.001$, and in overall satisfaction, $F(4, 105) = 12.845$, $p < 0.001$. Awareness and satisfaction were descriptively higher among younger respondents and lower among older respondents. The findings highlight the importance of strengthening customer communication, improving transparency, and enhancing customer understanding of AI-enabled banking services, particularly among older customers.

Keywords: Artificial Intelligence; Sustainable Banking; Customer Awareness; Customer Satisfaction; Guwahati

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INTRODUCTION

The banking sector has undergone substantial transformation with the rapid advancement of digital technologies, fundamentally changing the manner in which financial institutions deliver services to customers. Among the technologies contributing to this transformation, Artificial Intelligence (AI) has

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emerged as an important tool for improving operational efficiency, customer service, security, and personalization. AI is increasingly being applied through chatbots, virtual assistants, fraud detection systems, predictive analytics, recommendation systems, automated customer support, and other digital applications.

The growing use of AI is also associated with the broader movement towards more efficient and sustainable banking practices. Sustainable banking generally involves integrating economic, environmental, and social considerations into banking activities and decision-making. From this perspective, digital technologies can support resource-efficient banking by reducing dependence on paper-based processes, facilitating digital transactions, improving operational efficiency, and expanding access to financial services. AI may further support sustainable banking through automated processes, data-driven decision-making, improved risk assessment, fraud detection, and more efficient delivery of financial services. The increasing application of AI in banking has therefore created an intersection between technological innovation and sustainable banking practices. *Fares et al. (2023)*, in their systematic review of AI applications in banking, identified customer-related applications, processes, and strategic applications as major areas of AI utilization in the banking sector. AI-enabled banking can influence the customer experience by improving service speed, personalization, convenience, and accessibility.

However, technological advancement alone does not guarantee successful adoption or positive customer experiences. Customers need to understand the technologies being used by banks and the benefits associated with them. Customer awareness may influence how customers perceive, evaluate, and interact with AI-enabled banking services. *Fundira et al. (2024)* emphasize the importance of digital competencies and awareness of AI-related issues among banking customers. Similarly, *Stauropoulou et al. (2023)* highlight the importance of customer awareness in shaping attitudes towards banks' sustainability-related practices.

Customer evaluation is another important dimension of AI-enabled banking. Customers may evaluate AI-enabled services in terms of usefulness, convenience, speed, ease of use, security, reliability, and resource efficiency. These evaluations represent customers' perceptions of specific characteristics and benefits of AI-enabled services and should be distinguished from overall customer satisfaction. Satisfaction represents customers' overall assessment of the services received.

Previous studies have reported positive relationships between AI-enabled banking and customer experience. *Alnaser et al. (2023)*, for example, examined AI-enabled digital banking and found that factors such as expectation confirmation, perceived performance, communication quality, customization, and problem-solving contribute to users' satisfaction with AI-enabled digital banking. *Shaikh et al. (2024)* similarly examined customer satisfaction with AI-based banking services in India and highlighted the importance of the customer experience associated with AI-enabled banking.

Trust, transparency, security, and responsible use of customer data are also important considerations. Customers may be hesitant to rely on AI-based services when they are uncertain about how automated decisions are made or how their personal information is used. Explainability and transparency may therefore contribute to customer confidence in AI-enabled banking services. *Ni (2024)*, for example, discusses the relationship between explainable AI, customer trust, and satisfaction in banking. Although research on AI in banking has expanded considerably, relatively limited attention has been given to the specific combination of customer awareness, customer evaluation, and overall satisfaction with AI-enabled sustainable banking services. Much of the existing literature focuses on AI adoption, digital banking, service quality, customer trust, or technological acceptance. Moreover, empirical evidence concerning customers in Northeast India remains limited.

In this context, the present study examines AI-enabled sustainable banking services from the customers' perspective in Guwahati City. The study focuses on three related aspects: customer awareness

of AI-enabled sustainable banking services, customer evaluation of specific characteristics and perceived benefits of these services, and customers' overall satisfaction.

RESEARCH OBJECTIVES:

1. To assess the awareness of artificial intelligence-enabled sustainable banking services among bank customers.
2. To assess customers' evaluation of AI-enabled sustainable banking services and their overall satisfaction with these services.

REVIEW OF LITERATURE

Artificial Intelligence (AI) has become a revolutionary force in the banking industry, streamlining operations, enhancing customer service, securing banks, and advancing sustainable banking. These innovations have accelerated digital transformation and can contribute to more sustainable banking practices, particularly through greater use of digital channels, reduced dependence on paper-based processes, and improved resource efficiency. These innovations have sped up digital transformation while making banking more ecological by reducing paper consumption and utilizing digital financial services *(Fares et al., 2023)*. Recent studies have emphasized AI's increasingly important role in improving customer experience via personalized banking services. AI-powered systems analyze customer behaviour, transaction history and preferences to make personalized product recommendations, advice and real-time support. These personalized services enhance customer engagement, service quality and satisfaction. However, researchers note that the personalization should be done responsibly with good data management, transparency, and strong privacy protection in order to retain customers *(Huang & Rust, 2021)*. Customer acceptance of AI-enabled banking services hinges on various technological and behavioural factors. Mei et al. (2024) studied the adoption of AI-based sustainable banking services using the AIDUA model. Their findings showed that social influence, hedonic motivation, perceived anthropomorphism, and technological literacy drive customers to adopt AI-powered banking. The study also showed that customers who understand the environmental advantages of AI-based banking are more likely to adopt sustainable digital banking solutions. Many researchers have found that AI improves banking efficiency and customer satisfaction by reducing waiting time, offering 24-hour assistance, improving transaction accuracy and detecting fraud. AI-based applications such as virtual assistants, chatbots and automated financial advisory services have allowed banks to provide faster and more reliable services while cutting operational costs. Despite this, customer concerns over cybersecurity, data privacy and algorithmic transparency remain a hindrance to the adoption of AI in banking *(Shaikh et al., 2024)*. Research on the combination of AI and sustainable banking is growing. AI enables paperless banking, optimizes resource utilization, promotes green financing and improves operational sustainability. Digital banking services powered by AI can reduce reliance on physical branches and paper-based processes and may contribute to more resource-efficient banking practices. Studies show that AI-based digital transformation not only improves banking efficiency, but also provides customers with convenient, secure, and environmentally friendly banking services *(Bethapudi et al., 2025)*. Trust is still a key factor in customers' willingness to embrace AI banking services. Customers are more likely to use AI-powered financial services if they perceive them as secure, reliable, transparent, and easy to use. Ethical AI governance, explainable algorithms and robust regulations are therefore necessary for rebuilding the customer's confidence and long-term adoption of AI in banking *(Dwivedi et al., 2021)*.

Overall, the literature in general shows that AI increases banking efficiency, customer experience, operational performance, and sustainable banking. Previous research has focused extensively on AI adoption, digital transformation, service quality, and customer trust, but relatively little attention has been paid to customers' awareness of AI-enabled sustainable banking services. Moreover,

empirical evidence from Northeast India is very limited. Therefore, to fill this gap, the present study explores customers' awareness of AI-driven sustainable banking services, their evaluation of these services, and their overall satisfaction among bank customers in Guwahati City.

RESEARCH METHODOLOGY

The study employed a quantitative approach to investigate customers' awareness, evaluation, and overall satisfaction with AI-enabled sustainable banking services in Guwahati City. Primary data were collected through a questionnaire using convenience sampling from 110 bank customers. The questionnaire consisted of two parts: demographic characteristics and statements measuring respondents' awareness, evaluation of AI-enabled banking services, and overall satisfaction. The internal consistency of the six awareness items was assessed using Cronbach's alpha. The awareness scale demonstrated excellent internal consistency (Cronbach's $\alpha = 0.955$). Also, the six-item Evaluation scale demonstrated excellent internal consistency, with a Cronbach's alpha coefficient of 0.999.

For this study, AI-enabled sustainable banking services refer to technology-enabled banking services that incorporate AI or related digital technologies to improve service efficiency, accessibility, security, convenience, and resource efficiency. The awareness items covered respondents' familiarity with AI applications in banking and their understanding of the sustainability-related benefits of digital banking. The evaluation items assessed respondents' perceptions of the efficiency, convenience, usability, security, reliability, and resource-saving benefits of AI-enabled banking services. Overall customer satisfaction was assessed through a direct item measuring respondents' satisfaction with their bank's AI-enabled sustainable banking services. The data were analyzed using Microsoft Excel, and descriptive statistics, including frequency, percentage, mean, and standard deviation, were used to describe the demographic profile of the respondents and the levels of awareness and satisfaction. One-way Analysis of Variance (ANOVA) was used to compare awareness and satisfaction between age groups.

RESULTS AND DISCUSSIONS

Table 1: Demographic Profile of the Respondents

Variable	Frequency	Percentage
Gender		
Male	54	49.09
Female	56	50.91
Others	-	0.00
Age		
Below 25	47	42.73
25-35	35	31.82
36-45	18	16.36
46-55	7	6.36
Above 55	3	2.73
Educational Qualification		
Secondary	11	10.00
Higher Secondary	17	15.45

Graduate	52	47.27
Post Graduate	20	18.18
Others	10	9.09
Occupation		
Student	40	36.36
Government Employee	33	30.00
Private Employee	17	15.45
Business	9	8.18
Self Employed	5	4.55
Others	6	5.45
Type of Bank Used		
Public	57	51.82
Private	23	20.91
Both	30	27.27

Source: Primary data 2026

The demographic profile of the respondents shows a fairly balanced gender distribution with 50.91% of the respondents being female and 49.09% male. Regarding age, the largest proportion of respondents (42.73%) was below 25 years, followed by those aged 25–35 years (31.82%), indicating that the majority of the respondents were young adults. Respondents in the 36–45 years age group constituted 16.36%, and respondents belonging to the 46–55 years and above 55 years were only 6.36% and 2.73%, respectively.

Regarding educational qualification, nearly half of the respondents (47.27%) were graduates and 18.18% were postgraduates. Respondents with higher secondary education were 15.45%, secondary education respondents were 10.00%, and other educational qualifications were 9.09%. It indicates that most of the respondents had a graduate level education at least.

The occupational profile shows that students constituted the largest occupational group (36.36%), followed by government employees (30.00%), private employees (15.45%), business owners (8.18%), self-employed respondents (4.55%), and respondents in other occupations (5.45%). The occupational distribution reflects participation from both students and working respondents. In terms of the type of bank used, 51.82 percent of the respondents used public sector banks as their primary bank, and 27.27 percent of the respondents used both public and private banks. Only 20.91 per cent exclusively relied on private banks. The results indicate that public sector banks were the most commonly used type of banking institution among the respondents.

Reliability of the Awareness Scale

Before examining the individual awareness items, the internal consistency of the six-item awareness scale was assessed using Cronbach's alpha. The scale produced a Cronbach's alpha coefficient of 0.955, indicating excellent internal consistency among the awareness items. This suggests that the items consistently measure the underlying construct of customer awareness of AI-enabled sustainable banking services.

Table 2: Respondents' Awareness of AI-enabled Sustainable Banking Services

Statement	Mean	SD
I am aware that banks use AI in banking services	3.89	0.84
I am aware of AI services such as chatbots and virtual assistants.	3.89	0.84
I am aware that AI-enabled digital banking can contribute to reducing paper-based banking transactions.	3.70	0.81
I am aware that AI supports sustainable banking.	3.79	0.87
I am familiar with green digital banking services that contribute to more sustainable banking practices (e-statements, mobile banking, online transactions).	3.91	0.71
My bank informs customers about AI-enabled banking services.	3.30	0.57

Source: Primary data 2026

Table 2 presents the respondents' awareness of AI-enabled sustainable banking services. With mean scores ranging from 3.30 to 3.91, the results indicate a relatively high level of awareness among the respondents. The statement "I am familiar with green digital banking services that contribute to more sustainable banking practices (e-statements, mobile banking, online transactions)" received the highest mean score (M = 3.91, SD = 0.71), indicating a relatively high level of familiarity with these services. Similarly, respondents reported high awareness that banks use AI in banking services (M = 3.89, SD = 0.84) and awareness of AI services such as chatbots and virtual assistants (M = 3.89, SD = 0.84), indicating good awareness of AI applications in banking.

Additionally, respondents showed relatively high awareness of AI's contribution to sustainable banking practices, as reflected in the statement that AI supports sustainable banking (M = 3.79, SD = 0.87) and that AI-enabled digital banking can contribute to reducing paper-based banking transactions (M = 3.70, SD = 0.81). The statement "My bank informs customers about AI-enabled banking services" recorded the lowest mean score (M = 3.30, SD = 0.57). Although the score remained above the neutral point, it indicates comparatively lower agreement regarding bank-led communication about AI-enabled banking services. This suggests that banks could strengthen customer communication and awareness initiatives relating to AI-enabled banking services.

The results indicate a relatively high level of awareness of AI-enabled sustainable banking services among the respondents. The findings also suggest greater familiarity with digital banking services than agreement that banks actively inform customers about AI-enabled banking services.

Evaluation of AI-Enabled Banking Services

Before examining the individual evaluation items, the internal consistency of the seven-item evaluation scale was assessed using Cronbach's alpha. The scale produced a Cronbach's alpha coefficient of 0.999, indicating excellent internal consistency among the evaluation items. This suggests that the items consistently measure the underlying construct of customer evaluation of AI-enabled sustainable banking services.

Table 3: Respondents' Evaluation of AI-Enabled Sustainable Banking Services

Statement	Mean	SD
AI-enabled banking services provided by my bank meet my expectations	3.91	1.08
AI-enabled banking saves time	4.14	0.93
AI makes banking more convenient	4.02	1.13
AI-enabled banking services are easy to use	3.91	1.08
AI-enabled banking services are secure and reliable	3.92	0.94
AI-enabled banking services contribute to reducing paper-based transactions	4.00	1.13

Overall, I am satisfied with my bank's AI-enabled sustainable banking services	3.16	1.05

Source: Primary data 2026

Table 3 distinguishes between customers' evaluation of specific service attributes and their overall satisfaction. The first six statements represent customers' evaluations of particular characteristics and perceived benefits of AI-enabled banking services. The mean scores for these evaluation items ranged from 3.91 to 4.14, indicating generally favorable evaluations.

The highest mean score was recorded for the statement that AI-enabled banking saves time (M = 4.14, SD = 0.93). This was followed by the perception that AI makes banking more convenient (M = 4.02, SD = 1.13) and that AI-enabled banking contributes to reducing paper-based transactions (M = 4.00, SD = 1.13). Respondents also reported positive evaluations regarding the extent to which AI-enabled banking services meet their expectations (M = 3.91, SD = 1.08), are easy to use (M = 3.91, SD = 1.08), and are secure and reliable (M = 3.92, SD = 0.94). The direct measure of overall customer satisfaction recorded a mean score of 3.16 (SD = 1.05), indicating a moderate level of satisfaction. This indicates that respondents' overall satisfaction was positive but more moderate than their evaluations of individual service attributes. The difference between the evaluation scores and the overall satisfaction score is important. Respondents may view individual characteristics of AI-enabled banking services positively without reporting equally high overall satisfaction. Therefore, the six evaluation items should not be interpreted as direct measures of satisfaction. The first six statements assess respondents' evaluation of specific attributes of AI-enabled sustainable banking services, while the final statement is used as a single-item measure of overall satisfaction. A single global satisfaction item was adopted to capture respondents' overall assessment of the services directly, rather than treating satisfaction as a multidimensional construct. This approach also avoids conceptual overlap between the specific service evaluations and the overall satisfaction measure.

Table 4: Mean Awareness Scores across Age Groups

Age Group	N	Mean	SD
Below 25	47	4.32	0.38
25-35	35	3.69	0.37
36-45	18	3.06	0.08
46-55	7	2.50	0.62
Above 55	3	2.44	0.42

Source: Primary data 2026

The descriptive statistics indicate that awareness of AI-enabled sustainable banking services was highest among younger respondents and declined progressively with age. Respondents below 25 years recorded the highest mean awareness score (M = 4.32, SD = 0.38), followed by those aged 25–35 years (M = 3.69, SD = 0.37). The lowest awareness was observed among respondents above 55 years (M = 2.44, SD = 0.42). Overall, the results suggest that younger respondents had higher levels of awareness of AI-enabled sustainable banking services than older respondents.

Table 5: One-Way ANOVA: Awareness across Age Groups

Source of Variation	Sum of Squares	df	Mean Square	F	P
Between Groups	40.060	4	10.015	75.518	<0.001
Within Groups	13.925	105	0.133		
Total	53.985	109			

Source: Primary data 2026

Interpretation: A one-way ANOVA was conducted to determine whether awareness of AI-enabled sustainable banking services differed across age groups. The results revealed a statistically significant difference in awareness among the different age groups ($F(4, 105) = 75.518$, $p < 0.001$). Thus, the null hypothesis is rejected, indicating that respondents' awareness of AI-enabled sustainable banking services varies significantly according to age.

Table 6: Mean Overall Customer Satisfaction Scores across Age Groups

Age Group	N	Mean	SD
Below 25	47	3.36	0.49
25-35	35	3.20	0.41
36-45	18	3.00	0.00
46-55	7	2.57	0.53
Above 55	3	2.00	0.00
Total	110		

Source: Primary data 2026

Table 6 presents the mean overall satisfaction scores across the five age groups. The highest mean satisfaction score was recorded among respondents below 25 years ($M = 3.36$, $SD = 0.49$), followed by respondents aged 25–35 years ($M = 3.20$, $SD = 0.41$). Respondents aged 36–45 years recorded a mean satisfaction score of 3.00 ($SD = 0.00$), while respondents aged 46–55 years recorded a mean of 2.57 ($SD = 0.53$). The lowest mean satisfaction score was observed among respondents above 55 years ($M = 2.00$, $SD = 0.00$). The descriptive results therefore indicate a general decline in overall satisfaction with increasing age. Nevertheless, the very small number of respondents in the older age groups, particularly the above-55 group ($N = 3$), should be considered when interpreting these differences.

Table 7: One-Way ANOVA: Overall Customer Satisfaction across Age Groups

Source of Variation	Sum of Squares	df	Mean Square	F	P
Between Groups	8.889	4	2.222	12.845	<0.001
Within Groups	18.165	105	0.173		
Total	27.055	109			

Source: Primary data 2026

Interpretation: A one-way ANOVA was conducted to determine whether overall customer satisfaction differed across age groups. The results revealed a statistically significant difference in overall satisfaction among the five age groups, $F(4, 105) = 12.845$, $p < 0.001$. Therefore, the null hypothesis of equal mean satisfaction across the age groups is rejected. The descriptive results indicate that satisfaction was highest among respondents below 25 years ($M = 3.36$) and lowest among respondents above 55 years ($M = 2.00$). However, the ANOVA result only establishes that at least one age-group mean differs significantly from another; without a post-hoc test, the specific pairs of groups that differ cannot be identified. The very small number of respondents in the older age groups should also be considered when interpreting these differences.

FINDINGS

1. **Respondent profile:** The study comprised 110 bank customers in Guwahati City, with a relatively balanced gender distribution. The sample was predominantly younger and educated, with

respondents below 35 years constituting the majority. Graduates and students represented the largest educational and occupational groups, respectively. Public sector banks were the most commonly used, either exclusively or alongside private sector banks.

2. **Awareness of AI-enabled sustainable banking:** Respondents demonstrated a generally favorable level of awareness of AI-enabled sustainable banking services. Awareness was particularly evident regarding the contribution of green digital banking services to sustainable banking practices and the use of AI applications such as chatbots and virtual assistants. However, comparatively lower awareness was observed regarding direct communication by banks about their AI-enabled services, indicating scope for stronger customer-oriented communication.
3. **Evaluation of AI-enabled banking services:** Respondents evaluated the specific attributes of AI-enabled banking services positively. Time-saving emerged as the most favorably evaluated attribute, followed by convenience and the perceived contribution of AI-enabled banking to reducing paper-based transactions. These findings indicate that customers generally associate AI-enabled banking with greater efficiency, convenience, and sustainability.
4. **Overall customer satisfaction:** Despite the positive evaluation of specific service attributes, the direct measure of overall satisfaction indicated a moderately positive level of satisfaction. This suggests that favorable perceptions of individual service characteristics do not necessarily translate into an equally high overall satisfaction level.
5. **Age-related differences:** Age emerged as an important factor associated with both awareness and overall satisfaction. Significant differences were observed across age groups, with younger respondents generally demonstrating higher awareness and satisfaction than older respondents. This highlights the importance of considering age-related differences when promoting and delivering AI-enabled sustainable banking services.

CONCLUSION

AI-enabled sustainable banking represents an emerging dimension of customer-oriented banking in which digital technologies and artificial intelligence can contribute to service efficiency, convenience, accessibility, and resource efficiency. The present study examined customer awareness, evaluation, and overall satisfaction with AI-enabled sustainable banking services among 110 bank customers in Guwahati City. The findings indicate that respondents generally demonstrated a relatively high level of awareness of AI-enabled sustainable banking services. Customers were particularly familiar with digital banking practices associated with sustainable banking and with common AI applications such as chatbots and virtual assistants. However, comparatively lower agreement regarding banks' communication of AI-enabled services indicates a need for stronger customer education and communication. The evaluation results were generally positive, particularly regarding time-saving, convenience, and reduction of paper-based transactions. However, overall satisfaction, measured through a separate direct item, recorded a mean score of 3.16, indicating a moderately positive level of satisfaction. The study also found significant differences in both awareness and overall satisfaction across age groups. Younger respondents recorded higher mean awareness and satisfaction scores than older respondents. However, the small number of respondents in some older age categories warrants cautious interpretation of these age-related differences. The findings therefore indicate that technological advancement should be accompanied by effective customer communication, education, transparency, and confidence-building measures. Banks can potentially improve customers' understanding of AI-enabled services by clearly explaining how these technologies work, what benefits they provide, how customer data are protected, and how they contribute to efficient and resource-conscious banking practices.

LIMITATIONS OF THE STUDY

1. The sample consisted of only 110 respondents using convenience sampling method from Guwahati City. Therefore, the findings should not be generalized to all bank customers in Assam or India.
2. The older age categories contained relatively few respondents. In particular, only three respondents belonged to the above-55 age group. Therefore, age-group comparisons involving these categories should be interpreted cautiously.
3. The study focused primarily on awareness, evaluation, and overall satisfaction. Other potentially important factors, such as digital literacy, trust, perceived security, privacy concerns, perceived usefulness, and frequency of digital banking use, were not included in the present analysis.

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--Chapter--

Financial Technology for Rural Transformation: Bridging the Financial Inclusion Divide

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Artificial Intelligence and Inclusive Financial Services: Transforming Financial Access and Rural Development in North East India

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ABSTRACT

Artificial Intelligence (AI) is fundamentally reshaping financial inclusion in India by transforming how financial services are designed, delivered, and accessed by underserved populations. Adopting a desk-based, secondary-data methodology, this chapter examines the convergence of AI technologies with India's Digital Public Infrastructure (DPI) to advance financial inclusion, with particular emphasis on rural communities and the eight states of North East India. After situating the discussion within recent academic literature and identifying the specific research gap it addresses, the chapter draws on India's policy framework anchored by the JAM Trinity (Jan Dhan, Aadhaar, Mobile), BHASHINI's multilingual AI systems, and AI-powered lending platforms such as the Unified Lending Interface (ULI) to analyse how AI addresses persistent barriers to financial access, including information asymmetries, credit constraints, and linguistic exclusion. State-wise evidence from Assam, Meghalaya, Mizoram, Nagaland, Manipur, Tripura, Sikkim, and Arunachal Pradesh is used to demonstrate that AI-enabled solutions can strengthen credit assessment for MSMEs, informal workers, and women entrepreneurs, while reducing dependence on collateral-based lending. However, implementation challenges — including algorithmic bias, data privacy and consent gaps, cybersecurity vulnerabilities, digital literacy deficits, and the concentration of AI capability in urban centres — constrain this potential and require targeted, region-specific policy interventions. The chapter concludes, cautiously and in line with the evidence reviewed, that AI-powered financial inclusion can support, but cannot by itself guarantee, progress toward India's 'Viksit Bharat 2047' vision, and that its contribution to women's economic empowerment in North East India depends on complementary investments in digital literacy, SHG-linked outreach, and gender-sensitive product design.

Keywords: Artificial intelligence, Financial inclusion, Digital public infrastructure, North East India, Rural development, Women's empowerment, FinTech, Algorithmic bias

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INTRODUCTION

Financial inclusion remains a central priority for India's development agenda, yet substantial segments of the population — particularly in rural areas and North Eastern states — continue to face barriers to formal financial services. Historically, financial inclusion efforts focused on expanding basic banking access through branch networks and accounts *(Gabor & Brooks, 2016)*. However, this approach proved insufficient to serve populations with limited collateral, poor credit histories, or geographic constraints. Artificial Intelligence (AI) is catalysing a paradigm shift in financial services delivery, enabling the rapid assessment of credit risk, personalisation of financial products, and extension of formal finance to previously underserved segments *(Marak & Ayyagari, 2025).*

India's financial inclusion journey has entered a measurable phase of deepening rather than mere expansion. The Reserve Bank of India's (RBI) composite Financial Inclusion Index (FI-Index)—which tracks 97 indicators of access, usage, and quality on a 0–100 scale—rose from 53.9 in March 2021 to 67.0 in March 2025 and further to 70.0 in March 2026, with the RBI attributing the latest 4.48 per cent annual rise mainly to deepening usage rather than new account opening alone *(RBI, 2026)*. As of March 2026, over 144 crore Aadhaar numbers had been generated, providing biometric digital identity to the vast majority of India's population *(Unique Identification Authority of India, 2026)*. The JAM Trinity framework — integrating Jan Dhan accounts (holding ₹3.02 lakh crore in deposits), Aadhaar biometric authentication, and ubiquitous mobile connectivity — has created foundational infrastructure enabling AI-driven innovation in financial services. Simultaneously, the Unified Payments Interface (UPI), regulated by the RBI and operated by the National Payments Corporation of India (NPCI), processed 2,264.11 crore transactions worth ₹29.53 lakh crore in March 2026 alone, creating a transaction-dense digital ecosystem rich with behavioural and transactional data *(NPCI, 2026)*. This data, coupled with AI analytics capabilities, enables unprecedented opportunities for algorithmic credit assessment and financial service customisation.

The Northeastern region, encompassing eight states including Assam *(Maity & Sahu, 2021),* represents both a development challenge and an opportunity for AI-powered financial inclusion. Recent state-level research finds Assam recording the highest Index of Financial Inclusion (IFI) among North Eastern states at 0.60, while Arunachal Pradesh records an IFI of only 0.043, reflecting substantial regional heterogeneity that this chapter examines in greater depth in the proceeding part *(Hajam, Ahmad, & Rajab, 2026)*. FinTech adoption remains skewed toward urban millennials, with perceived risks—including cyberattacks, data loss, and technical difficulties—adversely affecting rural adoption *(Bordoloi & Pegu, 2026)*.

REVIEW OF LITERATURE

A growing body of scholarship addresses the intersection of AI, digital infrastructure, and financial inclusion, and this chapter situates itself within four overlapping strands of that literature.

First, an emerging literature examines Digital Public Infrastructure (DPI) as a distinct enabler of financial inclusion, separate from the financial services built upon it. Recent work models the causal relationship between DPI expansion and inclusion outcomes in India using time-series and econometric methods, arguing that DPI's population-scale identity and payment rails are a necessary but not sufficient condition for inclusion, and that the sustainability of inclusion gains depends on data protection and interoperability safeguards *(Chopra et al., 2025).*

Second, a substantial and rapidly expanding literature addresses AI's specific contribution to financial inclusion. *Akanfe, Bhatt, and Lawong (2025)* review technology-driven interventions in financial inclusion and identify AI-enabled credit scoring and personalisation as the most consequential recent development, while cautioning that evidence of impact at the household level remains thinner than evidence of platform-level adoption. *Bharathi, Perdana, and Kulkarni (2023)* synthesise the FinTech–

financial inclusion literature and note that most existing studies measure access and usage rather than the quality or welfare impact of inclusion. *Bhat, Lone, SivaKumar, and Krishna (2024)* provide Indian evidence that digital financial literacy, not merely digital access, is the stronger predictor of financial well-being, a finding directly relevant to North East India's literacy-constrained rural markets.

Third, a smaller but important literature examines algorithmic bias and fairness in AI-enabled banking. A recent systematic review of the banking and financial services literature identifies algorithmic opacity, fairness auditing, and responsible AI governance as under-researched relative to studies of AI's efficiency gains, and calls for context-specific bias audits rather than only global fairness metrics *(Krey et al., 2026).* This concern is echoed in Indian policy commentary noting that uncalibrated machine-learning credit models risk reproducing localised 'credit redlining' against thin-file, rural, and minority-language borrowers even as they expand aggregate access *(Press Information Bureau, 2026)*.

Fourth, region-specific and gender-specific studies provide the empirical anchor for this chapter's North East India focus. *Hajam, Ahmad, and Rajab (2026)* construct a comparative Index of Financial Inclusion across North Eastern states and Jammu & Kashmir, finding wide intra-regional variation. An earlier state-wise financial inclusion and human development study similarly ranked Tripura, Sikkim, and Assam above Meghalaya, Mizoram, Nagaland, Manipur, and Arunachal Pradesh, though on a different index construction *(Annemalla & Kasturi, 2025).* The World Bank's assessment of North East financial inclusion programming documents the specific frictions of terrain, branch distance, and self-help group (SHG) intermediation that shape access in the region *(World Bank, 2021)*, while *(Inostroza-Correa et al., 2025)* provides Barak Valley, Assam-specific evidence that SHG participation strengthens women's financial 'autonomy' — a dimension distinct from mere account ownership.

RESEARCH GAP

Despite this literature, three gaps remain. First, most AI–financial inclusion scholarship is framed at the India-wide, macro-policy level; comparatively little work examines how AI-enabled DPI applications interact with North East India's specific constraints — linguistic diversity across more than 220 languages spoken in the region, mountainous terrain limiting branch density, and SHG-centred (rather than purely individual) financial inclusion models. Second, the literature rarely distinguishes AI, DPI, and digital financial services (DFS) as conceptually separate layers, which obscures which interventions are actually AI-driven versus infrastructure-driven. Third, empirical evidence on whether AI-enabled financial access translates into women's decision-making autonomy — as opposed to account usage alone — remains limited specifically for North East India. This chapter addresses these gaps by integrating macro-level AI-DPI policy developments with disaggregated, state-wise secondary evidence and an explicit conceptual framework, while stopping short of claiming primary empirical validation, which is flagged as a direction for future field-based research.

RESEARCH METHODOLOGY

This chapter adopts a qualitative, desk-based analytical methodology appropriate to policy-oriented development research; it does not involve primary data collection (surveys, interviews, or field observation), and this is stated as an explicit scope limitation rather than an implicit one.

1. Sources of Secondary Data

- Regulatory and statistical releases: Reserve Bank of India (FI-Index annual releases, the FREE-AI Committee Report, and the Report on Trend and Progress of Banking in India), National Payments Corporation of India (UPI transaction statistics), and the Unique Identification Authority of India (Aadhaar enrolment data).

- Government policy sources: Ministry of Finance and Press Information Bureau releases on the JAM Trinity, Direct Benefit Transfer, Pradhan Mantri Jan Dhan Yojana (PMJDY), and the BHASHINI–RBI memorandum of understanding.
- Peer-reviewed academic literature: journal articles on AI-enabled financial inclusion, DPI, algorithmic bias, and North East India-specific financial inclusion indices, identified through targeted searches of recent (2023–2026) publications.
- Multilateral and policy-research reports: World Bank assessments of North East India financial inclusion programming and IMPRI Impact and Policy Research Institute analysis of regional banking penetration.

2. Data Analysis Method

The chapter uses descriptive-analytical and comparative methods. State-wise secondary indicators for the eight North Eastern states are compared against national averages and against one another, drawing on published financial inclusion indices. Thematic synthesis is used to organise the literature and policy evidence into recurring themes — DPI–AI convergence, alternative credit assessment, multilingual accessibility, fraud detection, women's empowerment, and implementation risk — each treated as a distinct sub-section. Where feasible, quantitative claims are cross-verified against more than one authoritative source before inclusion; for example, the March 2026 UPI transaction value of ₹29.53 lakh crore is corroborated across RBI, NPCI-derived, and financial-press reporting before being cited.

CONCEPTUAL FRAMEWORK: DISTINGUISHING AI, DIGITAL PUBLIC INFRASTRUCTURE, AND DIGITAL FINANCIAL SERVICES

Policy and media discussion often use 'AI', 'Digital Public Infrastructure', and 'digital financial services' interchangeably. For analytical clarity, this chapter treats them as three distinct but interconnected layers,

Table 1: Conceptual distinction between DPI, AI, and DFS

Layer	Working Definition	Core Components (India context)	Role in Financial Inclusion
Digital Public Infrastructure (DPI)	Foundational, interoperable, population-scale digital systems provided as public or quasi-public infrastructure, upon which other applications are built.	Aadhaar (identity); UPI (payments); Account Aggregator framework (consent-based data sharing); DBT rails.	Supplies the verified identity, transaction, and consent architecture that make a person 'visible' and reachable to formal finance.
Artificial Intelligence (AI)	Computational systems (including machine learning and natural language processing) that perform pattern recognition, prediction, or language tasks without being explicitly programmed for each individual case.	ML-based credit scoring; NLP/speech systems (BHASHINI); anomaly-detection fraud tools (MuleHunter.AI).	Acts as the analytical/decisioning capability layer that converts DPI-generated data into individualised assessments, translations, or risk flags.
Digital Financial Services (DFS)	The actual financial products and services delivered to end users over digital channels.	Mobile/UPI-based payments; digital lending via ULI; DBT payments; digital insurance and pension products.	The outcome/application layer where the end user experiences the combined effect of DPI and AI as a usable financial service.

Source: Authors compilation

These layers are interdependent rather than separable in practice. DPI supplies the population-scale, verified data (Aadhaar-linked KYC, UPI transaction histories, DBT beneficiary records) without which AI credit-scoring models would lack sufficient volume or verifiability to assess previously 'invisible' borrowers. AI, in turn, is what allows DPI's raw data to be converted into individualised decisions — a credit score, a fraud flag, a translated grievance response — at a scale no manual process could match. DFS is the point at which both are experienced by the citizen: a farmer receiving a Kisan Credit Card decision in minutes rather than weeks is experiencing an AI-scored decision (AI layer) made possible by Aadhaar- and land-record-linked data (DPI layer), delivered as a lending product (DFS layer).

Table 2: Conceptual framework linking DPI, AI, digital financial services, financial inclusion, and rural development outcomes

Stage	Description	Illustrative Mechanism
DPI foundation	Population-scale identity, payment, and consent-based data-sharing infrastructure is established.	JAM Trinity; UPI; Account Aggregator framework.
AI-enabled decisioning	AI models operate on DPI-generated data to assess creditworthiness, detect fraud, or bridge language barriers.	ULI alternative credit scoring; MuleHunter.AI; Banking BHASHINI.
Digital financial service delivery	Decisions are delivered to end users as usable financial products.	Collateral-free MSME/KCC loans; multilingual banking interfaces; DBT payments.
Financial inclusion outcomes	Previously underserved groups (informal workers, MSMEs, women, rural households) gain formal access and usage.	Higher FI-Index Access/Usage sub-scores; PMJDY account activity.
Rural development and empowerment outcomes	Sustained usage is hypothesised to support livelihood investment, MSME growth, and — subject to complementary conditions— women's decision-making autonomy.	SHG-linked credit deepening; informal-sector income formalisation.

Source: Authors compilation

Stage 5 is presented as a hypothesised pathway supported by the literature reviewed stated earlier, not as an empirically demonstrated outcome for North East India specifically.

DIGITAL PUBLIC INFRASTRUCTURE AS FOUNDATION FOR AI-ENABLED FINANCIAL SERVICES

India's approach to AI-powered financial inclusion is distinctive in anchoring technological innovation upon foundational Digital Public Infrastructure (DPI *(Chopra, Sidana, & Arora, 2025)*. This layered architecture, comprises interconnected systems designed to maximise the transformative potential of AI while supporting inclusivity, transparency, and consumer protection *(Government of India, 2026).*

The JAM Trinity provides the identity and account infrastructure enabling AI systems to function effectively. Jan Dhan accounts, established through the Pradhan Mantri Jan Dhan Yojana, extend access to formal banking services *(Johnson, 2024).* These accounts, often with zero minimum balance requirements, aggregate transactional history that enables AI credit assessment. Aadhaar's biometric authentication layer provides secure digital identity verification, reducing dependence on traditional documentation and enabling remote access to financial services. Mobile connectivity, particularly through 4G/5G expansion, extends the reach of digital financial services to remote populations. Together, these three components create a verified, digitally connected population with transactional footprints — the data foundation required for AI analytics.

The Direct Benefit Transfer (DBT) system exemplifies the data-generation potential of DPI. As of January 2026, the system had transferred ₹49.09 lakh crore directly to citizens while identifying and

eliminating duplicate and fake beneficiaries, saving the government an estimated ₹4.31 lakh crore *(Press Information Bureau, 2026)*. This generates structured, verified data on expenditure patterns and beneficiary characteristics that can, in principle, inform AI models assessing the creditworthiness of marginalised populations — though the chapter notes that consent and purpose-limitation safeguards for such secondary use of welfare data remain a live policy question. The Unified Payments Interface (UPI) functions as the transaction rail generating data for AI credit assessment *(Ghosh & Kulkarni, 2024)*. UPI's real-time, low-cost architecture has expanded digital payments, creating transactional records even for individuals with limited financial literacy. These payment patterns provide granular behavioural data — expenditure categories, transaction frequency, seasonal patterns — that is valuable for algorithmic credit decision-making, though its use for this purpose still depends on consent frameworks discussed later in the chapter.

AI APPLICATIONS FOR INCLUSIVE FINANCIAL SERVICES

AI is transforming financial inclusion through several mechanisms addressing distinct barriers faced by underserved populations.

Table 3: AI applications in financial inclusion, mapped to the barrier each is intended to address

Application Domain	AI Mechanism	Representative Platform / Initiative	Financial Inclusion Barrier Addressed
Alternative credit assessment	Machine-learning scoring using transactional and behavioural (non-collateral) data	Unified Lending Interface (ULI)	Absence of collateral and formal credit history
Multilingual service delivery	Natural language processing, speech recognition and translation	BHASHINI / Banking BHASHINI (RBI–DIBD MoU, Feb. 2026)	Language and literacy barriers across 22+ scheduled languages
Fraud detection and transaction security	Real-time anomaly detection and pattern recognition	MuleHunter.AI (deployed across RRBs and cooperative banks)	Perceived cybersecurity risk deterring adoption
Beneficiary targeting and de-duplication	AI-assisted identity verification and eligibility checks	Direct Benefit Transfer (DBT) analytics	Leakage and exclusion/inclusion errors in welfare delivery
Regulatory risk monitoring	AI-based governance aligned to the FREE-AI 'Sutras'	RBI Framework for Responsible and Ethical Enablement of AI (2025)	Institutional trust and consumer-protection gaps

Source: Authors compilation

1. **Alternative Credit Assessment:** Conventionally, credit access for rural populations and MSMEs has been constrained by the absence of collateral and limited credit histories. AI algorithms address these constraints by analysing alternative data sources — transactional patterns, behavioural indicators, and repayment-capacity indicators — to generate creditworthiness assessments. The Unified Lending Interface (ULI) platform, which evolved from the RBI's Public Tech Platform for Frictionless Credit pilot into a scaled digital public infrastructure in August 2024, exemplifies this approach. As of December 2025, 64 lenders (41 banks and 23 non-banking financial companies) had joined the ULI platform, drawing on more than 136 data services across 12 loan categories, up from 36 lenders and roughly 50 data services a year earlier *(Reserve Bank of India, 2025)*. The platform is being extended to Regional Rural Banks and District Central Co-operative Banks — including via NABARD's e-Kisan Credit Card channel, which has in several digitised journeys compressed loan processing from four to six weeks to under an hour — to enhance credit access in rural and semi-urban areas.

For MSMEs and informal workers, AI credit models can reduce information asymmetries that previously resulted in credit rationing; the RBI's own Trend and Progress data indicate that of roughly six lakh ULI-facilitated loans worth ₹27,000 crore disbursed by late 2024, about 1.6 lakh loans worth ₹14,500 crore went to MSMEs specifically — an underserved segment *(Reserve Bank of India, 2025)*. This transformation is particularly relevant for 'new-to-credit' segments, including informal workers, rural populations, and women-led enterprises. It should be noted, however, that consent management and grievance redress on the ULI platform currently rest with individual lenders rather than a uniform platform-level standard, a governance gap is examined.

2. **Multilingual Accessibility through AI Language Models:** Language barriers constitute a significant exclusion mechanism in financial services, particularly in linguistically diverse regions such as North East India, where dozens of distinct languages and dialects are spoken across the eight states. India's 22 scheduled languages create fragmentation in financial service delivery, as most banking interfaces are available only in English and Hindi; independent survey data indicate that only around 10 per cent of India's roughly 900 million smartphone users are comfortable operating in English *(IAMAI–KPMG, 2026)*. BHASHINI (Bharat AI for Language) addresses this exclusion through AI-powered multilingual translation and language-understanding systems. On 24 February 2026, the Digital India BHASHINI Division (DIBD) and the Reserve Bank of India signed a Memorandum of Understanding to develop 'Banking BHASHINI', a domain-specific multilingual AI model for banking and financial services *(Digital India BHASHINI Division & Reserve Bank of India, 2026)*. The initiative aims to enable banking access in all 22 scheduled Indian languages, potentially reducing literacy and language barriers that disproportionately affect rural, elderly, and first-time digital users, including in North East India.
3. **Fraud Detection and Cybersecurity:** Rural populations' adoption of digital financial services is constrained by perceived risks, including susceptibility to cyber-attacks, loss of financial and personal data, and technical difficulties. Survey research from Assam covering 1,066 respondents documents that awareness and utilisation of FinTech remain skewed toward younger, urban respondents, with perceived risks adversely affecting adoption across demographic groups *(Das & Das, 2024)***.** AI-powered fraud detection systems deployed across financial institutions and payment systems are intended to enhance transaction security and consumer protection. Deployment of real-time fraud-mitigation tools such as MuleHunter.AI across Regional Rural Banks and cooperative networks is a step toward strengthening institutional capacity to protect rural deposits *(Government of India, 2026)*, although, the underlying cybersecurity infrastructure of many rural and cooperative institutions still lags behind that of larger commercial banks.

REGIONAL ANALYSIS: AI-ENABLED FINANCIAL INCLUSION ACROSS NORTH EAST INDIA

India-level initiatives provide the policy architecture for AI-enabled financial inclusion, but their impact in North East India depends on state-specific conditions of infrastructure, terrain, and institutional density. This section disaggregates the regional picture beyond the Assam/Arunachal Pradesh contrast introduced in previous part.

Recent state-level research places Assam highest among North Eastern states on a 2026 Index of Financial Inclusion (IFI value of 0.60), with Arunachal Pradesh lowest (0.043) *(Hajam, Ahmad, & Rajab, 2026)*. An earlier, differently constructed state-wise financial inclusion index — not directly comparable in scale, but broadly consistent in ordering — similarly found Tripura and Sikkim performing at an 'intermediate' level (IFI of 0.31 and 0.41 respectively), with Assam, Mizoram, and Meghalaya clustered at a 'low' level (0.19–0.29), and Nagaland, Manipur, and Arunachal Pradesh at the bottom of the eight-state ranking (0.02–0.10) *(Bhanot, et al., 2012)*.

Table 4. State-wise financial inclusion indicators for North East India

State	Earlier State-Wise IFI (baseline reference; non-comparable scale)	2026 IFI, where available (Hajam et al., 2026)	Regional Position
Assam	0.2528 (Low)	0.60 (highest among NE states)	Marked reported improvement over time; largest PMJDY account base in the region.
Tripura	0.3102 (Intermediate)	Not separately reported	Among the more financially included NE states in both studies.
Sikkim	0.4068 (Intermediate)	Not separately reported	Highest baseline IFI among NE states; small population base.
Mizoram	0.1902 (Low)	Not separately reported	Constrained by terrain-driven branch access (World Bank, 2021).
Meghalaya	0.2872 (Low)	Not separately reported	Author's home state context; SHG-based models used for outreach.
Nagaland	0.1040 (Low)	Not separately reported	Low digital-transaction volume; scope for digital-literacy investment (IMPRI, 2024).
Manipur	0.0202 (Very low)	Not separately reported	Lowest baseline IFI in the earlier study; declining RRB penetration noted (IMPRI, 2024).
Arunachal Pradesh	0.2154 (Low)	0.043 (lowest among NE states)	Reported decline over time on the 2026 index; terrain among the most constraining in the region.

Source: Authors compilation

Institutional density data corroborate this heterogeneity. Regional Rural Bank (RRB) branch penetration in the North East rose from roughly 1.4 branches per lakh population in 2013 to about 1.8 per lakh by the early 2020s, above the national average of 1.5, with Arunachal Pradesh, Mizoram, and Meghalaya more than doubling their RRB density over the decade — yet RRB penetration has simultaneously declined in Manipur over the same period, and some blocks, such as parts of West Sikkim and Nagaland's Peren and Tuensang districts, remain without any bank branch *(IMPRI Impact and Policy Research Institute, 2024; World Bank, 2021)*. For AI-enabled DFS to reach such areas, mobile and digital channels — rather than physical branch expansion — are the more realistic near-term inclusion mechanism, which strengthens the policy case for BHASHINI-enabled multilingual mobile interfaces specifically in Nagaland, Mizoram, and interior Arunachal Pradesh, where digital-transaction volumes remain low relative to Assam and Tripura *(IMPRI Impact and Policy Research Institute, 2024).*

Two implications follow for AI-enabled inclusion strategy in the region. First, because SHG-based intermediation — rather than individual account access alone — has historically driven inclusion gains in the North East *(World Bank, 2021)*, AI credit-scoring models calibrated primarily on individual transactional data (as in mainstream ULI use cases) may under-assess creditworthy borrowers whose financial activity flows through group mechanisms; scoring models may need SHG-level data adaptations to be effective in the region. Second, given the wide intra-regional spread evident in Table 4, India-level financial inclusion statistics should not be extrapolated to North East India as a whole, and state-differentiated rather than region-wide policy targets are indicated.

AI-ENABLED FINANCIAL INCLUSION AND WOMEN'S EMPOWERMENT

Women's financial inclusion represents a critical dimension of inclusive development, yet women continue to face distinct barriers to formal financial access. Research from Barak Valley, Assam, involving

450 respondents, establishes the importance of 'autonomy' in determining women's financial inclusion and demonstrates the effectiveness of self-help group (SHG) participation in enhancing holistic financial inclusion *(Inostroza-Correa et al., 2025)*. This research is important for the argument of this chapter because it makes an explicit distinction — consistent with *Bharathi, Perdana, and Kulkarni's (2023)* broader observation that inclusion research over-emphasises access and usage — between access and usage of financial services on one hand, and women's autonomous decision-making regarding that usage on the other. Financial access is therefore treated here as a necessary but not sufficient condition for empowerment.

AI technologies, when coupled with targeted policy design, can plausibly advance women's financial access by reducing informational barriers, enabling remote service access, and personalising financial products to women's economic activities. Women are reported to be 19 per cent less likely than men to own mobile phones, which restricts access to mobile banking and FinTech solutions *(Grant Thornton, 2026)* — a gap that, left unaddressed, would limit any AI-enabled channel that depends on mobile access. Multilingual AI interfaces and voice-enabled platforms can reduce literacy and language barriers that disproportionately affect women in rural North East India, and AI-enabled alternative credit assessment can, in principle, recognise the economic contributions of women engaged in informal-sector activity — home-based enterprises, agricultural work, and animal husbandry — by analysing transactional patterns reflecting these activities, provided the underlying scoring models are trained on data that actually captures such activity.

Digital financial literacy — not access alone — is the more direct predictor of financial well-being outcomes in Indian evidence *(Bhat, Lone, SivaKumar, & Krishna, 2024),* which means that AI-enabled access without accompanying digital and financial literacy investment is unlikely, on its own, to translate into the autonomy dimension identified by *(Inostroza-Correa et al., 2025)*. For AI-enabled financial services to translate access into empowerment in North East India specifically, three complementary conditions are indicated by the literature reviewed here: (i) continued SHG-linked outreach, since SHG participation — rather than individual digital access alone — has been the demonstrated driver of autonomy gains in the region's evidence base; (ii) mobile-phone access and digital/financial literacy programmes targeted specifically at women, given the documented mobile-ownership gap; and (iii) AI product design (credit scoring, language interfaces) that is explicitly trained on and validated against women's informal-sector transaction patterns rather than assumed to generalise from male-dominated formal-sector data. This chapter does not claim that these conditions are currently met at scale in North East India; it presents them as the policy-relevant implications of the evidence reviewed, and as an explicit area for future field research.

IMPLEMENTATION CHALLENGES AND CRITICAL ANALYSIS

Despite the transformative potential outlined above, significant implementation challenges constrain the effective deployment of AI-powered financial inclusion in underserved regions, particularly North East India. This section expands the critical treatment of five interlinked risks.

1. **Digital Literacy and User Adoption:** Effective use of AI-enabled financial services requires baseline digital literacy, including familiarity with mobile interfaces, secure password management, and transaction verification. FinTech adoption studies from Assam document that awareness and utilisation remain concentrated among younger, urban populations, with adoption barriers persisting across rural demographics *(Das & Das, 2026)*. This digital-literacy gap compounds, rather than operates independently of the gender gap in mobile ownership, since rural women in North East India face a combined literacy and access constraint. Policy responses should priorities inclusive digital literacy programmes delivered through local organisations, including SHG networks, and should leverage multilingual, voice-enabled interfaces rather than assuming text-based literacy.

2. **Cybersecurity Infrastructure:** Rural financial institutions, particularly District Central Co-operative Banks and microfinance institutions, often lack the cybersecurity frameworks available to larger commercial banks, leaving customer data and institutional systems more exposed to cyber-threats. Deployment of institutional-grade fraud detection and cybersecurity systems, such as MuleHunter.AI, requires sustained investment in infrastructure and human-capacity building at exactly the institutional tier — RRBs and cooperative banks — that serves most of rural North East India, and this investment gap should be treated as a distinct policy priority rather than assumed to be resolved by the existence of the tools themselves.
3. **Data Privacy, Consent, and Algorithmic Accountability:** AI-powered financial services necessarily involve processing sensitive personal and financial data. Regulatory frameworks, including the Account Aggregator model, establish consent-based data-sharing protocols in principle, but implementation remains uneven. Independent analysis of the RBI's own Report on Trend and Progress of Banking in India finds that, on the ULI platform specifically, the RBI does not centrally manage consent boundaries or grievance redress; these functions currently rest with individual lenders, without a uniform platform-level standard *(Reserve Bank of India, 2025*). Because ULI increasingly draws on sensitive data sources — digitised land records, satellite and geospatial data, and dairy-related records — this consent fragmentation is a material governance gap rather than a marginal implementation detail, and is particularly relevant where borrowers have low digital literacy and limited capacity to exercise consent rights meaningfully, as documented for rural North East India.

   Closely related is the risk of algorithmic bias. A recent systematic review of AI and bias in banking and financial services identifies algorithmic opacity and the absence of context-specific fairness audits as persistent weaknesses in the literature, even as AI adoption in banking accelerates *(Krey et al., 2026).* In the Indian context, commentary on ULI-style alternative credit models has specifically flagged the risk that uncalibrated machine-learning models could generate localised 'credit redlining' against thin-file, rural, and linguistic-minority borrowers even while expanding aggregate access *(Government of India, 2026)*. For North East India, where transactional data density is lower than in urban centres and where models trained predominantly on mainland Indian data may not generalise well to the region's economic patterns (informal, SHG-mediated, agriculture- and animal-husbandry-based livelihoods), this risk is not hypothetical: it is a direct extension of the data-availability asymmetry already evident in Table 4. The RBI's Framework for Responsible and Ethical Enablement of Artificial Intelligence (FREE-AI), released on 13 August 2025 following an eight-member committee process chaired by Professor Pushpak Bhattacharyya of IIT Bombay, sets out seven guiding principles ('Sutras') and 26 recommendations across six pillars for AI governance in regulated financial entities, including a proposed 'tolerant supervisory stance' for early-stage AI errors where adequate safeguards exist *(Reserve Bank of India, 2025)*. This is a substantive governance response, but its effectiveness for North East India specifically will depend on whether implementation guidance addresses regional data representativeness, a gap this chapter recommends as a priority for the framework's rollout.
4. **Digital Exclusion and Concentration of AI Capability:** Advanced AI development and deployment capabilities remain concentrated in urban technology hubs and large financial institutions. Regional Rural Banks and semi-urban or rural financial institutions in North East India often lack the technical capacity to develop or deploy AI models independently, and instead depend on centrally developed models that may not be calibrated to local conditions. Addressing this gap requires knowledge-transfer mechanisms, capacity-building programmes, and shared AI-services platforms rather than reliance on individual institutions building capability from scratch *(Government of India, 2026).* Left unaddressed, this concentration risks reproducing — through an AI-enabled channel — the same

urban–rural and mainland–North East disparities that earlier, pre-AI phases of financial inclusion sought to close.

CONCLUSION

Artificial Intelligence, anchored upon India's Digital Public Infrastructure and integrated with targeted policy frameworks, can meaningfully extend financial access to previously underserved populations, including rural communities, MSMEs, informal workers, and women entrepreneurs. The convergence of the JAM Trinity's identity infrastructure, UPI's transaction ecosystem, BHASHINI's multilingual capabilities, and AI-powered lending platforms such as ULI represents a genuine and verifiable expansion of India's financial inclusion architecture, as documented through RBI, NPCI, and UIDAI in the previous section.

However, the evidence reviewed here — drawn entirely from secondary sources does not support an unqualified claim that this expansion automatically benefits North East India as a whole. Table 4 demonstrates that the region is highly heterogeneous: Assam, Tripura, and Sikkim show comparatively stronger financial inclusion indicators, while Arunachal Pradesh, Manipur, and Nagaland lag substantially, constrained by terrain-driven branch access, lower digital-transaction density, and, in Manipur's case, declining rather than improving RRB penetration. Region-wide policy statements should therefore give way to state-differentiated targets.

POLICY IMPLICATIONS

The review of the literature on women's empowerment indicates that AI-enabled financial access is a necessary but not sufficient condition for the autonomy dimension of empowerment identified in the regional evidence *(Inostroza-Correa et al., 2025)*; claims that AI-enabled inclusion will, by itself, translate into women's economic empowerment are not supported by the evidence reviewed and are avoided here. Likewise, the governance indicates that implementation risks — algorithmic bias, fragmented consent management, and cybersecurity gaps at the rural-institution level — are material rather than peripheral, and that the RBI's FREE-AI framework, while a substantive step, has not yet been shown to address North East India's specific data-representativeness constraints. On this basis, the following policy priorities are indicated by, and proportionate to, the evidence reviewed:

1. Pursue state-differentiated rather than region-wide North East financial inclusion targets, using disaggregated indices of the kind presented in Table 4, and commission updated, consistently constructed state-wise indices to replace the currently non-comparable data points identified in this chapter.
2. Extend multilingual, voice-enabled AI interfaces (Banking BHASHINI) with priority to states showing the lowest digital-transaction density — Nagaland, Manipur, and interior Arunachal Pradesh — rather than a uniform national rollout sequence.
3. Invest in cybersecurity and consent-management standardisation at the District Central Co-operative Bank and Regional Rural Bank tier specifically, given that this is where the documented infrastructure gap is concentrated.
4. Require, as part of FREE-AI implementation guidance, explicit data-representativeness and bias-audit obligations for AI credit models operating in regions with lower transactional data density, including North East India.
5. Sustain and adapt SHG-linked outreach models — rather than substituting them with purely individual-account digital channels — given the region's demonstrated reliance on group-based financial intermediation.
6. Commission primary, field-based research on women's decision-making autonomy in AI-enabled financial services in North East India, to test rather than assume the empowerment pathway.

As India advances toward its 'Viksit Bharat 2047' vision, AI-powered financial inclusion can be a contributing strategy for rural development and reduced regional disparity, but — on the evidence reviewed in this chapter — it is one input among several rather than a self-executing solution, and its benefit for North East India specifically will depend on the region-differentiated, governance-conscious implementation choices outlined above.

SCOPE AND LIMITATIONS

Three limitations bound the analysis. First, this is a single time-point synthesis of secondary data as available at the time of writing (2026); figures such as ULI lender onboarding or UPI monthly volumes will continue to change and should be updated in any subsequent revision. Second, published national and state-level statistics may lag ground realities in remote North Eastern districts, where data collection infrastructure is itself uneven — a limitation acknowledged rather than resolved here. Third, in the absence of primary field data from women beneficiaries, MSME borrowers, or SHG members in the region, claims about lived impact (particularly regarding empowerment) are presented as plausible pathways supported by the literature rather than as demonstrated outcomes; this is flagged explicitly wherever such claims are made.

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Financial Technology for Rural Transformation: Bridging the Financial Inclusion Divide

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Determinants of Constraints in Hybrid Rice Cultivation among the Farmers of Barpeta District

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ABSTRACT

Assam has the highly variable rice growing ecosystems and 53% of total work force is engaged in agricultural activities based on 2001 census report. As per the Economic Survey, Assam falls under the top 10 major states producing rice. Due to the technological advancement like hybrid rice, agrochemicals and support in infrastructure, irrigation facilities, the state's production grows significantly. However, in 2020–21, the total area planted with hybrid rice reduces by 5% from the previous year. In this context, the study is focused on the constraints of the farmers of Barpeta District, where they are extensively engaged in hybrid rice cultivation. The multistage random sampling technique applied for the study. With the help of pre tested structured schedule responds were collected from the key informants. To identify the factors, Exploratory Factor Analysis has been conducted. The study reveals that farmers cultivating hybrid rice faced some sort of constraints like lack of organized market, involvement of middleman, high price of supply inputs, lack of credit facility etc. For sustainable agriculture, a dynamic approach should be adopted by the farmers which includes Integrated Farming practices, uniform market information system, accessible credit facility, proper time to time training, demonstration and extensive services from the agricultural department about the improve varieties, technological know-how and modern cultivation techniques i.e., SRI technique demonstration, which will be benefited for the them.

Keywords: Hybrid rice, Sustainable farming, Constraints, Agriculture, Food security

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INTRODUCTION

World's half of the population staple food is rice and over the one-fifth of world population, cultivation of rice is the primary income source (*Sporchia et al., 2021, Anwar et al., 2021*). Alarmingly, tremendous growth of population and earnings in many African and Asian countries over the years steadily increases the demand and scarcity of rice. Global demand for food is rising because of population growth, increasing

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affluence and changing dietary habits. The UN/FAO forecasts that global food production will need to increase by over 40% by 2030 and 70% by 2050 (*FAO, 2009*). Hence, to ensure food security and worldwide balanced the demand and supply, sustainable rice farming is needed. Moreover, it will also enhance the income, productivity and employment generation. Worlds 90% rice production and consumption region is Asian countries (*FAO, 2000*). Ironically there is little scope or no scope for the land extension. The grain productivity which derives from the short duration fertilizer responsive, modern high yielding variety were near exhaust after the Green Revolution. To meet the rising demand for rice in Asian countries a critical shift in rice production was required in that situation. Towards achieving food security China increased the yield after the green revolution by adopting hybrid rice. Due to its high yield characteristics, hybrid rice can produce 15-20% more grains than the traditionally developed varieties. Because of the yielding advantage prevailing law and order of south and south east Asian countries encourage the farmers to adopt the new technology. In India majority of rural population subsist on farming which leads the country to a large agrarian economy. As a principal food in India rice is the most important food crop in terms of production, productivity, area occupied and consumption. A substantial proportion of India's population directly or indirectly generates their livelihood from agricultural economic activities (*Pradhan et al., 2020*). During the year 1980 India produces overall 53.6 million tons of rice which increases to 122.3 million tons by the tear 2020-21 (*raj et al 2022*). The Gross Value Added (GVA) at current basic price in the year 2020-21 is Rs. 3609494 crore which account for 3.3% countries total GVA. In the year 2020 the total kharif rice production is 97.83 million tonnes (*DoAFW, 2021-22*). Because of the technological advancement like high yielding varieties, hybrid rice, agrochemicals and support in infrastructure, irrigation and financial facilities India production grows significantly. To bring the green revolution in Assam and increase the rice production & productivity of farmers, in 2009–10 the Agriculture Department of Assam has made a special effort to encourage the cultivation of hybrid rice varieties on an experimental basis due to their potential for higher yields than traditional high producing types. In the same year the area covered 0.47 lakh hectare under hybrid rice cultivation which was expanded to 0.62 lakh hectare in 2010-11 and 1.91 lakh hectare in the year 2017-18. In the year 2019–20, the area planted with hybrid rice for kharif (autumn + winter) is 112.568 thousand hectares, and the area planted with hybrid rice for rabi (summer) is 177.862 thousand hectares. The acreage of kharif rice has decreased to 99.29 thousand hectares in the year 2020–21, whereas Rabi rice has increased to 175.00 thousand hectares. However, in 2020–21, the total area planted with hybrid rice reduces by 5% from the previous year. Therefore, in this context, the present study tries to evacuate the problems of hybrid rice cultivation in Barpeta District. The study mainly focused on the farming constraints like communication with extension department, Supply inputs problems and so on.

LITERATURE REVIEW

Under the identical conditions, hybrid rice can achieve a yield advantage of 15-20% over other varieties (*Azam, 2014; Janaiah et al., 2010*). The hybrid rice technology has a substantial contribution in food security, employment opportunity and environmental protection (*Yan et al., 2010*). The study of *Awal et al (2007)* found that the superiority of hybrid rice than conventional varieties, in aman season transplanting. The cultivation of hybrid cropraises productivity and yield per cropping by 29.44% *(Alzate, 2015)*. However, the cost of production of hybrid rice is higher than inbred variety due to high cost of involvement in fertilizer, seeds and labour. But the cost of production compensates by the high yielding advantage, therefore the adoption of hybrid rice will bring profitable results for the farmers as such the return was higher than the inbred and creates employment opportunity (*Gogoi et al., 2020)*. For commercial production the hybrid rice provides the producer an alternative cultivation over conventional cultivation. The revenue includes the rice yields, processing after post harvesting or milling (*Nalley et al, 2016).* Farmers age, family size, education has the significant impact on the adoption level of hybrid rice (Pervez *et al.,* 2017). After the commencement of Bringing Green Revolution to Eastern India (BGREI)

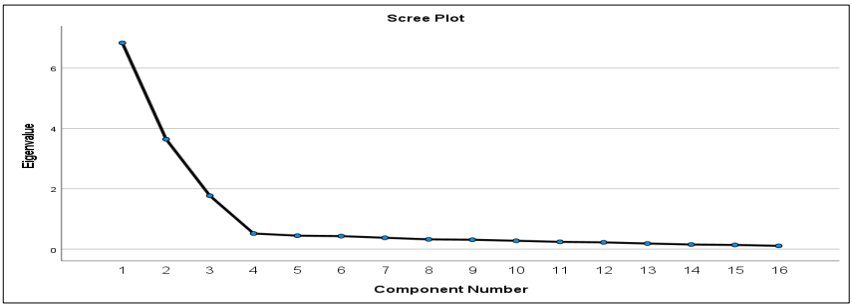
scheme in Assam, the state had introduced hybrid seeds among the farmers. This rice mainly grows in Boro season in the state under the various schemes among the targeted districts of the country (*Gogoi et al., 2022*). *Gogoi et al., (2020)* found yield advantage of hybrid rice in Assam. It enhances the sustainability of farming, food security and generates farming and farm related economic activities. However, the adoption of hybrid rice was confined mainly to the central part of the state (*Gogoi et al., 2022*). Therefore, a question arises: What demotivates the farmers to adopt and cultivate hybrid rice despite of several advantages? With this context the present study was conducted to explore the factors affecting or creating difficulty for the farmers regarding cultivation of hybrid rice.

METHODOLOGY

A multistage random sampling technique has been used for the study. In the first stage Barpeta district was selected. Hybrid paddy cultivation is the only livelihood of the people resided in the bank of Brahmaputra (Char areas) during monsoon season. The flood affected areas can't go for summer paddy cultivation due to heavy flow of water. So, the char areas are highly engaged in hybrid paddy cultivation. As per socio-economic survey report 2002-03, Barpeta District of Assam has the third highest numbers of char villages. Therefore, Barpeta district has been selected for the study. In the second stage two development blocks were selected from the district randomly. In the final stage, 250 farmers growing hybrid rice were selected randomly for the study. Farmer's constraints of cultivation of hybrid rice were studied with factor analysis. This study postulated that farmers constraints depended on Supply input factors, support and post harvesting factors.

RESULTS AND DISCUSSION

Considering the large number of constraint variables, factor analysis was employed to identify the underlying variables and reduce the dimensionality of the data. The measure of sampling adequacy i.e., KMO was 0.894, exceeding the recommended minimum level and confirm the suitability of the considered sample size. The Bartlett's test of Sphericity yielded p value 0.000 and chi square value 3211.14, indicating statistically significant corelations between the variables and are sufficient for factor analysis.



Source: Computed by the author using IBM – SPSS

Figure:1

The scree plot depicts the eigenvalues associated with component numbers. An eigenvalue reveals the extent of total variance explained by the underlying variables in observed variable. It has been observed from the screed plot that, after the third factor the curve of the plot has flatten which suggested the retention of three observed variables for the study (Figure 1).

Table 1: Extracted variables with eigenvalues, variances and cumulative variances:

Factors	Eigenvalues	% of variances	Cumulative variances
Post harvest constraints	7.041	26.988	26.988
Support constraints	3.200	26.947	53.935
Supply input constraints	1.715	20.794	74.729

Source: Computed by the author using IBM-SPSS

The eigen value of each factor represents the contribution of each underlying observed variable in the total variance of the explained variances. A higher value indicates, greater impact of the variable. Post harvest factor has the highest eigenvalue and is about 7.041, which explained 26.98% of explained variance. Support and supply factors with eigenvalues of 3.200 and 1.715 respectively, each explained 26.947%and 20.794% of the total variance. Together these three factors explained about 74.729% (Table 1).

Principal Component Analysis with varimax rotation has been applied to conduct EFA. After rotation in post-harvest and support factors, there were six latent variables identified in each of the category. In case of supply input factor there were four latent variables retained after rotation. Each factor loading was found higher than the threshold limit i.e., 0.70 *(Hair et al, 2010)*, thereby highlighting the importance of each variable in relation to its observed variables (Table 2).

Table 2: Factor loading of variables after rotation

Factors	Variables	Factor load
Supply input constraints	Non availability of other inputs item	**.817**
	High Seeds Price	**.870**
	High fertilizer price	**.885**
	High charges of input equipments	**.860**
Support constraints	Insufficient training	**.804**
	No Exposure Visit	**.828**
	Insufficient credit policy	**.867**
	No price support for input	**.802**
	Lack of easy disposal of facilities	**.757**
	Lack of Consultancy	**.786**
Post harvest constraints	High Transportation cost	**.812**
	Lack of organized market	**.857**
	Poor storage	**.805**
	Lack of efficient labour	**.835**
	Lack of post harvesting equipment	**.835**
	Role played by middleman	**.837**

Source: Compiled by the author using IBM-SPSS

The empirical findings of the study identified the key factors that contribute to farmers constraints in hybrid rice cultivation. The extracted result of EFA showed that 74.729% variance was explained by the identified factors. Out of the three observed variables, post-harvest variable has the highest eigen value, reflecting the influence and substantial contribution of the respective variable in the study. The second highest variable among the three variables was support constraints, which indicates the association of hybrid rice cultivation with the challenges arising from inadequate macro level planning and improper execution of the policies throughout the nation. In the present study supply Input was categorised as the third significant variable, indicating the volatility of market price and under developed infrastructure, highlight the need to pay greater attention regarding this sector. The highest

impactful latent variables of each of the observed variables were High fertilizer price, insufficient credit policy and Lack of organized market. These were the most significant challenges faced by the farmers respectively and restrict the cultivation and adoption of hybrid rice among the farmers (Table 1 and 2).

CONCLUSION

The increasing trend of population demands more rice and other food items than earlier. Due to the rapid urbanization in the region, there is no scope of increasing crop land but to enhance the per capita productivity of the land holdings. The explosive increase in population, the future demand can't meet merely concentrating on traditional rice cultivation. The thrust has to be on enhancing productivity in every ecosystem by cultivating suitable variety of rice. Recent times there are many varieties available to enhance rice yield in different ecosystem such as high yield variety, short duration variety, flood or sub mergence tolerant varieties, temperature tolerant varieties, pest tolerant varieties etc. These varieties have the staggering ability to accelerate the production as well the productivity. Farmers increasingly adopted hybrid varieties with the objective of food sufficiency. However, due to certain constraints the rate of adoption is low. For sustainable agriculture a dynamic approach should be adopted by the farmers which includes Integrated Farming practices, uniform market information system and Accessible credit facility. Moreover, In Assam there is no proper data base available regarding the area specific variety of cultivation. Block wise agricultural department should made an effort about the suitable variety, yield, profitability and productivity. Although, through the NFSM and RKVY Schemes Government provide extension support to the hybrid paddy cultivators but for the high rate of adoption and to enhance the states productivity Government should mobilize and activate the program of extension in every nook and corner of the state.

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