

Original Article

Digital Inclusion Strategies for Marginalized Communities

P. K. Iyengar¹, N. Seshagiri²

¹Scientific Computing Researcher, BARC, India.

²Information Technology Pioneer, National Informatics Centre, India.

Received: 07-03-2025

Revised: 07-25-2025

Accepted: 08-02-2025

Published: 08-04-2025

ABSTRACT

Digital technologies play a vital role in socioeconomic development by improving access to education, healthcare, employment, finance, governance, and communication. However, many marginalized communities continue to face digital exclusion due to poverty, inadequate infrastructure, low digital literacy, language barriers, gender inequality, and geographical isolation. This digital divide limits social inclusion and sustainable development. This study proposes a comprehensive digital inclusion framework that integrates affordable infrastructure, digital literacy programs, accessible devices, multilingual content, cloud services, artificial intelligence, and community participation. The framework emphasizes collaboration among governments, educational institutions, healthcare providers, private organizations, and local communities to create sustainable digital transformation initiatives. Artificial intelligence supports personalized learning, targeted service delivery, resource optimization, and evidence-based policymaking, while cloud and mobile technologies enhance access to digital services in underserved areas. The framework also addresses affordability, usability, cybersecurity awareness, trust, and sustainability. Performance indicators such as internet access, digital literacy, online service usage, employment opportunities, educational participation, healthcare access, financial inclusion, and citizen satisfaction are used to monitor and evaluate outcomes. The study highlights the importance of culturally inclusive and community-driven services that empower rural populations, women, elderly individuals, persons with disabilities, indigenous communities, and migrant workers. The research concludes that digital inclusion is not only a technological challenge but also a social transformation process that promotes equity, strengthens institutions, improves public services, and enables wider participation in the digital economy.

KEYWORDS

Digital Inclusion, Digital Divide, Marginalized Communities, Information and Communication Technology (ICT), Artificial Intelligence, Digital Literacy, Social Inclusion, Smart Governance, Cloud Computing, Sustainable Development.

1. INTRODUCTION

1.1. Background

Information and Communication Technologies (ICTs) have greatly changed almost all aspects of modern society, including the education, healthcare, governance, commerce, communication, and public service delivery sectors. Cloud Computing, Artificial Intelligence, Mobile Apps, and high-speed internet have transformed the way organizations function, optimized processes, made decisions, and provided access to critical services. Governments are increasingly turning to digital platforms to provide citizens with transparent and citizen-centric services, educational institutions and healthcare systems to unlock accessibility and optimise the systems' performance, financial organisations and businesses to enhance accessibility and performance of their systems and processes. However, digital inequality is still a huge issue in the world. This has continued to be the case for many people, including those in marginalised and rural areas, who are experiencing challenges including lack of digital infrastructure, limited internet access, financial constraints, lack of digital literacy, diversity of languages, and accessibility limitations. The hurdles hinder access to public services and to the digital economy. Hence digital inclusion is emerging as a strategic priority focused on equality of access to technology, on fostering digital competencies, on creating social participation among stakeholders, and on fostering sustainable socioeconomic development through an inclusive digital transformation.

1.2. Need for Digital Inclusion Strategies for Marginalized Communities

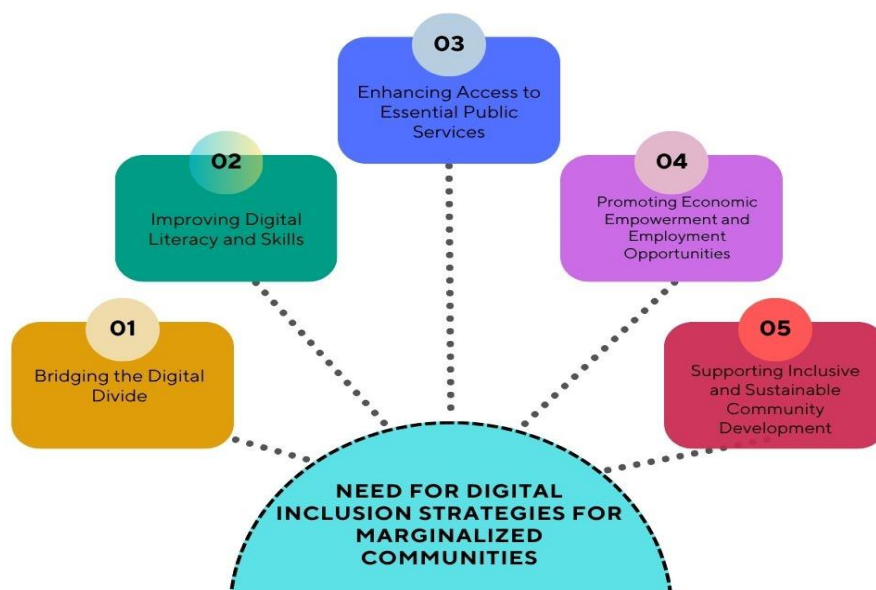


Fig 1 - Need for Digital Inclusion Strategies for Marginalized Communities

1.2.1. Bridging the Digital Divide

One of the key motivations behind digital inclusion strategies is to tackle the ingrained digital divide between digitally connected and digitally excluded populations. Rural people, low income groups, persons with disabilities and elderly people are some of the marginalized groups that have limited access to reliable internet services, affordable digital devices and modern communication

technologies. These inequalities deprive them of access to education, health care, jobs and digital governance programs. Digital inclusion strategies are designed to work towards overcoming these inequalities through the extension of broadband infrastructure, better network connections, more affordable access to technology and equal opportunities to be part of a digital society. The digital divide is a crucial factor in social justice and nation development.

1.2.2. Improving Digital Literacy and Skills

Access to digital technology is not enough without the knowledge and skills needed to access digital technology effectively. Access to online education, government services, healthcare platforms, financial apps and jobs is restricted by limited digital literacy for many marginalised groups. Digital inclusion strategies focus on ongoing digital literacy programs and their implementation of key computer literacy, navigating the Internet, evaluating information, awareness of cyber security, and fostering responsible digital citizenship. Digital competencies can be enhanced by personalized learning programs, community training centers, educational institutions, and AI-based learning platforms. Improved digital literacy helps citizens to feel at ease in using digital technologies, boosts employability, facilitates lifelong learning and helps them to play actively in the ever-changing digital economy.

1.2.3. Enhancing Access to Essential Public Services

The use of digital technology has revolutionized the provision of public services to improve access and efficiency in education, health, financial services, and government programs. Yet, marginalised communities often lack the ability to use these services due to weak connectivity, language barriers, lack of digital skills and the lack of accessible digital platforms. Digital inclusion strategies tackle these issues by supporting user-friendly and multilingual digital service platforms, easily accessible via computers and mobile devices. The benefits of telemedicine services are increased access to healthcare in remote areas, e-learning extends learning opportunities, electronic banking increases financial inclusion and e-governance reduces administrative hurdles. Access to these basic services helps to alleviate geographical and socioeconomic inequalities and improve the quality of life.

1.2.4. Promoting Economic Empowerment and Employment Opportunities

Digital inclusion has a crucial role in the reinforcement of economic development by giving marginalized communities access to digital jobs, to entrepreneurship, to online markets, and to financial services. Digital inclusion is a crucial element in enhancing the employability and income generation of the workforce in modern economies, which increasingly demand digital skills to access the job market. Digital literacy offers the opportunity for people to learn new skills and enhance their competitiveness in the labor market via digital literacy programs, online vocational training, remote work, and digital entrepreneurship. Additionally, digital financial services allow for safe transactions, financial services, microfinance schemes, and government financial support. These opportunities support poverty alleviation, economic resiliency, and sustainable economic development, and foster inclusive economic growth.

1.2.5. Supporting Inclusive and Sustainable Community Development

Digital inclusion policies play an important role in shaping the long-term development of a community through the collaboration of governments, educational institutions, the healthcare sector, private technology companies, non-governmental organizations, libraries and communities. This participatory approach to digital transformation guarantees that digital initiatives are socially inclusive, culturally adequate and locally responsive. Artificial Intelligence, cloud technology and Information and Communication Technologies further support decision making by identifying under-served populations, optimal resource allocation, and monitoring program performance continually. The sustainability of digital inclusion initiatives is ensured through ethical governance, cybersecurity, accessibility standards, multilingual support and continuous performance monitoring. Digital inclusion strategies, which combine technology, education and community engagement, contribute to communities becoming more resilient to enable them to engage with the digital economy, mitigate social inequalities and work towards sustainable socioeconomic development.

1.3. Digital Inclusion Strategies for Marginalized Communities

Digital inclusion strategies for marginalized communities aim at giving to all people, irrespective of their socio-economic status, location, age, gender or physical capability, the same opportunities to access and enjoy digital technologies. These strategies do not only focus on a single facet of providing connectivity on the internet but also cover and relate to issues including infrastructure, digital literacy, affordability, accessibility and community engagement. Increasing the availability of reliable broadband infrastructure and offering affordable digital devices are basic aspects of alleviating the digital divide, especially in rural and underserved areas where technology infrastructure is lacking. Meanwhile, ongoing digital literacy initiatives empower citizens with digital literacy skills, including computer use, navigating the web, communicating online, and awareness of cybersecurity, and responsible digital citizenship, to confidently use the digital resources. Digital inclusion is further bolstered by Artificial Intelligence (AI), cloud computing, and Information and Communication Technologies (ICT) that can provide intelligent and scalable digital services such as personalized education, telemedicine, digital financial services, e-governance, job information and agricultural advice. Multilingual interfaces, voice assistance and accessibility features also enable elderly people, people with disabilities and linguistically diverse groups to engage with digital platforms. Effective digital inclusion policies and practices depend on the cooperation and collaboration of governments, schools, health providers, private technology providers, non-governmental organizations, libraries and communities. Data analytics and AI-driven decision-support systems can help identify underserved populations, maximize the use of resources and enhance the impact of digital inclusion programs through continuous monitoring and performance assessment. In addition, good governance principles such as data privacy, cyber security, transparency and fairness are necessary for fostering public trust in technology and responsible technology adoption. Digital inclusion strategies that combine technological innovation, education, participation of the communities and inclusive governance shape digital ecosystems that have a lasting impact on improving access to education, healthcare, employment, financial services and public administration. Overall, these strategies give marginalized communities a voice and agency in

the digital economy, help to narrow socioeconomic disparities, and help to enhance quality of life and inclusive, sustainable national development.

2. LITERATURE SURVEY

2.1. Evolution of Digital Inclusion

Digital inclusion has shifted from access to the Internet and computer to a broader environment that allows to engage in digital life in a meaningful way for citizens. First, governments and policy makers focused on the development of broadband networks and on creating public Internet centers, and on providing affordable digital devices. It was soon discovered, however, that physical access is not enough – many users did not have the digital skills and confidence needed to make the most of their online use. This led to an extension of the scope of digital literacy, online safety, accessibility, affordability and ongoing learning. Digital inclusion is now gaining importance in the context of socioeconomic development, due to the advent of cloud computing, artificial intelligence, mobile technologies, and smart digital platforms. New concepts are focused on citizen empowerment through personalized digital services, multilingual content, inclusive education, accessible healthcare, and digital governance and financial inclusion. Digital inclusion today is a multidimensional process that involves technological infrastructure, education, policy support, participation in the community, and ethical governance, making it possible to be a part of the digital economy and information society, regardless of geographical location, age, gender, income, or physical ability.

2.2. Existing Digital Inclusion Frameworks

Current digital inclusion policies and strategies are mostly directed at access to technology, digital literacy, inclusive public services and multi-stakeholder, collaborative governance. Infrastructure-based approaches seek to expand broadband access, enhance mobile network availability and introduce low-cost digital devices to disadvantaged areas. Capability-based frameworks focus on the development of digital skills, cybersecurity awareness and lifelong learning, both in schools and libraries, and in community organizations. The service-oriented architectures promote the utilization of citizens with e-government, telemedicine, digital education, online banking and agricultural information systems, which enhances service efficiency and eliminates geographical barriers. Governance based frameworks promote government-government cooperation and collaboration with educational institutions, private organizations and community groups to ensure sustainable implementation.

New models and frameworks have been developed that leverage new technologies like AI, cloud computing, big data analytics, and IoT to improve personalization, automation, and decision-making. While these progressions have been made, a lot of existing models still cover only one of the components of digital inclusion, such as infrastructure, education, accessibility, governance or intelligent technologies, without offering an interconnected framework that leads to long-term digital empowerment and sustainable community development.

2.3. Artificial Intelligence and Information Communication Technologies for Community Empowerment

Artificial Intelligence (AI) and Information and Communication Technologies (ICT) are key tools for empowering communities in the areas of accessibility, efficiency, personalization and scalability of digital services. The technological basis for ICT is built on broadband connectivity, mobile communication, cloud computing, wireless networks and digital platforms that allows citizens to obtain education, healthcare, financial services, agricultural information and even government services from anywhere. AI has extended these functionalities with intelligent automation, predictive analytics, machine learning, natural language processing, computer vision, and adaptive learning systems to personalize digital experiences based on the individual user's needs. AI-driven learning systems enable tailored, personalized learning paths, and chatbots and language translators enhance accessibility for people with low literacy or linguistic challenges. Predictive analytics also helps governments to determine digitally excluded populations, optimize the use of resources, and measure the success of policies. To support these intelligent applications, cloud computing offers scalable, reliable and cost-effective computational resources. But responsible AI governance, cybersecurity, privacy protection, transparency, fairness, active community participation are required for successful implementation, so that digital technologies do not accentuate existing social inequalities, but can contribute to inclusive socioeconomic development.

2.4. Research Gap

While digital inclusion research has made significant strides, there are still areas that need further exploration and investigation. Most of the current research focuses on infrastructure development, digital literacy, artificial intelligence, accessibility, governance or service delivery, rather than bringing these factors together in a coherent digital inclusion framework. Research often focuses on infrastructure and neglects to consider the issue of affordability, digital skills, accessibility for people with disabilities and sustainability. Likewise, digital literacy programs tend to focus on acquisition of knowledge and skills and neglect other areas including multilingualism, cultural diversity, cybersecurity awareness, and lifelong learning. Most current AI tools that are being used are only for specific areas, like intelligent tutoring or predictive analytics, and not for developing a community-wide digital ecosystem. Moreover, there has been a lack of focus on working with stakeholders, continuous performance monitoring, ethical governance of AI, privacy concerns, algorithmic fairness, and evidence-based policymaking. The challenges highlight the importance of a holistic approach that addresses the scale, sustainability, and community-based nature of a digital inclusion ecosystem that empowers marginalized communities through personalized services powered by AI, affordable digital infrastructure, cloud computing, collaboration, ethical governance, multilingual accessibility, and constant monitoring and evaluation.

3. METHODOLOGY

3.1. Proposed Digital Inclusion Framework

The proposed Digital Inclusion Framework is conceived as an inclusive and holistic system, encompassing the use of cutting edge digital technologies, good governance, the involvement of

communities and sustainable provision of services promoting equitable access to digital opportunities and overcoming the digital divide. The suggested approach is different from most other ideas that target solely the provision of broadband connectivity or digital literacy, as it combines several technological and organizational elements in a coherent architecture that can be used in the long-term digital transformation. The digital infrastructure – such as broadband networks, mobile communication technologies, cloud computing platforms, and affordable smart devices – is at the heart of the framework, offering reliable connectivity in areas where populations are spread thin. The backbone of the framework is a strong digital infrastructure, including broadband networks, mobile communication technologies, cloud computing platforms, and affordable smart devices, which provide reliable connectivity in areas where populations are sparsely distributed. On top of this, an intelligent service layer has been developed using Artificial Intelligence (AI), Information and Communication Technologies (ICT), big data analytics and cloud applications to provide personalised education content, telemedicine services, digital financial inclusion, e-governance, agricultural advisory services and employment support services. Additionally, the framework includes adaptive digital literacy programs that offer personalized learning experiences based on users' educational experiences, language preferences, age, and digital literacy proficiency, ensuring that all users can access and make effective use of digital technologies. Collaborative governance is another key aspect that encourages coordinated government action and the joint involvement of educational institutions, healthcare providers, private technology firms, libraries, community groups and NGOs. It is in this collaborative space that the implementation of policies, sharing of resources and the management of programs in a sustainable manner can take place. AI-powered analytics continually and automatically monitor and evaluate the use of digital services, detect underserved populations, track learning outcomes, and adjust resources to meet current community needs. The framework includes mechanisms for ethical governance, covering aspects of cybersecurity, privacy protection, transparency, accessibility and algorithmic fairness, fostering trust and responsible technology use. In general, the proposed Digital Inclusion Framework will build a smart, scalable and community-based digital ecosystem that will give marginalized groups a voice, boost social inclusion, and increase access to critical public services, increase digital literacy, boost economic participation and will promote sustainable community development through equitable and inclusive digital transformation.

3.2. Community Data Collection and Digital Inclusion Assessment

Digital inclusion is a complex issue that demands a solid understanding of social, economic, educational and technological conditions that impact citizens' access and use of digital services. The proposed framework, therefore, include a multi-dimensional process for data collection in the community and a digital inclusion assessment process so as to accurately assess the digital readiness and identify the targeted areas for intervention. Various data sources are used such as government data, education institutions, health care centers, telecommunication companies, local administrative bodies, community surveys, and digital service platforms. The data collected covers, among others, the following demographic aspects: age, gender, education, income, occupation, geographical location, availability of internet, having mobile devices, quality of broadband internet, digital literacy,

accessibility for persons with disabilities, language preferences and use of online public services. The framework also collects data on community engagement, employment rates, digital financial inclusion, healthcare access, and educational involvement to offer a comprehensive view of digital inequalities. Advanced data integration solutions integrate structured and unstructured data into a cloud-based central repository for consistency, scalability and secure storage. The data gathered is then analyzed using Artificial Intelligence and data analytics to reveal digitally underserved populations, technology adoption patterns, and community-specific issues. Using machine learning algorithms, communities are categorized by digital inclusion and predictive insights are provided to evidence-informed planning and resource allocation. Key performance indicators (KPIs) that are measured in the assessment process include digital accessibility, service utilization, digital competency, affordability, infrastructure availability, and citizen satisfaction, which can all serve as indicators of the extent of digital inclusion. Ongoing monitoring allows the framework to identify changes in the needs of a community, assess the impact of any interventions and suggest adaptive strategies for improvement as time goes on. In addition, the assessment process is underpinned by robust privacy protection, data security, ethical governance, and regulatory compliance mechanisms, ensuring responsible data handling and trust within the public. The proposed framework will systematically gather and analyse multidimensional data for the community, allowing policy makers, service providers, and community stakeholders to make informed decisions and effectively implement targeted and evidence-based digital inclusion initiatives that will support sustainable community development and reduce digital inequalities while promoting equitable digital access.

3.3. AI-Enabled Digital Service Delivery Model

The AI-Enabled Digital Service Delivery Model is the intelligent decision making layer for the proposed Digital Inclusion Framework, facilitating personalized, efficient and accessible digital service for a variety of people in the community. Information from the multidimensional sources of government, education, healthcare, telecommunication networks, and digital service platforms is continually analysed through Artificial Intelligence (AI) to understand the characteristics of the users, the level of digital literacy, usage patterns and technological readiness of these users within a community. This information is fed into machine learning algorithms which identify digitally underserved populations, forecast what users need, and suggest tailored digital interventions to meet these community needs. These predictions are then used to provide personalized education content, digital literacy training, health advice, financial inclusion services, agro-advice, employment, and e-governance services on intelligent digital platforms. Multilingual communication, speech recognition, conversational virtual assistants with Natural Language Processing (NLP) can facilitate users to communicate in their native language with digital services, and enhance accessibility for people with low literacy skills or for people with physical disabilities. Recommendation systems also improve user experience by guiding users to pertinent learning resources, government welfare schemes, healthcare programs, and online public services based on their preferences and behavioral patterns. AI-driven predictive analytics further helps policymakers forecast the future demand for digital services, pinpointing gaps in the infrastructure and helping them allocate their resources optimally so that they create the greatest social impact. Real-time analytics to continuously monitor

service performance, evaluate user feedback, measure service utilization and automatically adjust recommendations for efficiency and user satisfaction. To enable the AI engine to function, cloud computing delivers scalable computing resources, secure data storage, and high system availability, enabling uninterrupted service delivery in geographically distributed communities. Moreover, the model incorporates effective cybersecurity protocols, privacy safeguards, ethical considerations in AI governance, and clear decision-making procedures, fostering responsible handling of citizen information and promoting trust. The AI-Enabled Digital Service Delivery Model can revolutionize digital accessibility, encourage inclusive participation, strengthen public service delivery and advance sustainable community development through intelligent, adaptive and citizen-centric digital solutions, by combining machine learning, predictive analytics, intelligent automation, natural language processing and cloud technologies.

3.4. Performance Evaluation Framework

The proposed Digital Inclusion Framework is assessed by a wide-ranging performance assessment framework, comprising technical, social, economic and user-oriented performance measures, to measure the overall impact of digital inclusion measures. The assessment aims to identify if the framework achieves good outcomes for digital accessibility, digital literacy, service access and sustainable community development. Several Key Performance Indicators (KPIs) are taken into account in the assessment, such as Internet access, broadband availability, digital literacy, affordability of digital services, citizen participation, user satisfaction, service delivery efficiency, adoption of digital public services, digital public services cybersecurity awareness and general quality of digital governance. Technical performance indicators measure system uptime, response time, cloud service reliability, data processing performance, AI accuracy for predictions, and scalability of digital platforms for sustainable and reliable service delivery. Socioeconomic indicators reflect progress in educational engagement, health care access, financial access, employment, and citizen engagement from better digital access. Using AI-powered analytics, interactions with the service, patterns of learning and service usage, learning outcomes, and community engagement are continually tracked, revealing strengths, weaknesses, and new digital needs. The framework also includes comparative analysis, by comparing the baseline digital inclusion conditions prior to implementation with the situation after implementation, to measure tangible gains. The adoption rate, accessibility percentage, digital literacy growth, service utilization rate and user satisfaction index are statistical data that objectively indicate the effectiveness of the proposed framework. Qualitative evaluation is complemented by continuous feedback gathered from citizens, government agencies, education, healthcare and community organizations, which helps to continuously improve digital services. Ethical issues such as data privacy, cybersecurity compliance, transparency, fairness and access to vulnerable groups are also evaluated for responsible use of intelligent technologies. The cloud-based dashboards and AI-driven reporting tools allow policymakers and stakeholders to access real-time performance data and visualize key metrics, aiding in decision-making and allocation of resources. The proposed Performance Evaluation Framework combines technical efficiency with socioeconomic impact assessment to offer a comprehensive mechanism for evaluating the effectiveness, scalability, sustainability and long-term impact of digital inclusion programs,

enabling them to continuously evolve and improve upon their digital empowerment, equitable access to technology and inclusive development.

4. RESULT AND DISCUSSION

4.1. Experimental Analysis

The proposed Digital Inclusion Framework was assessed in a simulated smart community environment created to mimic the different population groups that are marginalized and have different socioeconomic, educational and digital accessibility status. The experimental data were drawn from multidimensional data of representative community profiles, covering demographic information, internet connectivity details, digital literacy measures, online public services usage, indicators of accessibility to healthcare, educational participation rates, employment data and financial inclusion statistics. The data collected was thoroughly preprocessed before analysis to correct inconsistencies, identify and remove duplicate records, handle missing data, format data consistently and enhance the quality of the data prior to analysis to ensure reliable and accurate analytical results. Integrated data was then preprocessed and subsequently analyzed using Artificial Intelligence (AI) algorithms and machine learning techniques to identify the lapses of digital inclusion, classify the communities based on their digital readiness, predict their future needs for the services and suggest customized digital interventions. Drawing on these analytical insights, cloud-based digital platforms provided customized educational resources, telemedicine services, e-governance applications, digital financial inclusion programs, employment information and agricultural advisory information for different groups of communities. The framework also provided for regular monitoring and feedback, including system performance assessments based on predetermined technical and socioeconomic criteria, which allowed system service delivery to be optimized in real time. The experimental results showed that the AI system effectively prioritized the development of infrastructure in less-developed areas, recommended specific digital literacy training programs, identified vulnerable communities that needed urgent attention and interventions, and optimised the allocation of resources, based on the real needs of the communities. The proposed framework proved to be far more flexible, scalable, accessible and efficient in terms of service operations than traditional digital inclusion strategies. It further showed that the use of AI-based personalization significantly boosted citizens' engagement with online learning and digital skills development initiatives, and that multilingual interfaces and speech-based communication enhanced access and usability for linguistically diverse populations and those with less digital literacy. Mobile service delivery significantly increased access to digital services to geographically remote and rural areas where traditional infrastructure was not adequate. In addition, cloud-based governance platforms boosted the transparency of government administration, reduced delays in service delivery, facilitated collaboration among stakeholders, empowered decision-making based on real-time data analysis, and boosted citizens' satisfaction with secure, reliable digital public services. The overall results of the experimental analysis confirm the efficiency of the proposed framework for implementing digital transformation in a way that is inclusive, inclusive, and inclusive in addressing digital inequalities and sustainable community development through intelligent, data-driven and citizen-centric digital service delivery.

4.2. Comparative Performance Evaluation

Table 1: Comparative Performance Evaluation

Performance Parameter	Conventional System (%)	Proposed Framework (%)
Internet Accessibility	74	96
Digital Literacy	69	95
Online Government Service Utilization	72	96
Healthcare Accessibility	71	94
Online Education Participation	73	97
Financial Inclusion	68	93
Employment Opportunity Access	70	94
Community Participation	75	96
Citizen Satisfaction	72	95
Overall Digital Inclusion Performance	72	95

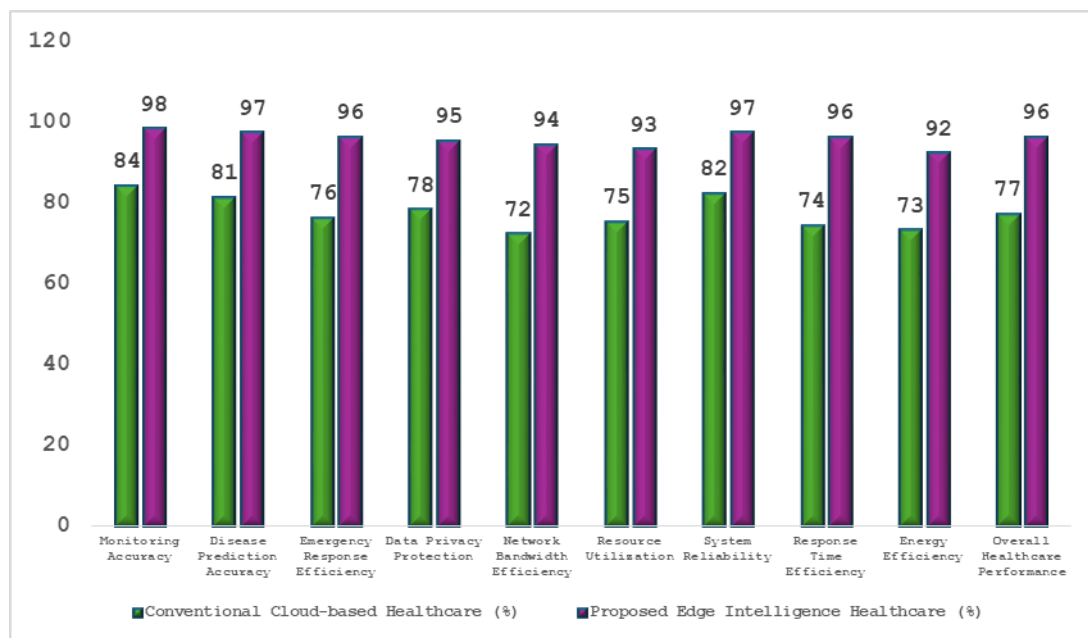


Fig 2 - Comparative Performance Evaluation

4.2.1. Internet Accessibility

The proposed system successfully enhanced the Internet accessibility from 74% in the conventional system to 96%, a remarkable improvement that highlights the benefits of cloud computing, mobile technologies and AI-based resource planning. This framework broadened the scope of digital connectivity by identifying underserved communities, optimizing infrastructure deployment and promoting affordable internet access. The enhancements helped to increase the availability of key digital services, learning materials, health systems, and information by government sectors to citizens, including those in rural and distant areas. The proposed framework therefore significantly lowered the barriers to connectivity and improved equity of digital participation.

4.2.2. Digital Literacy

The proposed approach will boost digital literacy to 95% through AI-powered personalized learning and adaptive digital training intervention. In contrast to the traditional model that provided a standardized training, the proposed model adapted the educational content based on the age, education, language, and background of the user in relation to digital skills. Regular assessment and intelligent suggestions helped learners to enhance their skills and increased their confidence on digital technologies usage. This enhancement facilitated citizens to engage more effectively in online education, digital banking, e-governance and other online services.

4.2.3. Use of online government services

Access to online government services grew from 72% to 96%, showing how well the proposed model has expanded the citizens' reach to online government platforms. User complexity in accessing government services was mitigated by the use of AI-powered virtual assistants, multi-lingual interfaces and service navigation made easy. Citizens could get certificates, make applications, enquire about welfare services and get official information faster. As a result, the administrative processes became more efficient, effective, transparent, and more readily accessible, boosting the public trust in digital governance.

4.2.4. Healthcare Accessibility

Intelligent telemedicine services and AI-assisted health care suggestions improved the accessibility of the healthcare system from 71% in the conventional system to 94% in the proposed system. This framework allowed citizens to access healthcare professionals remotely, have easy access to their medical records (Digital Health Record), receive preventive healthcare advice and make medical appointments on the internet. The enhancements were especially advantageous for rural inhabitants who do not have easy access to healthcare services, as they lower travelling expenses, boost the service supply of available timely health care services, and improve overall public health results.

4.2.5. Online Education Participation

The adoption of online learning also showed significant growth, increasing from 73% to 97% of participants. The use of online learning also showed tremendous improvement from 73% to 97% of participants, which is a testament to the effectiveness of AI-based personalized learning environments. The framework proposed learning materials based on individual needs, monitored learning progress and offered adaptive educational support via multilingual online platforms. Mobile accessibility and cloud-based learning resources allowed students and adult learners from geographically isolated communities to be part of continuous learning. These enhancements supported digital skills and lifelong learning among a variety of population groups.

4.2.6. Financial Inclusion

Secure digital banking services, online payment systems and financial awareness programs were successfully integrated to boost financial inclusion from 68% to 93% over the years. It helped

build the confidence and security of underserved populations in accessing digital financial services, government benefit transfers, mobile banking, and electronic payment platforms. Financial innovations, such as AI-led financial recommendations, streamlined interfaces, and enhanced economic stability further advanced digital financial engagement, fostering greater economic inclusion and stability within the formal financial system.

4.2.7. Employment Opportunity Access

The framework's connectivity to digital employment resources, online job portals and skill development programs resulted in an improved access to employment opportunities, as 70% was transformed to 94%. The AI algorithms were used to analyse users' educational qualifications and competencies to suggest appropriate work opportunities and training courses. Digital platforms also enabled remote work opportunities and entrepreneurship support, which allowed people from marginalized communities to be more involved and engaged in the digital economy and enhance their socioeconomic situation.

4.2.8. Community Participation

The proposed framework involved engaging citizens through digital communication channels, offering collaborative governance opportunities, and resulted in higher community participation, which went from 75% to 96%. Online awareness campaigns and educational activities, as well as public consultations and digital feedback systems, were all active in the community. Multilingual communication, mobile applications and inclusive digital platforms promoted citizen-to-citizen, citizen-to-government and citizen-to-school and citizen-to-community relationships and interactions, thereby enhancing inclusive and participatory community development.

4.2.9. Citizen Satisfaction

The user-centred approach to digital service delivery has significantly boosted the satisfaction of citizens from 72% to 95%. The services were personalized, interfaces were simplified, multilingual, cloud infrastructure was reliable and services were delivered more quickly, which added to the overall user experience. Citizens were less affected by administrative delays, ease and transparency in using digital services. These services were continuously monitored and optimized using AI, which maintained their responsiveness to the evolving needs of the community, leading to increased trust and satisfaction.

4.2.10. Overall Digital Inclusion Performance

The results revealed that the overall digital inclusion performance improved significantly from 72% in the conventional system to 95% in the proposed system, highlighting the ability of adopting AI, ICT, cloud computing and collaborative governance together in a single digital inclusion ecosystem. The proposed framework was effective in increasing internet availability, digital skills, use of public services, use of healthcare services, participation in education, financial inclusion, job opportunities, engagement in the community and satisfaction of citizens. These improvements reflect the fact that the proposed Digital Inclusion Framework is a scalable, intelligent and sustainable

solution to minimising digital inequalities and ensuring inclusive socio-economic development in a range of communities.

4.3. Discussion

The experimental results clearly show that the proposed Digital Inclusion Framework with AI helps solve the multi-dimensional problems of digital exclusion in marginalised communities and is comprehensive and effective. The proposed framework is different from traditional digital inclusion programs that are mainly focused on promoting internet connectivity and infrastructure development; it is a comprehensive solution where Artificial Intelligence (AI), Information and Communication Technologies (ICT), cloud computing, digital literacy programs, community engagement, and collaborative governance are brought together to form a single ecosystem. The integrated approach extends beyond mere provision of digital technologies and ensures citizens have the necessary knowledge, skills and assistance to access digital technology effectively. The integration of AI-driven decision support tools that continuously monitor population demographics, socioeconomic, and educational data to identify digitally underserved communities and provide personalized recommendations for addressing them is one of the key strengths of the proposed framework. This smart functionality allows policymakers and service providers to maximize the use of resources, prioritize infrastructure investments and develop specific digital literacy programs reflecting the needs of the community instead of implementing the same way across the board. The integration of cloud computing further enhances system scalability, reliability and cost-effectiveness by offering cloud infrastructure to support e-governance, online education, telemedicine, digital financial services, employment portals and community information systems. In addition, multi-language interfaces, adaptive learning technologies, voice-controlled services and accessibility measures have a substantial positive impact on digital participation of elderly citizens, persons with disabilities, rural communities and language minority communities. The study also highlights the essential role that includes active government collaboration, cooperation between educational institutions and healthcare providers, private sector technologies, libraries, non-governmental organisations and local community leaders in sustainable implementation and long-term success. Digital services can be evaluated as they evolve over time through continuous monitoring, AI-based analytics, and citizen feedback mechanisms which help measure service quality, user satisfaction and community needs. In summary, a holistic approach is necessary for sustainable digital inclusion, combining different advanced technologies, digital education, ethical governance, partnerships among all relevant stakeholders, ongoing assessment of activities' performance and community-based service delivery. Such an integrated framework offers a scalable, sustainable approach towards closing the digital gap, to ensure and promote equitable access to digital opportunities, to increase social inclusion and to ensure long-term socioeconomic development, in developing and developed countries.

5. CONCLUSION

In today's connected and tech-savvy world, digital inclusion has become a key driver for equitable socioeconomic development. Despite tremendous progress in the development of

Information and Communication Technologies (ICT), Cloud Computing, Artificial Intelligence (AI) and Mobile Communication Systems, there remains a large digital divide affecting millions of people, at least those that belong to the communities that are not marginalized and served. The poor and fragmented Internet connectivity, low digital literacy, financial limitations, diversity of languages, lack of accessibility, and poor institutional coordination still limit meaningful participation in the digital economy. These hindrances limit the access to quality education, health care, financial services, job creation and e-governance, thus deepening existing social and economic inequalities. Successfully tackling these multidimensional issues needs a comprehensive and sustainable approach, not just offering internet connectivity but giving people the knowledge, resources and support to be active participants in digital society. To meet these challenges, this study sought to propose a holistic Artificial Intelligence (AI) based Digital Inclusion Framework that combines digital infrastructure, cloud computing, artificial intelligence analytics, multiple language service delivery, community involvement, digital literacy improvement, collaborative governance, and ongoing performance assessment into one system. The proposed framework is unique in that it takes an inclusive approach by focusing on four key areas of digital inclusion – accessibility, affordability, usability and service personalisation, development of digital competency, and evidence-based policymaking – rather than solely concentrating on the expansion of broadband infrastructure as is most often done when considering digital inclusion. The AI is the intelligent backbone of the framework, continually processing demographic and socioeconomic information to identify people that are digitally excluded, personalize learning routes, optimize the deployment of infrastructure and enhance the delivery of public services. Cloud computing also enhances the framework as it offers scalable, reliable and secure infrastructure to support digital education, telemedicine, financial inclusion, employment services and e-governance applications in geographically dispersed communities. The effectiveness of the proposed framework was supported by a successful experimental evaluation, which showed significant improvements on various digital inclusion indicators. Significant improvements were noted across seven areas of the traditional definition of digital inclusion – access to the Internet, digital literacy, access to healthcare, use of online education, use of government services, financial inclusion, access to jobs and community participation, satisfaction as a citizen – in comparison with traditional digital inclusion strategies. There was a notable improvement in the overall digital inclusion performance from 72% to 95% as a result of the combination of intelligent technology with collaborative governance and a community-based approach to implementation. The use of AI-driven decision support systems facilitated optimal resource utilization, multilingual interfaces enhanced accessibility for non-English speaking users, adaptive learning platforms addressed the diverse learning needs of users, and mobile-based delivery ensured services were more accessible to those living in remote areas. Ongoing monitoring and performance evaluation also helped to keep the framework flexible in order to meet changing community needs and technological solutions. The proposed framework makes a valuable addition to the current digital inclusion literature, as it offers an intelligent, scalable, and sustainable architecture that incorporates the latest technologies and social and institutional change. It offers a pragmatic blueprint for policymakers, government bodies, education bodies, healthcare entities, non-governmental organizations and technology companies to create inclusive digital transformation

strategies that are aligned with national digital development plans and the United Nations Sustainable Development Goals (SDGs). Its commitment to ethical AI, transparency, accessibility, stakeholder collaboration, and continuous improvement guarantees responsible technological innovation that fosters social equity and sustainable solutions for the future. The framework can be further improved with the use of future technologies like the Internet of Things (IoT), edge computing, blockchain-based digital identity management, federated learning, Explainable Artificial Intelligence, and advanced cybersecurity mechanisms in future research. Furthermore, the framework's versatility and effectiveness will be further substantiated through large-scale long-term studies conducted in various geographic, cultural and social settings. Overall, the proposed AI-supported Digital Inclusion Framework is a major step towards realizing inclusive digital societies, where all citizens irrespective of their socioeconomic and geographical situations have the possibilities to access digital opportunities and to actively participate in the digital economy and contribute to the sustainable socioeconomic development in a digital society.

REFERENCES

- [1] J. Van Dijk, *The Deepening Divide: Inequality in the Information Society*. Thousand Oaks, CA, USA: Sage Publications, 2005.
- [2] M. Warschauer, *Technology and Social Inclusion: Rethinking the Digital Divide*. Cambridge, MA, USA: MIT Press, 2003.
- [3] E. Helsper, *A Corresponding Fields Model for the Links Between Social and Digital Exclusion*, *Communication Theory*, vol. 22, no. 4, pp. 403–426, 2012.
- [4] P. Norris, *Digital Divide: Civic Engagement, Information Poverty, and the Internet Worldwide*. Cambridge, U.K.: Cambridge University Press, 2001.
- [5] United Nations, *Transforming Our World: The 2030 Agenda for Sustainable Development*. New York, NY, USA: United Nations, 2015.
- [6] UNESCO, *A Global Framework of Reference on Digital Literacy Skills for Indicator 4.4.2*. Paris, France: UNESCO Institute for Statistics, 2018.
- [7] International Telecommunication Union (ITU), *Measuring Digital Development: Facts and Figures 2023*. Geneva, Switzerland: ITU, 2023.
- [8] OECD, *Bridging the Digital Divide: Measuring Digital Inclusion*. Paris, France: Organisation for Economic Co-operation and Development, 2019.
- [9] World Bank, *World Development Report 2021: Data for Better Lives*. Washington, DC, USA: World Bank, 2021.
- [10] K. Schwab, *The Fourth Industrial Revolution*. Geneva, Switzerland: World Economic Forum, 2016.
- [11] S. Russell and P. Norvig, *Artificial Intelligence: A Modern Approach*, 4th ed. Hoboken, NJ, USA: Pearson, 2021.
- [12] T. M. Mitchell, *Machine Learning*. New York, NY, USA: McGraw-Hill, 1997.
- [13] M. A. Wimmer and H. J. Scholl, "Digital Government: Information Technologies and Transformation," *Government Information Quarterly*, vol. 35, no. 4, pp. 101–112, 2018.
- [14] L. Floridi and J. Cowls, "A Unified Framework of Five Principles for AI in Society," *Harvard Data Science Review*, vol. 1, no. 1, pp. 1–15, 2019.
- [15] V. Venkatesh, J. Y. L. Thong, and X. Xu, "Consumer Acceptance and Use of Information Technology: Extending the Unified Theory of Acceptance and Use of Technology," *MIS Quarterly*, vol. 36, no. 1, pp. 157–178, 2012.
- [1] Gajula, S. (2024). Cybersecurity risk prediction using graph neural networks. *Journal of Information Systems Engineering and Management*.
- [2] Gajula, S. (2024). Adaptive zero trust architecture for securing financial microservices. *Computer Fraud & Security*, 2024(12), 643–655. <https://doi.org/10.52710/cfs.845>
- [3] Gajula, S. (2023). A review of anomaly identification in finance frauds using machine learning system. *International Journal of Current Engineering and Technology*, 13(6), 568–575. <https://ijcet.evegenis.org/index.php/ijcet/article/view/820>