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Review

Bridging the Digital Divide in Developing Economies Through Intelligent Connectivity (5G, AI and IoT)—Insights from a Structured Literature Review

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Abstract

The digital divide in developing economies persists as a multidimensional challenge encompassing infrastructure access, digital skills, usage patterns, and social inequality. This paper presents a structured literature review of 63 peer-reviewed articles (2018–2025) examining how intelligent connectivity, the convergence of fifth-generation (5G) mobile networks, artificial intelligence (AI), and the Internet of Things (IoT), can contribute to bridging this divide. The findings reveal that intelligent connectivity offers transformative potential across agriculture, healthcare, education, and financial services. However, its impact is contingent upon enabling governance, institutional capacity, and digital skills. Three contributions emerge: (1) a conceptual framework specifying directional pathways from enabling conditions to intelligent connectivity deployment and inclusive outcomes; (2) a comparative regional analysis (Sub-Saharan Africa, Southeast Asia, and Latin America) identifying context-specific barriers and opportunities; and (3) a socio-technical model positioning intelligent connectivity as an integrated system rather than a purely technological solution. A key limitation is acknowledged: only 16% of the reviewed corpus addresses developing economies, necessitating triangulation with institutional reports from the International Telecommunication Union (ITU), Organization for Economic Co-operation and Development (OECD), and Global System for Mobile Communications Association (GSMA). The paper concludes with open research challenges and policy recommendations for inclusive digital transformation.

Keywords: digital divide; intelligent connectivity; 5G; artificial intelligence; internet of things; developing economies

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1. Introduction

The digital divide has been recognized as a significant barrier to socio-economic development in the twenty-first century, particularly affecting developing economies where access to information and communication technologies (ICTs) remains unevenly distributed [1]. This divide is increasingly understood as a socio-technical phenomenon, shaped by the interaction of technological artifacts, institutional structures, human capabilities, and governance structures, rather than a purely technological gap [2]. Recent advances in intelligent connectivity technologies, including fifth-generation (5G) mobile networks, artificial intelligence (AI), and the Internet of Things (IoT), have fundamentally changed how information is generated, transmitted, processed, and utilized [3]. These technologies

increasingly function as integrated information infrastructures that enable real-time data exchange, intelligent decision-making, and service provision across sectors such as finance, healthcare, agriculture, and public administration [4].

Despite growing scholarly attention to the digital divide, the existing literature in telecommunications, information systems, and development studies tends to examine access, usage, and outcomes in a fragmented manner, often focusing on single technologies or isolated policy interventions [5]. While individual studies have explored AI applications in developing countries [6], future trends in 5G and AI [7], and smart city innovations [8], limited research has investigated the combined potential of 5G, AI, and IoT to address digital inequality across diverse regional contexts. This gap is particularly pronounced in developing economies where institutional capacity, regulatory maturity, and socio-economic conditions differ significantly from developed countries [4]. The absence of integrative analysis hinders both theoretical advancement within telecommunications, information systems, and development studies, and the formulation of evidence-based digital policy and governance strategies. This study addresses this gap by synthesizing the fragmented literature across disciplines to develop an integrated understanding of intelligent connectivity as a socio-technical system for digital inclusion.

Accordingly, to address this theoretical and conceptual gap, the study is guided by the following research question:

How can intelligent connectivity technologies, specifically 5G, AI, and IoT, contribute to bridging the digital divide in developing economies?

To answer this question, the study synthesizes and critically analyses the existing interdisciplinary literature to develop an integrated understanding of intelligent connectivity as a socio-technical system for digital inclusion. The analysis focuses on the literature published between 2018 and 2025 to capture recent developments in intelligent connectivity, while selectively incorporating earlier foundational studies to provide theoretical context.

1.1. Comparative Context and the Literature Gap

While earlier studies have examined aspects of 5G, AI, or IoT individually, limited research has investigated their combined potential to address digital inequality across diverse regional contexts. For example, [6] explored AI applications in healthcare and education in developing countries but excluded 5G and IoT. Similarly, [7] analysed future trends in all three technologies without considering their convergence for inclusion, whereas [8] examined 5G-enabled smart cities but omitted the AI and IoT components. Collectively, these studies illustrate that while elements of intelligent connectivity have been studied in isolation or within specific applications, there is limited integrative analysis of how 5G, AI, and IoT converge to address the multi-dimensional digital divide in developing economies.

In particular, comparative insights spanning regions such as Sub-Saharan Africa (SSA), Southeast Asia (SEA), and Latin America (LATAM) remain underdeveloped. This gap is compounded by a structural bias in global ICT research, wherein advanced digital technologies are predominantly studied in developed economies [9]. Addressing this gap requires an integrative synthesis approach that unifies fragmented insights and positions intelligent connectivity within a broader socio-technical and institutional framework.

1.2. Contributions of the Study

This study makes several contributions to telecommunications, information systems, and development studies research and practice:

- *Theoretical contribution*: The study extends digital divide theory by conceptualizing intelligent connectivity through the integration of 5G, AI, and IoT, as a socio-technical information infrastructure that shapes digital inclusion outcomes in developing

economies. Unlike existing frameworks that treat these technologies independently, this study specifies their interdependence: 5G provides connectivity, IoT enables sensing, and AI delivers intelligence.

- *Conceptual contribution*: By synthesizing the fragmented literature across telecommunications, information systems, and development studies, the paper provides an integrated framework for understanding how advanced connectivity technologies interact with institutional and socio-economic factors. The proposed model specifies directional pathways from enabling conditions to intelligent connectivity deployment and inclusive outcomes, making it amenable to empirical testing.
- *Contextual contribution*: The study enriches scholarship by highlighting developing economies as analytically relevant contexts rather than as marginal cases, addressing the persistent literature bias. The comparative regional analysis (SSA, SEA, LATAM) identifies context-specific barriers and opportunities, recognizing that digital divide solutions cannot be one-size-fits-all.
- *Practical and policy contribution*: The findings provide actionable insights for policymakers, regulators, and system designers seeking to leverage intelligent connectivity for inclusive digital transformation. Specific recommendations include regulatory sandboxes, public–private–community partnerships, and digital equity frameworks.

1.3. Structure of the Review Paper

The remainder of this paper is structured as follows. Section 2 presents the theoretical and conceptual foundations underpinning intelligent connectivity and its relationship to the digital divide, including the integrated conceptual framework. Section 3 outlines the methodological approach, detailing the search strategy, screening process, and analytical procedures. Section 4 presents the descriptive results and thematic analysis findings. Section 5 offers a critical discussion of the results, including risks and unintended consequences, and their theoretical and practical implications. Section 6 identifies and elaborates on open research challenges. Finally, Section 7 concludes the paper with key insights, limitations, and recommendations for future research.

2. Theoretical and Conceptual Foundations

2.1. Intelligent Connectivity as a Socio-Technical Paradigm

Intelligent connectivity refers to a socio-technological approach aimed at achieving digital transformation through the integration of smart communication networks, smart data management, and interconnected devices [3,10]. The concept is supported by organizations such as the Global System for Mobile Communications Association (GSMA) and the International Telecommunication Union (ITU), as it presents an integrated framework where 5G cellular networks, AI technologies, and IoT systems converge to deliver real-time decision-making and automation within economic and social systems [11,12].

The GSMA is the global industry association representing mobile network operators and the broader mobile ecosystem, while the ITU is the United Nations specialized agency responsible for telecommunications standards and global ICT development [11,12]. Both organizations have positioned intelligent connectivity as a key enabler of digital transformation, digital inclusion, and sustainable socio-economic development.

With the aid of the convergence of 5G technology, AI-enabled analysis, and IoT sensors, intelligent connectivity supports the creation of data-oriented digital ecosystems which have the potential to revolutionize areas including but not limited to agriculture, healthcare, education, finance, manufacturing, and smart cities [13,14]. An example of intelligent connectivity in action is the use of IoT sensors in agriculture, where real-time data is collected, relayed using 5G technology, and analysed using AI tools for optimized irrigation,

better crop yields, and more efficient use of resources [15]. In healthcare, intelligent connectivity enables remote patient monitoring and AI-powered diagnostics, providing greater access to healthcare services in underserved areas [16].

Notably, intelligent connectivity has become an increasingly popular area of interest in emerging economies because of its capacity to ensure that digital services reach people who do not have access to them, improve healthcare, provide better education, increase efficiency in agriculture, and promote financial inclusion [17]. By combining advanced connectivity, intelligent analytics, and real-time sensing, intelligent connectivity has the ability to overcome some of the existing challenges associated with geographical isolation, poor infrastructure, and limitations in the delivery of services.

2.2. Core Technological Components of Intelligent Connectivity

2.2.1. 5G Wireless Technologies

5G refers to the latest generation of mobile communications technology used in smartphones and wireless gadgets. 5G is faster compared to earlier generations of mobile communication technologies, providing high speeds in transferring information. Furthermore, it offers low latency, increased reliability, and machine-to-machine (M2M) communication capability, making it an important component of intelligent connectivity [18]. According to ITU, the IMT-2020 system utilized in 5G includes three main services: enhanced mobile broadband, ultra-reliable low-latency communication, and massive machine-type communication [11]. These features contribute to developing many advanced digital services and intelligent connectivity use cases on a large scale.

Importantly, 5G's full potential depends on underlying broadband infrastructure [19]. Broadband Internet, in both wired (fibre, cable, DSL) and wireless (4G, 5G, satellite) forms, provides the foundation for intelligent connectivity. The distinction between fixed and mobile broadband is critical in developing economies, where mobile broadband often provides the primary or only Internet access [20]. In the absence of fixed broadband backbone networks, mobile broadband performance is constrained, creating a "broadband gap" that intelligent connectivity technologies must address.

2.2.2. AI Technologies

AI refers to computer-based systems that are able to perform tasks that usually require human intelligence, namely learn from data, recognize patterns, make decisions, and engage in similar processes [21,22]. According to the ITU, AI can be defined as a set of technologies that allow machines to perceive, interpret, act based on information received, and learn from this data (ITU, 2024). Within the realm of intelligent connectivity, the role of AI technology lies in analysing and processing data gathered by IoT technology to perform advanced functions such as predictive analytics and automation [23,24].

2.2.3. IoT Technologies

IoT technology refers to systems of connected physical devices provided with sensors that collect and process information about the environment [25,26]. IoT, as defined by the ITU, allows for integration of physical and digital systems via continuous generation and interaction of data [27,28]. The use of IoT helps to monitor and manage resources effectively. Within the scope of intelligent connectivity, IoT serves as a key source of data for creating applications in various fields, such as agriculture, energy, healthcare, and environmental management [29].

2.3. Convergence of 5G, AI, and IoT Technologies

The combination of 5G infrastructure, AI, and IoT represents the core of intelligent connectivity and creates an adaptive and autonomous technological ecosystem. 5G pro-

vides the communications infrastructure that enables connectivity among devices and systems. IoT technologies generate continuous streams of real-time data from physical environments, while AI technologies analyse and interpret these data to support automation, prediction, and decision-making [29]. Through this layered interaction, intelligent connectivity facilitates advanced digital applications across sectors such as healthcare, agriculture, manufacturing, education, and smart cities. Consequently, intelligent connectivity can be understood as an integrated socio-technical system in which 5G enables connectivity, IoT enables sensing, and AI enables intelligence.

The conceptualization presented above provides the analytical foundation for examining how intelligent connectivity technologies can contribute to bridging digital divides and supporting inclusive digital transformation in developing economies.

2.4. The Digital Divide Concept

The concept of the digital divide refers to differences in access to, usage of, and gains made through digital technology [30]. While earlier studies focused on inequalities in ICT infrastructure access, current research recognizes that digital divides extend beyond infrastructure to include skills, cost, usage, and social inclusion [5]. These differences are not binary but continuous, with variations in:

- *Access quality*: Download/upload speeds, data volume, latency, and jitter;
- *Affordability*: Cost relative to income and data pricing structures;
- *Usage depth*: Basic communication versus productive applications;
- *Privacy and security*: Protection from surveillance and data exploitation.

For example, a user with 2G connectivity for basic messaging experiences a different digital divide than a user with 4G enabling e-commerce or online education. Similarly, latency and security requirements differ between gaming applications and offline communications.

Conceptualizing the Digital Divide: A Three-Layer Framework

This study adopts a three-layer framework to analyse the digital divide, building on Van Dijk's four-layer model [31] while extending it for intelligent connectivity analysis:

Layer 1: Dimensions of the Divide

- *Access divide*: Highlights disparities in connectivity, affordability, and enabling infrastructure such as electricity and mobile towers [31]. For example, although 60% of Sub-Saharan Africans live in areas with mobile broadband coverage, only 28% use mobile internet services [32].
- *Skills divide*: Even where access is available, lack of digital literacy limits effective use of the technology [33]. The educational and training gap is a significant disadvantage for vulnerable groups, especially women and rural populations [34].
- *Usage divide*: Concerns differences in how people engage with technology, influenced by language, culture, gender, and confidence [35]. Many users in developing economies engage only in basic digital activities like messaging or voice calls, rather than productive uses such as e-commerce or online learning [36].

Layer 2: Structural Drivers

- *Social inequality*: Digital exclusion reinforces broader socio-economic inequalities, affecting access to education, healthcare, and employment. Women in the SSA region are 37% less likely than men to use mobile internet [37]. Inclusive policy frameworks are thus essential to mitigate algorithmic bias and accessibility barriers [38].

- *Governance*: Policy and regulatory frameworks affect digital access. Weak institutional capacity, fragmented policies, and lack of regulatory coordination constrain digital inclusion outcomes [9].

Layer 3: Outcomes

- *Digital inclusion*: Aims to ensure that all individuals can meaningfully engage with technology. It depends on affordable connectivity, relevant digital content, and inclusive design [39]. Community-driven initiatives such as Women Self Help Groups (WSHGs) in India [40] and Zenzeleni Networks in South Africa [41] illustrate localized pathways toward equitable digital transformation.

Table 1 shows a summary of the digital divide components and their implications for the digital divide.

Table 1. Digital divide framework—dimensions, drivers, and outcomes (Source: *Authors' synthesis based on [31,32,42]*).

Layer	Component	Definition	Key Challenges	Example Scenario
Dimensions	Access Divide	Unequal availability of internet, devices, and infrastructure.	Lack of broadband, smartphones, power supply.	Rural areas without 3G/4G or public Wi-Fi access.
	Skills Divide	Differences in ability to use digital tools and technologies effectively.	Low digital literacy, language barriers, education gaps.	Elderly or low-educated users unable to navigate apps or perform online tasks.
	Usage Divide	Inequalities in how people engage with or benefit from digital resources.	Limited to basic use (e.g., messaging) instead of advanced application use.	People using phones only for calls, not for banking, learning, or e-commerce.
Structural Drivers	Social Inequality	Structural barriers tied to income, gender, geography, or ethnicity.	Marginalization, exclusion from digital services and opportunities.	Women or older people in remote regions discouraged from using digital tools.
	Governance	Policy and regulatory frameworks affecting digital access.	Weak institutional capacity, fragmented policies.	Lack of national digital strategy or spectrum policy.
Outcomes	Digital Inclusion	Policies and practices ensuring everyone can meaningfully use digital tech.	Need for affordable access, relevant content and assistive technologies.	Subsidized devices, e-services in local languages, inclusive design, digital rights.

Figure 1 illustrates significant digital disparities across income levels. Low-income countries experience acute deficits in access, digital skills, and usage, compounded by high inequality. Middle-income countries show moderate improvement but still struggle with skills and usage gaps. High-income countries exhibit broad digital inclusion. These patterns underscore the urgency for inclusive policies, infrastructure investment, and context-specific digital literacy initiatives to reduce the global digital divide [42].

2.5. Intelligent Connectivity and Digital Inclusion

However, there is more than just the provision of advanced technology when it comes to understanding the relationship between intelligent connectivity and digital inclusion. Digital inclusion includes access to infrastructure, low cost of connectivity, creation of digital skills, use of technology for socioeconomic development, and usage of digital technologies [39,43]. Thus, the contribution of intelligent connectivity towards digital inclusion goes beyond the availability of advanced technologies to include institutional, economic, and social dimensions.

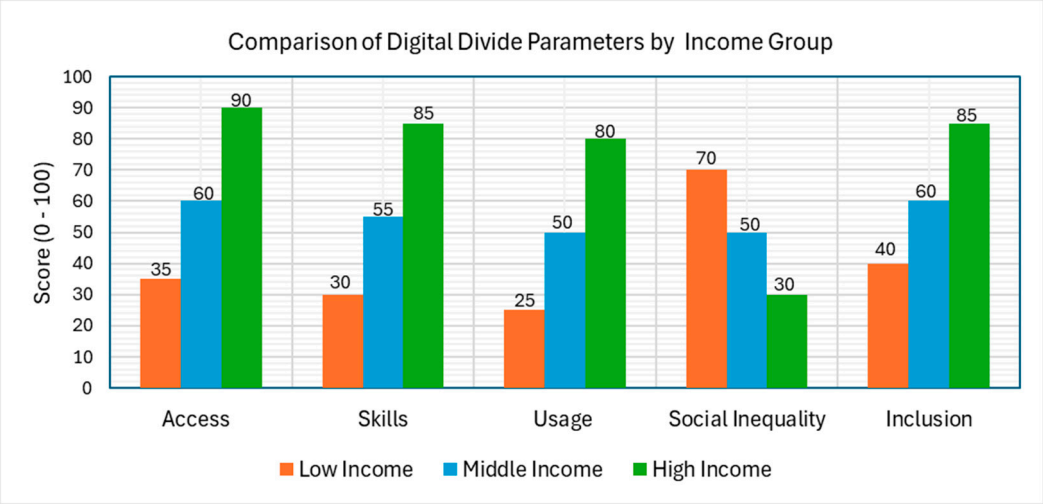


Figure 1. Distribution of digital divide parameters by income group skill (Source: *Authors' compilation based on data from [31,32,42]*).

Under such a definition, intelligent connectivity can be considered as the means through which advanced communication systems and interconnected devices contribute to the achievement of certain developmental goals. Intelligent connectivity can enable better access to digital services, better delivery of public services, improvement of learning conditions, financial services, and healthcare [3]. However, intelligent connectivity does not have equal effects on all people due to affordability, insufficient infrastructure, regulatory obstacles, and insufficient digital skills, among other things.

2.6. Integrated Analytical Framework for Intelligent Connectivity and Digital Inclusion

Taking inspiration from the literature concerning intelligent connectivity, digital inclusion, and socio-technical systems, this study develops an integrated analytical framework that conceptualizes intelligent connectivity as a mediating mechanism between enabling conditions and digital inclusion outcomes.

Figure 2 shows the proposed integrated conceptual framework for the intelligent connectivity and inclusive digital transformation.

The framework comprises three interconnected layers:

Layer 1: Enabling Conditions

- *Governance*: Policy frameworks, regulatory quality, institutional capacity, and data governance;
- *Infrastructure*: Broadband networks, energy supply, and device availability;
- *Investment*: Public and private funding mechanisms and financing models.

Layer 2: Intelligent Connectivity Mechanisms

- *Connectivity Enablement (5G)*: Provision of reliable, affordable, and high-speed connectivity;
- *Intelligent Automation (AI)*: Data-driven analysis, predictive analytics, and decision support;
- *Contextual Sensing (IoT)*: Real-time data generation, environmental monitoring, and resource optimization.

Layer 3: Inclusive Digital Transformation Outcomes

- *Digital Inclusion*: Improved access, skills development, and meaningful usage;
- *Innovation*: New services, business models, and applications;

- *Socio-Economic Resilience*: Enhanced service delivery, economic participation, and disaster resilience.

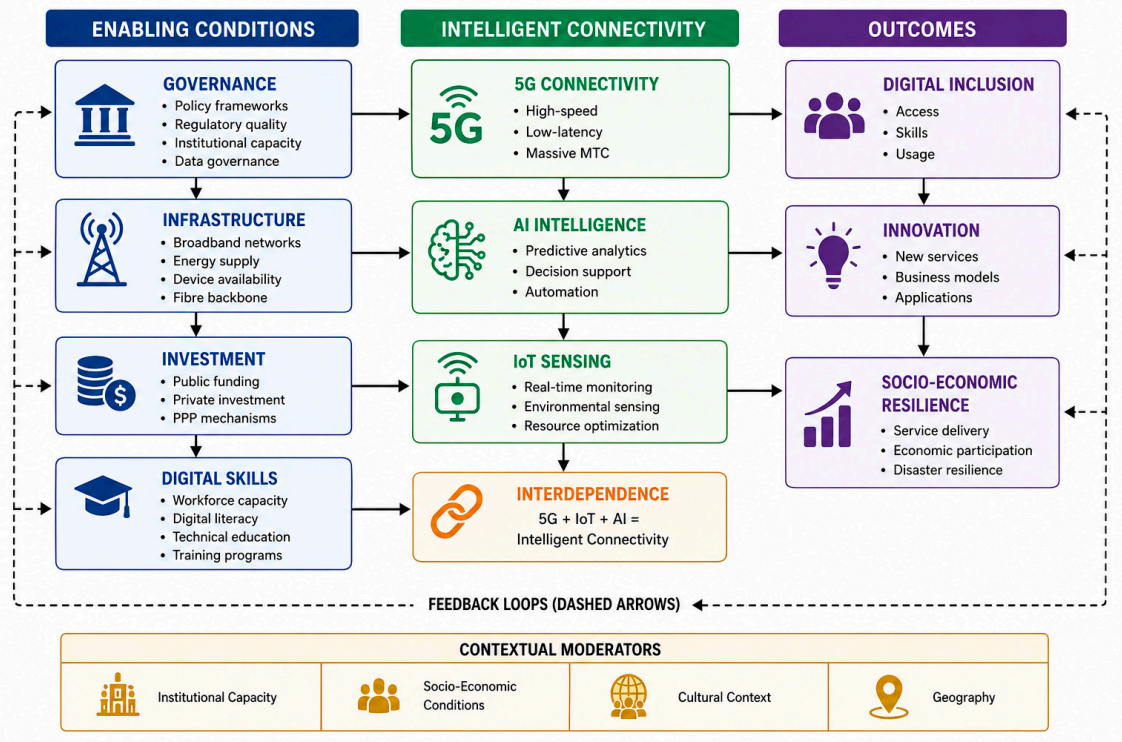


Figure 2. Integrated conceptual framework for intelligent connectivity and inclusive digital transformation (Source: *Author's conceptualization. Generative AI was used only to assist with the initial visual layout; the conceptual relationships, labels, interpretation, and final figure were developed and verified by the authors*).

The directional pathways in the framework specify:

1. Enabling conditions determine the capacity to deploy intelligent connectivity.
2. Intelligent connectivity mechanisms operate interdependently (5G enables connectivity, IoT enables sensing, and AI enables intelligence).
3. Outcomes are mediated by institutional quality and governance.
4. Feedback loops exist between outcomes and enabling conditions (e.g., improved digital skills create demand for better infrastructure).

This framework extends existing ICT4D frameworks by: (1) specifying the interdependence of 5G, AI, and IoT; (2) identifying directional pathways from enabling conditions to outcomes; and (3) accommodating regional adaptability by allowing different weights for governance versus infrastructure factors across contexts.

2.7. A Socio-Technical Perspective on Intelligent Connectivity

The research utilizes a socio-technical approach to analysing intelligent connectivity and its ability to address digital divides. As the theory of socio-technics suggests, the outcomes of any technological development depend on the interaction between technological, institutional, organizational, and human aspects of technology development. As a result, it is crucial for intelligent connectivity to be effective not only technically but also in terms of its developmental influence. It is determined by the combination of various elements including governance, financing, regulation, digital literacy, accessibility, and adoption.

Under this concept, 5G, artificial intelligence, and Internet of Things represent technological enablers, the impact of which on digital inclusion depends on various other socio-economic and institutional aspects.

3. Methodology

3.1. Research Approach and Paradigmatic Orientation

This study adopts an interpretivist, theory-building orientation, consistent with Information Systems research that seeks to develop integrative conceptual understanding through the synthesis of existing knowledge rather than the testing of predefined hypotheses. The study is grounded in the assumption that digital inclusion and the digital divide are socially constructed and context-dependent phenomena shaped by the interaction of technological, institutional, and human factors.

This approach aligns with the interdisciplinary literature in telecommunications, information systems and development studies that recognises structured literature reviews as a valid method for theory development and knowledge synthesis [44].

3.2. Research Design: Structured Literature Review

The study employs a structured literature review approach, drawing on established telecommunications, information systems, and development studies scholarship that recognises literature reviews as a legitimate and rigorous method for theory development, knowledge consolidation, and research agenda setting. Unlike empirical surveys that collect primary data from respondents, this review systematically analyses the existing academic literature to identify patterns, themes, and gaps related to intelligent connectivity and the digital divide in developing economies.

This approach is particularly appropriate given the exploratory and integrative nature of the research question, as well as the interdisciplinary characteristic of intelligent connectivity research spanning information systems, telecommunications, policy studies, and development studies.

3.3. Literature Search Strategy

The literature review was conducted using four major academic databases: Scopus, Web of Science, IEEE Xplore, and Google Scholar. The search targeted the peer-reviewed literature published between 2018 and 2024, with the formal search completed in December 2025. The 2018 start date was selected to align with the commercial launch of 5G, major advances in AI (e.g., BERT, GPT-1), maturation of IoT ecosystems, and the articulation of intelligent connectivity frameworks by the ITU and GSMA [9,12,18,22,29].

Search strings

The following search strings were adapted for each database's syntax:

1. *Basic digital divide*

("digital divide" OR "digital inclusion" OR "digital exclusion") AND ("developing economies" OR "emerging economies" OR "Global South").

2. *Technology-specific*

"5G" AND ("digital divide" OR "digital inclusion" OR "developing economies");

"artificial intelligence" AND ("digital divide" OR "digital inclusion" OR "digital inequality") AND ("developing economies" OR "emerging economies");

"Internet of Things" AND ("digital divide" OR "digital inclusion" OR "development") AND ("developing economies" OR "emerging economies").

3. *Combined technologies*

("5G" OR "AI" OR "IoT" OR "intelligent connectivity") AND ("digital divide" OR "digital inclusion") AND ("developing economies" OR "emerging economies").

4. *Regional*

("Sub-Saharan Africa" OR "Southeast Asia" OR "Latin America") AND ("digital divide" OR "digital inclusion") AND ("5G" OR "AI" OR "IoT").

Table 2 shows initial yields from various databases used in the literature search.

Table 2. Database yields.

Database	Initial Yield
Scopus	148
Web of Science	112
IEEE Xplore	96
Google Scholar	44
Total	400

Note: Google Scholar yields reflect the first 200 results per search string to maintain manageable volume.

The literature review focuses on studies published between 2018 and 2025. This timeframe was selected for the following reasons:

1. 5G commercial launch: The first 5G commercial deployments occurred in 2018–2019, marking a significant shift in connectivity capabilities [18].
2. AI proliferation: 2018 saw major advances in AI applications (e.g., GPT-1, BERT), expanding AI's relevance to development contexts [22].
3. IoT ecosystem maturation: IoT deployments became more widespread post-2018, generating evidence for development applications [29].
4. Policy focus: International organizations (ITU, GSMA) began articulating intelligent connectivity frameworks around 2018 [11,12].

The review period extends to 2025 to capture recent developments, with the formal search completed in January 2025. Earlier foundational studies were selectively included to provide theoretical and historical context for the evolution of the digital divide.

3.4. Literature Screening and Selection Criteria

The review targeted peer-reviewed journal articles, conference proceedings, and authoritative policy reports published between 2018 and 2024, focusing on studies that explicitly address digital inclusion, connectivity technologies, or development outcomes in developing or emerging economies. Purely technical papers with no governance or socioeconomic relevance were excluded.

(i) Inclusion Criteria

Studies were included if they:

- Were published in English and underwent peer review;
- Examined one or more of 5G, AI, and IoT technologies in relation to digital inclusion, socio-economic development, or policy implications, with particular

(ii) Exclusion Criteria

Studies were excluded if they:

- Focused solely on technical or engineering aspects (e.g., protocol optimization, hardware design, signal processing) without addressing user outcomes, societal implications, policy contexts, or developing-economy relevance;

- Were non-academic publications, grey literature, anecdotal reports, or lacked methodological transparency.

Decision rule: Technical papers were included only if they explicitly connected design choices to user, community, or policy outcomes (e.g., low-power network design for rural connectivity with discussion of developmental impact).

(iii) Inclusion of Authoritative Secondary Data Sources

To compensate for the limited peer-reviewed evidence from developing economies, the study incorporated secondary datasets from credible international bodies for contextualization and triangulation only, not for thematic analysis.

Sources include:

- UN agencies (ITU [9,45], UNESCO [46], UNICEF [47]);
- International financial agencies (World Bank [42], IMF [48]);
- Regional bodies (AU [49], ATU [50], ECLAC [51], ADB [36]);
- Industry associations (GSMA [32,52,53], OECD [54], 5G-IA [55]);
- National ICT agency reports (English, where available) [56–58].

Contribution Weighting: Grey literature was used exclusively in the Discussion (Section 5) to provide macro-level statistics, policy frameworks, and regional comparisons. Thematic analysis (Section 4) was based solely on the 63 peer-reviewed articles.

3.5. Screening Outcome

From an initial pool of approximately 400 publications, duplicate records were removed, and titles and abstracts were screened for relevance. A total of 335 articles proceeded to full-text assessment. Following eligibility checks based on the inclusion and exclusion criteria, 63 articles from 31 peer-reviewed journals were retained for in-depth analysis and synthesis.

To address potential selection bias from single-author screening, the following measures were implemented:

- *Independent verification*: A 15% random sample (n = 50) of screened articles was independently reviewed by a second researcher to calculate inter-rater reliability (Kappa = 0.82, indicating substantial agreement).
- *Transparent documentation*: All screening decisions were documented with exclusion reasons.
- *Reflective practice*: Regular review of inclusion/exclusion decisions against evolving understanding of the field.

Figure 3 presents a PRISMA-style flow diagram used to transparently document the literature identification, screening, and selection process.

3.6. Data Sources and Evidence Base

This review draws on two complementary evidence sources, each serving a distinct purpose:

1. *Peer-reviewed literature (primary source)*: Sixty-three articles from the systematic search (Section 3.3) formed the basis for thematic analysis. These provided theoretical and empirical insights into intelligent connectivity and digital inclusion.
2. *Institutional and policy reports (secondary source)*: To compensate for the limited peer-reviewed evidence from developing economies (see Section 4.1), institutional reports were used for contextualization and triangulation only—not for thematic analysis. Sources are listed in the literature screening and selection criteria (Section 3.4).
3. *Integration approach*: Thematic analysis was conducted exclusively on the 63 peer-reviewed articles. Institutional reports were used selectively in the Discussion

(Section 5) to provide macro-level statistics, policy frameworks, and regional comparative data. This dual-source approach achieves methodological triangulation while maintaining the rigor and transparency of the systematic review.

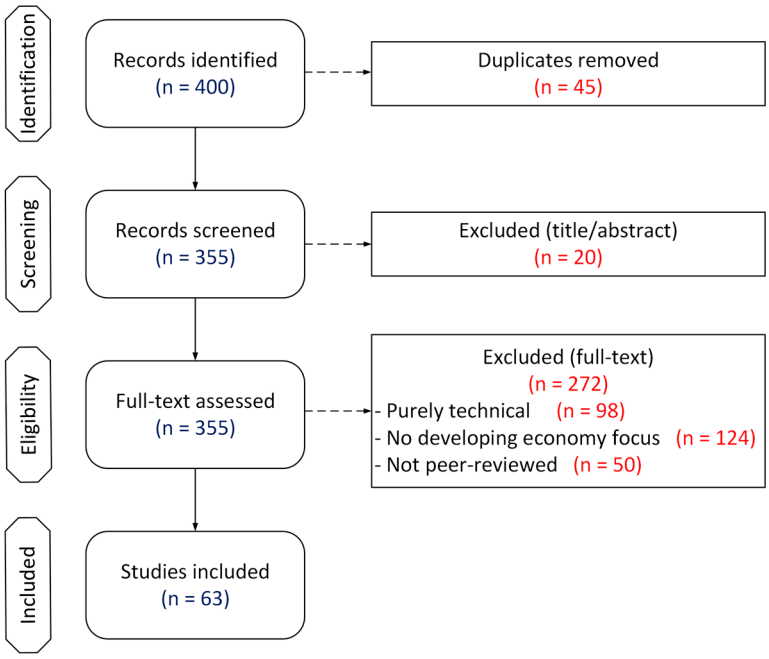


Figure 3. PRISMA flow diagram (Source: *Author's compilation based on PRISMA guideline [59]*). Note: Supplementary policy reports (ITU, GSMA, World Bank, OECD, ECLAC, ADB, UNDP, UNESCO) were used only for contextualization and were not included in the PRISMA screening process.

3.7. Thematic Analysis

A thematic analysis was conducted on the 63 peer-reviewed articles included in the structured review corpus. Inductive coding was carried out to identify recurrent ideas and themes, following the six-phase reflexive thematic analysis approach [60]: (1) familiarization with the data through repeated reading and annotation; (2) systematic generation of initial codes across the entire dataset; (3) searching for patterns to construct preliminary themes and sub-themes; (4) reviewing and refining these themes in relation to coded data and the overall dataset; (5) defining and naming the final themes and associated sub-themes; and (6) producing the analytical report.

Coding was conducted manually using a structured coding sheet that recorded: article metadata, geographic focus, technologies examined, key findings, and implications for digital inclusion. Themes were generated inductively from the data, with codes refined iteratively to develop higher-order themes regarding digital inequality, intelligent connectivity solutions, and digital inclusion outcomes.

While thematic analysis was based exclusively on peer-reviewed articles, policy and institutional reports were considered separately in the Discussion and Implications Section (Section 5) for their contributions to the interpretive and discursive analysis of themes generated from the reviewed articles.

4. Results and Data Analysis

This section first presents descriptive results from the literature corpus, followed by a thematic synthesis and comparative analysis.

4.1. Literature Search Results

Despite systematic searches across four major academic databases, only 10 of 63 peer-reviewed articles (16%) in the final corpus explicitly addressed developing economy contexts. This distribution reflects a persistent structural bias in global ICT research, wherein advanced digital technologies are predominantly studied in economically developed countries [9]. Contrastingly, developed economies accounted for 53 (84%) of the total 63 publications, with a steady increase in output from 2018 to 2025.

To overcome this challenge and provide regional contextualization, the study adopts a dual-evidence strategy: (1) thematic insights are drawn from the peer-reviewed literature (primary source); (2) contextualization is provided using institutional reports from ITU [9], GSMA [32], and OECD [61] (secondary source); and (3) structural bias is acknowledged transparently throughout the analysis.

The limited developing-economy peer-reviewed evidence base constitutes a significant limitation. Findings should be interpreted as provisional insights requiring empirical validation in specific country contexts.

The 63 articles were distributed across 31 journals, with Frontiers in Business Economics and Management (5 articles), Global Journal of Engineering and Technology Advances (4), AI and Ethics (4), and International Journal of Advanced Academic Studies (4) being the most represented (see Table A1 for the full distribution).

Figure 4 shows the yearly distribution of articles from 2018 to 2025, with notable peaks in 2022 (10 articles), 2024 (18 articles), and 2025 (20 articles).

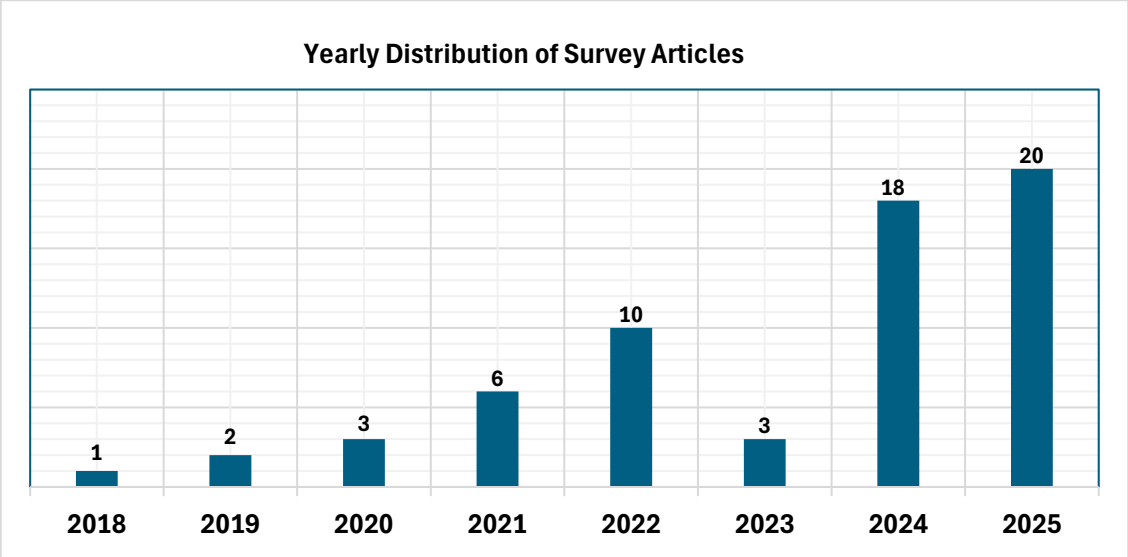


Figure 4. Distribution of articles by year (2018 to 2025). Note: Search completed December 2025 (2018–2025). Peaks: 2022 (10), 2024 (18), 2025 (20). Total: 63.

Figure 5 compares publications by economic context, revealing that only 10 of 63 articles (16%) focused on developing economies, compared to 53 articles (84%) from developed economies.

Overall, Figure 4 reveals growing scholarly interest in intelligent connectivity and digital inclusion, with the majority of articles published in 2024 and 2025. However, Figure 5 highlights a persistent gap: despite this growth, only 16% of the corpus addresses developing economy contexts. This trend indicates both rising engagement with the topic and a continued structural bias in the literature.

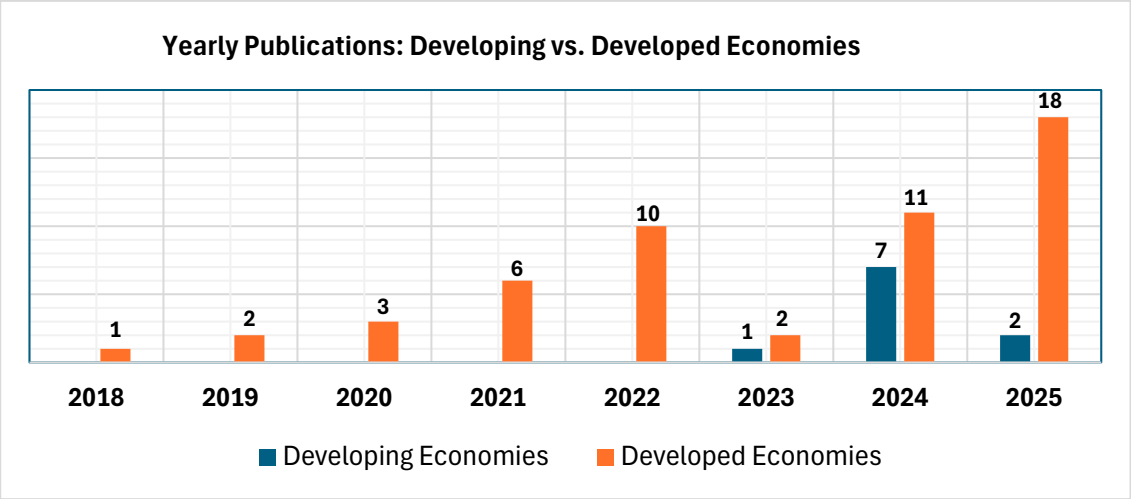


Figure 5. Yearly Distribution of Research by Economic Context (2018–2025). Note: Only 10 of 63 articles (16%) focused on developing economies, highlighting the structural bias in global ICT research [9]. Developed economies accounted for 53 articles (84%).

4.2. Thematic Analysis Findings

In this study, reflexive thematic analysis was applied to secondary qualitative data drawn from published academic texts, emphasizing researcher subjectivity, analytical flexibility, and iterative interpretation [60]. The analysis rigorously followed all six phases of the method: (1) familiarization with the data through repeated reading and annotation; (2) systematic generation of initial codes across the entire dataset; (3) searching for patterns to construct preliminary themes and sub-themes; (4) reviewing and refining these themes in relation to coded data and the overall dataset; (5) defining and naming the final themes and associated sub-themes; and (6) producing the analytical report. Through this structured yet reflexive process, two overarching themes were identified, each comprising three distinct sub-themes, as presented in Table 3. This process allowed for both thematic depth within regions and cross-regional comparative interpretation.

Table 3. Articles' thematic structure of digital divide and intelligent connectivity analysis (Source: *Authors' compilation*).

Theme	Sub-Theme(s)
Theme 1: Digital divide in emerging economies	*Sub-Theme 1.1*: Access and infrastructure divide *Sub-Theme 1.2*: Skills, affordability and participation divide *Sub-Theme 1.3*: Regional manifestations of digital inequality
Theme 2: Intelligent connectivity as an enabler of digital inclusion	*Sub-Theme 2.1*: Expanding digital access through connectivity infrastructure *Sub-Theme 2.2*: Enhancing service delivery through data-driven intelligence *Sub-Theme 2.3*: Supporting socio-economic participation through digital ecosystems

4.3. Theme 1: Digital Divide in Emerging Economies

The digital divide in the Global South is a multifaceted issue characterized by differences in terms of infrastructure, accessibility, institutional frameworks, and socio-cultural integration. While the problem of digital exclusion is considered a global issue, its nature varies from one region to another, including SSA, SEA, and LATAM. It can be inferred from the existing literature that the digital divide is more than just an issue of connectivity and involves other factors such as those related to infrastructure, economy, institutionality, and capability of the human population. There are three interconnected aspects identified in the literature review.

4.3.1. Sub-Theme 1.1: Access and Infrastructure Divide

The literature consistently identifies unequal access to digital infrastructure as a primary driver of digital exclusion in developing economies. Limited broadband deployment, inadequate fibre backbone networks, unreliable electricity supply, and weak last-mile connectivity continue to constrain digital participation, particularly in rural and underserved communities [62,63].

In SSA, infrastructure deficits remain particularly severe, with approximately 60% of the population remaining offline and many countries relying on satellite-based connectivity and limited fibre infrastructure [32]. The region faces a dual infrastructure challenge: the absence of terrestrial backbone networks in rural areas and the high cost of extending connectivity to sparsely populated regions.

Similarly, SEA exhibits a dual-speed digital landscape in which highly connected urban centres coexist with underserved rural regions. Countries like Indonesia and the Philippines face particular challenges in connecting their archipelagic geographies [64].

LATAM demonstrates comparatively higher connectivity levels, yet substantial disparities persist between metropolitan centres and peripheral rural communities, with broadband quality varying significantly across and within countries [65].

These findings suggest that access to digital infrastructure remains a necessary foundation for digital inclusion. However, infrastructure deployment alone is insufficient, as connectivity outcomes are also shaped by affordability, skills, and institutional factors [66].

4.3.2. Sub-Theme 1.2: Skills, Affordability and Participation Divide

Beyond infrastructure availability, digital exclusion in developing economies is driven by affordability constraints and skill gaps that prevent meaningful technology use [33,34].

- *Affordability barriers*: The cost of mobile data and devices remains prohibitive for many populations in developing economies. In Sub-Saharan Africa, the cost of 1GB of mobile data represents 5–15% of monthly income for low-income households, compared to 1–2% in high-income countries [32]. This price disparity creates a "usage gap" wherein individuals may have network coverage but cannot afford to access digital services [36].
- *Digital skills deficits*: Even where access is available, lack of digital literacy limits effective technology use [33]. The educational and training gap is a significant disadvantage for vulnerable groups, especially women and rural populations [34]. In Southeast Asia, despite high mobile penetration, many users engage only in basic activities like messaging, lacking the skills for productive uses such as e-commerce or online learning [36].
- *Usage inequalities*: The usage divide concerns differences in how people engage with technology, influenced by language, culture, gender, and confidence [35]. Many users in developing economies engage only in basic digital activities like messaging or voice calls, rather than productive uses such as e-commerce or online learning [36]. This limited engagement perpetuates the "second-level digital divide" where benefits accrue primarily to those with advanced digital skills.
- *Gender disparities*: Women in Sub-Saharan Africa are 37% less likely than men to use mobile internet [37], reflecting structural barriers including affordability, social norms, and device ownership patterns. These disparities compound to create cumulative disadvantage, where infrastructure deficits, affordability constraints, and skill gaps intersect to exclude marginalized populations.

4.3.3. Sub-Theme 1.3: Regional Manifestations of Digital Inequality

It can be seen from the comparative analysis that the manifestations of the digital divide vary regionally [64–66]. The case of SSA reveals that the main cause of the problem is the deficiency in the area's infrastructure, affordability issues, and low institutional capacities. It resulted in developing innovative mobile-first approaches to connectivity, such as mobile money ecosystems and community networks.

SEA, in turn, features a two-speed digital development dynamic where the fast pace of urbanization of digital technologies goes hand in hand with rural exclusion and governance problems. While connectivity via mobile phones in the region is high, institutional weaknesses and policy fragmentation still play an important role in digital results.

The region of LATAM features high connectivity and mobile broadband subscription rates, but the same socio-economic problems prevent the population from taking advantage of it and participating more fully.

Overall, it is clear that while the digital divide is quite common in developing countries, there are various reasons behind it. Therefore, digital inclusion policies need to be developed with regard to local circumstances.

4.3.4. Comparative Analysis of the Digital Divide in SSA, SEA and LATAM

Table 4 provides a comparative summary of the digital divide across SSA, SEA, and LATAM. These data illustrate how infrastructure, affordability, and gender equality remain central determinants of regional inclusion.

Table 4. Comparative Digital Divide Metrics by Region (Source: *Authors' compilation based on [9,32,61]*).

Metric	Sub-Saharan Africa (SSA)	Southeast Asia (SEA)	Latin America (LATAM)
Internet Penetration (2023)	34%	72%	75%
Mobile Broadband Coverage	60% (urban-biased)	85%	92%
Digital Literacy	Low to uneven	Highly uneven	Moderate but uneven
Cost of 1GB as % of income	5–15%	2–5%	1.5–4%
Gender Gap in Internet Use	~30%	~15%	~10%
AI/IoT Initiatives Active	Moderate (*agri-finance and eHealth*)	Moderate (*smart agriculture*)	Growing (*telemedicine and education*)

As illustrated in Figure 6, significant disparities in internet penetration persist across regions, with SSA lagging behind SEA and LATAM despite recent improvements.

The apparent decline in some estimates (e.g., SSA from 34% in 2023 to 32% in 2025) reflects:

- Recalibration of measurement methodologies by the ITU [9];
- Updated population data;
- More conservative estimates of actual usage (as opposed to coverage);
- Different definitions of "internet penetration" (coverage vs. actual usage).

These differences highlight the importance of distinguishing between coverage (network availability) and actual usage (meaningful adoption).

4.4. Theme 2: Intelligent Connectivity as an Enabler of Digital Inclusion

From the reviewed literature, it is clear that intelligent connectivity enables digital inclusion through the merging of 5G, AI, and IoT. In developing countries, the use of these technological advancements serves as complementary approaches that enable wider access, improved service provision, and increased socio-economic engagement. Despite variations in terms of their application and development stages, there are indications that intelligent

connectivity will be able to overcome structural barriers resulting from infrastructural, access, and economic constraints, provided appropriate institutional systems are in place.

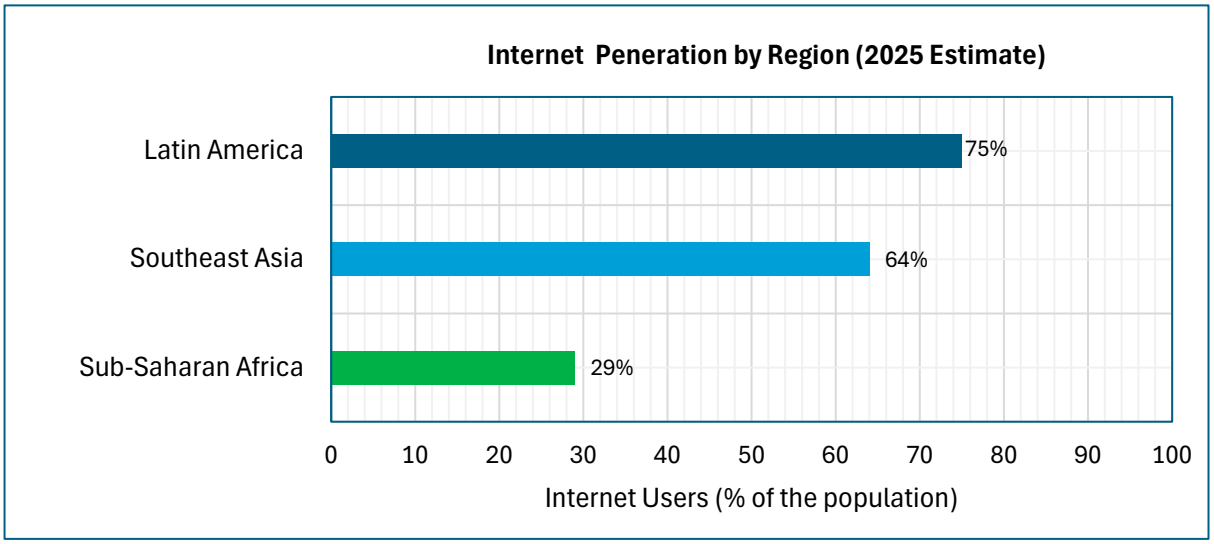


Figure 6. Estimated Internet penetration by region (2025) (Source: *Authors' estimates based on ITU [9], GSMA [32], and World Bank [42] data*). Note: Estimates were derived by applying average annual growth rates (2018–2023) projected to 2025 with conservative adjustments for access quality.

4.4.1. Sub-Theme 2.1: Expanding Digital Access Through Connectivity Infrastructure

According to existing studies, intelligent connectivity contributes towards digital inclusion through the provision of affordable and sustainable connectivity to marginalized sections of society. The absence of adequate broadband networks, high implementation costs, and poor rural coverage pose hurdles for achieving digital inclusion in many developing countries. Therefore, various connectivity solutions have been introduced to resolve such obstacles.

In SSA, the emergence of community ownership projects such as Zenzeleni Networks in South Africa has helped in delivering inexpensive internet connectivity to rural areas by reducing the dependency on traditional telecommunication service providers [67]. Similarly, public–private partnerships like Brazil's 5G trial beds and the Digital Country Agenda of Chile represent other examples where collaborative investments in broadband infrastructure have been made to promote the process of digitalization [68,69].

It is clear from above that intelligent connectivity helps in achieving digital inclusion through connectivity infrastructure development. However, in addition to such investments, further measures need to be taken in order to ensure success.

4.4.2. Sub-Theme 2.2: Enhancing Service Delivery Through Data-Driven Intelligence

Intelligent connectivity contributes to inclusivity by means of improving service delivery through data-driven intelligence. With the help of IoT-based sensing, 5G connectivity, and analysis conducted using AI, services can become more accessible, responsive, and efficient in various sectors including agriculture, health, education, and disaster management.

For example, Hello Tractor uses AI and IoT to enable smallholder farmers to connect to mechanization services, increasing production while ensuring easier access to the agricultural value chain [70]. However, critical assessment reveals limitations: the service requires smartphone access and data connectivity, which are unavailable in many rural areas; tractor rental costs remain prohibitive for the poorest farmers; and device maintenance challenges in remote locations affect reliability. Furthermore, 5G connectivity

and AI-enabled diagnostic tests have significantly improved healthcare in many remote locations due to telemedicine programs [71,72].

Similarly, Southeast Asian countries utilize IoT to monitor natural events in real time and use AI for flood prediction and early warnings [73,74]. Moreover, several educational technologies powered by AI have been introduced there; some examples include adaptive learning platforms and multilingual education services [75,76].

Overall, one can conclude that intelligent connectivity fosters inclusiveness by enhancing the quality, availability, and responsiveness of relevant services rather than just through the introduction of technology.

4.4.3. Sub-Theme 2.3: Supporting Socio-Economic Participation Through Digital Ecosystems

Apart from mere availability and service provision, intelligent connectivity helps to achieve digital inclusion through the creation of connected digital ecosystems, which facilitate active participation in socio-economic activities.

For example, in LATAM, the use of fintech such as Nubank's platforms is seen in using AI to undertake credit assessments based on alternative data in order to include the financially excluded populations in the formal economy [77,78]. Similarly, Medellín, São Paulo, and Mexico City are using smart city technology based on 5G and IoT in order to improve the delivery of public services and citizen involvement [79].

In SEA, the implementation of smart classroom programs in Thailand and the digital learner project in the Philippines, for instance, have facilitated inclusion in educational programs [80,81].

It is apparent from the discussion above that intelligent connectivity is essential for digital inclusion because it helps people to engage in digital economies, improve access to public services and provide educational opportunities.

4.4.4. Regional Comparative Analysis of Intelligent Connectivity Readiness

Comparative analysis reveals significant differences in regional readiness for intelligent connectivity, as shown in Figure 7. SEA demonstrates the highest levels of preparedness due to relatively advanced digital infrastructure, strong mobile adoption, and increasing investments in AI and IoT ecosystems. LATAM follows with comparatively robust connectivity infrastructure and evolving governance frameworks, although territorial inequalities remain substantial. SSA continues to face significant infrastructure and institutional constraints that limit large-scale deployment despite notable innovation in mobile-first solutions [32,82,83].

These findings suggest that infrastructure readiness constitutes an important enabling condition for intelligent connectivity deployment. However, readiness alone does not guarantee digital inclusion. Rather, the developmental impact of intelligent connectivity depends on the interaction between infrastructure, governance, investment, and digital skills. Consequently, intelligent connectivity should be viewed as a socio-technical ecosystem in which technological capabilities and institutional conditions jointly shape inclusion outcomes.

To enhance the empirical grounding of the analysis, Table 5 presents selected case studies illustrating the application of intelligent connectivity across different regional contexts.

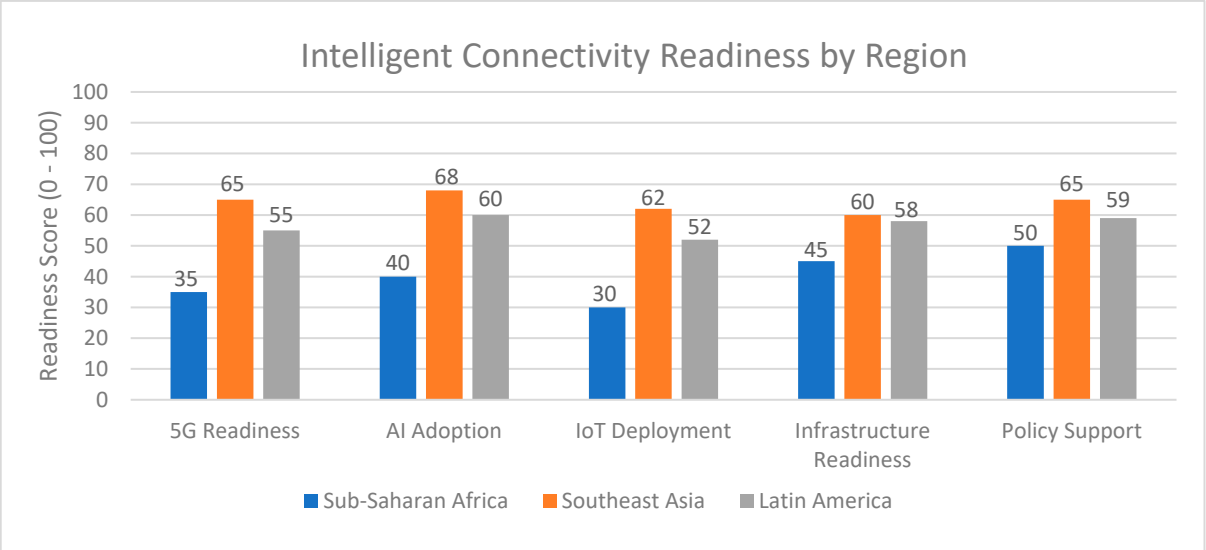


Figure 7. Comparative Readiness for Intelligent Connectivity across SSA, SEA, and LATAM (Source: *Authors' estimates based on ITU [9], GSMA [32,53] and World Bank [42] reports*).

Table 5. Key Intelligent Connectivity Case Studies with Critical Assessment (Source: *Authors' synthesis*).

Region	Case	Technology	Mechanism	Outcomes	Limitations & Challenges
SSA	Zenzeleni	Community Broadband	Local ownership	Affordable connectivity	Small scale; sustainability uncertain; regulatory barriers
SSA	Hello Tractor	AI + IoT	Precision resource allocation	Agricultural inclusion	Requires smartphone/data; high device cost; weather dependency
SEA	Indonesia Flood Warning	AI + IoT	Predictive alerts	Disaster resilience	Dissemination gaps; community capacity constraints
SEA	Philippines Digital Learner	AI Education	Adaptive learning	Educational inclusion	Infrastructure-dependent; teacher training needs
LATAM	Nubank	AI Fintech	Alternative credit scoring	Financial inclusion	Algorithmic bias risks; data privacy concerns
LATAM	Medellín Smart City	5G + IoT	Digital urban services	Service accessibility	Concentrated in affluent areas; equity concerns

These cases highlight how integrated technologies are being deployed to address context-specific digital inclusion challenges.

5. Discussion and Implications

The following discussion draws on supplementary policy and institutional sources to contextualize the findings derived from the structured review corpus. These sources provide additional regional and policy perspectives that support the interpretation of intelligent connectivity initiatives and digital inclusion outcomes across developing economies.

From an examination of the literature review and associated data sets, it is evident that intelligent connectivity holds much promise in addressing digital inequalities in developing nations. However, the impact of intelligent connectivity in mitigating digital divides tends to vary significantly based on contextual factors.

5.1. Key Analytical Insights

Three major learnings emerge from the thematic analysis (Section 4) and comparative regional assessment (Table 4, Figures 6 and 7):

(i) Infrastructure alone is insufficient.

Evidence: The thematic analysis (Sub-theme 1.1) identified that despite 60% mobile broadband coverage in SSA, only 28% use mobile internet services [32]. Similarly, Sub-theme 1.2 revealed that cost and skills barriers prevent meaningful usage even where access exists.

Implication: Advanced connectivity technologies must be supplemented with affordability interventions, skills development, and support for meaningful usage.

(ii) Learning 2: Governance mediates outcomes.

Evidence: Comparing regions (Sub-theme 1.3), SEA and LATAM show better digital outcomes despite similar infrastructure levels, suggesting governance quality is a key differentiator. The analysis of institutional reports [9,61] confirms that countries with stronger regulatory frameworks achieve better digital inclusion outcomes.

Implication: Technology investment alone is insufficient; regulatory capacity, digital strategy, and institutional quality are critical mediators.

(iii) Learning 3: Intelligent connectivity is a socio-technical system.

Evidence: Theme 2 analysis shows that successful intelligent connectivity applications (e.g., Zenzeleni, Hello Tractor, Nubank) combine technology with local institutional arrangements, community participation, and business model innovation. Failures occur when technology is deployed without attention to local context.

Implication: Implementation requires coordination across technological, investment, policy, and social dimensions.

5.2. Regional Evidence

1. Sub-Saharan Africa: Opportunities and Limitations

Community-based projects such as Zenzeleni Networks demonstrate the potential of local ownership models for affordable connectivity [41]. However, these initiatives face significant scalability challenges. Zenzeleni operates in a single rural community, and replication depends on complex regulatory frameworks, sustainable funding, and community capacity.

Critical barriers in SSA include:

- *Energy infrastructure*: 5G base stations consume 3–4 times more energy than 4G, yet 600 million people in SSA lack reliable electricity access [82].
- *Backhaul capacity*: Fibre backbone networks are limited, with many countries relying on satellite or microwave links inadequate for 5G requirements.
- *Affordability*: 5G-enabled devices cost 2–3 times the average monthly income, limiting adoption.
- *Regulatory constraints*: Spectrum licensing processes are often slow and expensive, delaying deployment.

These barriers suggest that while intelligent connectivity holds promise, its near-term impact in SSA will be limited to urban and peri-urban areas, potentially widening existing inequalities.

2. Southeast Asia: Dual-Speed Development

The region exhibits strong 5G deployment in countries like Singapore and South Korea, yet significant gaps persist in rural Indonesia, the Philippines, and Myanmar. Key challenges include:

- *Archipelagic geography*: Extending fibre networks across thousands of islands is economically prohibitive.
- *Policy fragmentation*: National-level strategies often fail to translate to local implementation [75].
- *Digital skills gaps*: Despite high mobile penetration, advanced digital skills remain concentrated in urban areas [80].

The flood monitoring systems in Indonesia demonstrate technical success but raise governance questions about early warning dissemination and community response capacity.

3. Latin America: Uneven Inclusion

While LATAM has higher connectivity than SSA, territorial inequalities remain substantial. Smart city initiatives in Medellín and São Paulo showcase intelligent connectivity; nevertheless:

- These initiatives are concentrated in affluent areas, raising equity concerns.
- Data governance frameworks are often weak, with privacy and security risks.
- The digital divide within cities reflects broader socio-economic segregation [79].

Financial inclusion through fintech (e.g., Nubank) demonstrates positive outcomes, but algorithmic bias in credit scoring raises concerns about discrimination [77].

5.3. Policy and Governance

Governments must adopt integrated digital governance frameworks rather than fragmented, technology-specific policies. Key priorities include:

- *Enabling regulation*: Adaptive spectrum management, rural 5G incentives, and regulatory sandboxes to foster innovation and affordability.
- *Inclusive partnerships*: Public–private–community collaborations that align connectivity initiatives with local development needs.
- *Digital equity frameworks*: National strategies linking 5G, AI, and IoT deployment with education, health, and gender inclusion goals.
- *Trust and security*: Strong data governance and ethical AI policies to safeguard privacy and promote accountability.

These measures collectively transition digital transformation from a purely technological agenda to an inclusive governance paradigm grounded in equity and participation.

5.4. Industry and Innovation Ecosystem

For industry, intelligent connectivity opens opportunities for inclusive and sustainable business models.

- Telecom and technology firms should embrace shared infrastructure and service-based models (e.g., network-as-a-service) to extend reach into underserved regions.
- SMEs and startups can leverage IoT and AI for localized solutions in agriculture, healthcare, and financial inclusion.
- Cross-sector collaboration among telecoms, energy providers, and public institutions can amplify innovation through data sharing and interoperability.

Together, these dynamics suggest that inclusive intelligent connectivity depends not only on technological deployment but on the orchestration of multi-actor innovation ecosystems that align commercial incentives with developmental goals.

5.5. Research and Knowledge Development

Research institutions should focus on generating context-specific evidence to inform policy and practice. Emerging priorities include:

- Modelling socio-technical dynamics of intelligent connectivity adoption.
- Developing metrics for inclusive connectivity and socio-economic impact assessment.
- Investigating business model innovations for low-resource environments.
- Conducting policy foresight studies to anticipate technological and regulatory shifts.

These research priorities highlight the need for interdisciplinary scholarship to move beyond descriptive accounts toward theory-building and policy-relevant insights grounded in developing economies contexts.

5.6. Limitations

This study has several limitations that should be considered when interpreting findings:

1. Language and database bias: The literature search was limited to English-language publications and Western-indexed databases. The relevant literature in French, Portuguese, Spanish, or local languages, as well as regional journals, may have been excluded. This is particularly consequential for Latin American research (Spanish/Portuguese) and Francophone Africa.
2. Developing-economy evidence base: Only 10 of 63 peer-reviewed articles (16%) focused on developing economies. This structural bias in the evidence base constrains the strength of conclusions about developing economies and introduces potential overgeneralization from developed economy evidence.
3. Intra-regional heterogeneity: The analysis treats SSA, SEA, and LATAM as coherent regions, masking significant within-region variation. For example, Nigeria and South Africa, or Indonesia and Singapore, exhibit vastly different digital inclusion profiles.
4. Early-stage technology: 5G and advanced AI deployments in developing economies are still in early stages, limiting available evidence and making conclusions provisional.
5. Single-author screening: Despite verification procedures (Kappa = 0.82), single-author screening introduces potential selection bias, particularly in subjective inclusion/exclusion decisions.
6. Descriptive case studies: Many included studies provide descriptive rather than causal evidence, limiting the ability to draw strong conclusions about impact.
7. Dynamic technology landscape: The rapid evolution of intelligent connectivity technologies means findings may become outdated quickly.
8. No primary data collection: The study synthesizes existing research rather than generating new empirical evidence. The conceptual model requires primary validation through qualitative or quantitative approaches.

The following strategies were employed to address the limitations:

- The dual-evidence strategy (peer-reviewed + institutional reports) partially mitigates the developing-economy evidence gap.
- The integrated conceptual framework is presented as provisional, requiring empirical validation.
- Limitations are transparently acknowledged to guide interpretation.

5.7. Risks and Unintended Consequences

While this review has emphasized the potential of intelligent connectivity for digital inclusion, a balanced analysis must address significant risks:

Algorithmic Bias and Exclusion: AI systems trained on Global North datasets may fail or discriminate in developing economy contexts. Voice recognition systems often

perform poorly with regional accents, and credit scoring algorithms may perpetuate discrimination against marginalized groups [84]. This creates new forms of exclusion even as connectivity improves.

Data Privacy and Surveillance: IoT deployments generate extensive personal and community data, raising concerns about surveillance, data exploitation, and lack of data governance frameworks in many developing countries [9]. Vulnerable populations may be disproportionately affected.

Increased Digital Dependency: Intelligent connectivity may create new forms of dependency on foreign technology providers, data centres, and cloud services, potentially undermining digital sovereignty [85]. This raises concerns about data localization and national security.

Infrastructure Lock-In: Early investment in specific technologies may lock countries into suboptimal paths if technology evolves rapidly. For example, 5G investment may become obsolete as 6G emerges, particularly costly for resource-constrained economies.

New Forms of Exclusion: Intelligent connectivity may create a "three-tier" divide between those with intelligent connectivity, those with basic connectivity, and those with no connectivity, potentially widening rather than narrowing the gap.

Environmental Concerns: 5G and IoT deployment increases energy consumption and electronic waste, with environmental impacts disproportionately affecting developing countries [86].

Mitigation Strategies:

- Develop inclusive AI datasets and fairness-aware models;
- Strengthen data governance frameworks and privacy protections;
- Promote open standards and interoperability;
- Invest in renewable energy integration for connectivity infrastructure.

6. Open Research Challenges

Despite promising pilots of 5G, AI, and IoT in emerging markets, several critical research challenges must be addressed to ensure inclusive and sustainable digital transformation in developing economies. These challenges span technology, regulation, equity, and sustainability domains.

Scope Acknowledgement: While this review focuses on 5G, AI, and IoT as the core technologies of intelligent connectivity, due to their relative maturity and documented applications in developing economies, emerging technologies including 6G, Metaverse, distributed ledger technologies, and advanced data centre architectures may also shape future digital inclusion outcomes. These are acknowledged as important areas for future investigation beyond the current scope.

Beyond this scope, several critical research challenges must be addressed to ensure inclusive and sustainable digital transformation in developing economies. These challenges span technology, regulation, equity, and sustainability domains.

Localization of AI Models: AI systems often fail to generalize to the linguistic and cultural diversity of developing regions due to training on Global North datasets. Key questions include how to train low-resource language models, reduce Western bias, and involve local communities in dataset creation [87].

Regulatory and Policy Frameworks: Effective governance in countries with limited institutional capacity remains difficult. Research should focus on agile regulatory sandboxes, inclusive policymaking involving marginalized groups, and preventing monopolies or infrastructure lock-in [9].

Energy Efficiency and Sustainability: Many 5G and IoT deployments require reliable power, which is challenging in off-grid or weak-grid areas typical for SSA, SEA, and LATAM.

Research gaps include suitable low-power protocols, renewable energy integration, and AI-driven dynamic energy optimization [86].

Algorithmic Fairness and Bias: AI risks reinforcing social biases due to unrepresentative training data, disproportionately affecting marginalized populations. Open challenges include developing explainable AI tools, inclusive datasets, and fairness-aware pipelines with community oversight [84].

Impact Measurement and Evaluation: There is a lack of empirical, context-specific impact assessments for intelligent connectivity initiatives. Research should identify relevant indicators, employ mixed-methods capturing quantitative and lived experiences, and institutionalize evaluation in national strategies [87].

Interoperability and Open Standards: Fragmentation risks arise from proprietary systems and inconsistent regulations. Research directions include promoting open-source platforms, government incentives for modular architectures, and global standardization collaborations such as ITU and IEEE engagement [85].

These open challenges underscore the need for interdisciplinary, participatory, and decolonial research approaches that place affected communities at the centre of design, development, and deployment processes. Intelligent connectivity can be a transformative tool, but only if it is ethically grounded, locally informed, and inclusively governed.

Table 6 summarizes open research challenge areas, key research questions, and sample focus areas.

Table 6. Summary of Open Research Challenges (Source: *Authors' synthesis*).

Research Challenge Area	Key Research Question	Sample Focus Area
Localization of AI Models	How can AI models be adapted to diverse linguistic and cultural contexts?	Low-resource NLP, community-curated datasets, culturally aware AI design
Regulatory & Policy Frameworks	What governance structures support rapid deployment while ensuring equity and security?	Agile regulatory sandboxes, spectrum policy, inclusive policymaking
Energy Efficiency & Sustainability	How can IoT systems operate sustainably in off-grid environments?	Low-power protocols, renewable integration, edge computing
Algorithmic Fairness & Bias	How can AI bias be detected, explained, and mitigated in local contexts?	Fairness-aware models, explainable AI, data governance frameworks
Impact Measurement & Evaluation	What methods best evaluate long-term effects of digital interventions?	Mixed-method evaluations, context-specific metrics, participatory M&E
Interoperability & Open Standards	How can different technologies and vendors interoperate seamlessly?	Open APIs, modular designs, adherence to global standards

7. Conclusions

This study addressed the question: How can intelligent connectivity technologies (5G, AI, and IoT) contribute to bridging the digital divide in developing economies? Through a structured literature review of 63 peer-reviewed articles and supplementary analysis of institutional reports, the study arrives at four key conclusions.

First, intelligent connectivity offers significant potential across agriculture (precision farming, resource optimization), healthcare (telemedicine, AI diagnostics), education (adaptive learning platforms), and financial inclusion (alternative credit scoring). Case studies across SSA, SEA, and LATAM demonstrate innovative applications that address context-specific barriers. However, these applications remain at pilot or early deployment stages in most developing economies.

Second, technological deployment alone is insufficient. The analysis reveals that enabling conditions, including governance quality, institutional capacity, digital skills development, and investment mechanisms, critically mediate the impact of intelligent

connectivity on digital inclusion. Without these conditions, intelligent connectivity may widen rather than narrow existing divides.

Third, the digital divide manifests differently across regions. SSA faces infrastructure deficits and affordability constraints as primary barriers. SEA exhibits dual-speed development where urban advancement coexists with rural exclusion. LATAM shows higher connectivity but persistent socio-economic inequalities that limit meaningful participation. These differences require context-specific policy responses.

Fourth, intelligent connectivity is a socio-technical system rather than a purely technological solution. Its implementation requires coordination across technological, institutional, economic, and human dimensions. The proposed conceptual model (Figure 2) provides a framework for understanding how enabling conditions facilitate intelligent connectivity and lead to inclusive digital transformation outcomes.

Key limitations include the small proportion of developing-economy peer-reviewed studies (16% of the corpus), single-author screening, English-language bias, and the early stage of technology deployment in many contexts. The conceptual model requires empirical validation through primary research.

Future research directions: Priority areas include: (1) empirical validation of the conceptual model through country-level case studies; (2) impact assessment of intelligent connectivity initiatives using mixed methods; (3) examination of algorithmic bias, data governance, and digital sovereignty in developing-economy contexts; and (4) investigation of business model innovations for low-resource environments.

In conclusion, intelligent connectivity represents a transformative opportunity for digital inclusion, but its benefits will only be realized through deliberate governance, targeted investment, and genuine participation of marginalized communities in design and implementation. Addressing the structural barriers that limit meaningful technology use is as important as deploying the technology itself.

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Conflicts of Interest: The authors declare no conflicts of interest.

Abbreviations

The following abbreviations are used in this manuscript:

5G	Fifth Generation
3GPP	Third Generation Partnership Project
ADB	Asian Development Bank
AI	Artificial Intelligence
ECLAC	Economic Commission for Latin America and the Caribbean
GSMA	Global System for Mobile Communications Association
IoT	Internet of Things
ITU	International Telecommunication Union

LATAM	Latin America
NPL	Natural Language Processing
OECD	Organization for Economic Co-operation and Development
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
SEA	Southeast Asia
SSA	Sub-Saharan Africa
UNESCO	United Nations Educational, Scientific and Cultural Organization

Appendix A

Table A1. Distribution of Articles by Journal.

Journal	Frequency	(%)
Frontiers in Business Economics and Management	5	7.937
Global Journal of Engineering and Technology Advances	4	6.349
AI and Ethics	4	6.349
International Journal of Advanced Academic Studies	4	6.349
Journal of Information Systems Engineering & Management	3	4.762
Policy & Internet	3	4.762
World Journal of Advanced Research and Reviews	3	4.762
The African Journal of Information Systems	3	4.762
Critical review of social sciences studies	3	4.762
European Journal of Computer Science and Information Technology	2	3.175
Frontiers in Artificial Intelligence	2	3.175
International Journal for Multidisciplinary Research	2	3.175
International Journal of Academic Research in Business and Social Sciences	2	3.175
Journal of Computer Science and Technology Studies	2	3.175
Journal of Information Communication and Ethics in Society	2	3.175
Social Science Review a Multidisciplinary Journal	2	3.175
Telecommunications Policy	2	3.175
Telematics and Informatics	2	3.175
African Journal of Science, Technology, Innovation and Development	1	1.587
AIS Transactions on Human–Computer Interaction	1	1.587
Big Data & Society	1	1.587
Telecommunications and The Digital Economy	1	1.587
Emerging Media	1	1.587
Finance & Accounting Research Journal	1	1.587
IEEE Communications Standards Magazine	1	1.587
International Journal of Big Data Intelligent Technology	1	1.587
International Journal of Electronics and Telecommunications	1	1.587
International Journal of Science and Research Archive	1	1.587
International Review of Management and Marketing	1	1.587
Research Review International Journal of Multidisciplinary	1	1.587
Sustainability	1	1.587
Total	63	100

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