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Beyond Hype and Hardware: The Structural Determinants of EdTech Sustainability in Ethiopia's Quest for SDG 4

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Abstract:
Ethiopia, Africa's second most populous nation, confronts a profound educational paradox: a youthful demographic dividend – with over 70% of the population under 30, coexists with a failing education system characterised by a 8.4% university admission rate, 42% graduate unemployment, and over 9 million children out of school. Educational technology (EdTech) has been heralded as a transformative solution, yet sustainability remains elusive. This paper critically examines the structural determinants shaping EdTech sustainability in Ethiopia, moving beyond techno-solutionist narratives to interrogate the interconnected infrastructural, human, financial, and geopolitical factors that perpetuate a self-reinforcing vicious cycle of unsustainability. Employing a Critical Interpretive Synthesis (CIS) combined with a single-embedded case study design, the study synthesises evidence from policy documents, startup ecosystem data, and scholarly literature. The findings reveal that infrastructural failure, characterised by unreliable electricity (44% rural access), limited connectivity (9% rural internet penetration), and prohibitive data costs diminishes teacher morale and agency, reducing technology utilisation and perceived impact. This dissuades investors, reinforcing governmental reluctance to scale digital contracts and perpetuating infrastructural neglect. The paper introduces the 3-P Alignment Model (People, Partnerships, Policy) as an analytical framework for sustainable EdTech deployment. Policy recommendations include prioritizing universal electrification and subsidized bandwidth over hardware procurement, shifting donor funding from short-term pilots to patient capital (5-10 year horizons), and centring foundational literacy through low-tech, high-touch approaches. The paper concludes that systemic integration, not piecemeal digitization, constitutes the only sustainable pathway to leveraging technology for educational development in Ethiopia and analogous fragile states.
Keywords:
Educational technology (EdTech); Ethiopia, structural determinants; 3-P Alignment Model; sustainable development goal 4 (SDG 4)

I. Introduction

1.1 The Global Impetus: Situating EdTech within the UN's SDG 4 Agenda and the Post-COVID-19 "Digital Transformation" Rush in Developing Economies

The global education landscape has undergone a profound transformation over the past decade, driven by the convergence of technological innovation, international development imperatives, and the disruptive shock of the COVID-19 pandemic. At the heart of this transformation lies Sustainable Development Goal 4 (SDG 4), which aims to "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all" (United Nations, 2015). The pandemic, which at its peak forced 1.6 billion children out of school worldwide, served as both a catalyst and a magnifying glass for the potential of educational technology (EdTech) to sustain learning amidst crisis (Education Outcomes Fund, 2025).

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The acceleration of EdTech adoption during the pandemic was unprecedented. Governments, international organisations, and private sector actors rapidly pivoted to digital and remote learning solutions, often framing technology as the primary vehicle for educational continuity and recovery (Biliaminu et al., 2025). This "digital transformation" rush, however, has been accompanied by growing concerns about its equity implications. As Biliaminu et al. (2025) observed in their systematic review of Learning Management Systems (LMS) adoption in Nigeria, while such technologies expanded educational access, they simultaneously "widened the digital divide, affecting low-income and rural students". The authors further emphasised that "pedagogical challenges" and "disparities in learning outcomes" persisted due to "digital literacy gaps and inadequate teacher training".

UNESCO has been at the forefront of efforts to harness digital technologies for educational development, operating ICT in Education programmes that "support Member States in harnessing the potential of information and communications technologies for their achievement of Sustainable Development Goal 4 (SDG4) and inclusive quality digital learning" (UNESCO, 2025). Yet even as these programmes expand, UNESCO has cautioned that "while technology has provided lifelines to millions, it simultaneously excludes a significant number of students due to unequal access" (Linis-Dinco, 2025). This disparity, the organisation argues, is "more pronounced in regions ravaged by conflict and poverty, marked by limited Internet connectivity and lack of fundamental infrastructures to even meet basic needs".

The global EdTech discourse, therefore, exists in a state of productive tension. On one hand, technology is celebrated as a transformative force capable of leapfrogging traditional educational constraints in developing economies. On the other, a growing body of evidence suggests that without deliberate attention to structural inequities, EdTech risks replicating, and even exacerbating, and existing patterns of exclusion. This tension is nowhere more acute than in Sub-Saharan Africa, where the promise of digital education confronts the reality of infrastructural deficits, resource constraints, and profound educational crises. Ethiopia, as this paper will argue, represents a paradigmatic case of this global dilemma.

1.2 The Ethiopian Paradox: Presenting the Core Tension

Ethiopia presents a striking paradox. It is one of the youngest nations on earth—with over half of its population under 18 and approximately two-thirds under 30, yet its education system is profoundly failing to meet the needs of this demographic dividend. The scale of the crisis is stark. In 2025, only 8.4% of the 585,882 students who sat for the national Grade 12 examination attained the minimum passing score of 50%, qualifying them for university enrollment (Addis Standard, 2025; Goshu, 2024; Goshu, et al. 2024). While this represented a slight improvement from the previous year's 5.4% and the 3.3% pass rate in 2023, it nonetheless "paints a consistent picture of a profound systemic fracture that extends far beyond the classroom". The fact that more than one-third of the nation's schools did not produce a single passing student has been described as a clear indication of systemic deficiencies, highlighting deep structural challenges instead of isolated cases of examination malpractice.

The crisis extends beyond secondary education into higher education and the labour market. Research investigating the relationship between rising enrolment in Ethiopian universities and graduate employability found that 38.7% of graduates were unemployed or had not yet started their own businesses, a condition attributed to "skill gaps, job security concerns, weak economic conditions, and misalignment between academic programmes and

labour market demands" (Tadesse, 2025; Goshu, et al. 2024). The study further found that "making higher education more accessible significantly reduces both the quality ($\beta = -0.26$, $p < 0.01$) and career chances for graduates ($\beta = -0.23$, $p < 0.01$)". Other estimates suggest that graduate unemployment within the first year after graduation may be as high as 60–70% (APPEAR project, 2025). As one analysis concluded, "high enrolment in higher education institutions (HEIs) degraded education quality and left graduates unprepared for the workforce, posing a risk to national stability" (Tadesse, 2025).

Compounding these educational challenges is a profound digital divide. Internet penetration in Ethiopia reached only 19.4% in 2024, with access heavily concentrated in urban areas (Health Care Professionals Study, 2025). The disparity in electricity access is equally pronounced: while 95.7% of urban residents have access to grid electricity, only 43.6% of rural residents are covered. This urban-rural divide in infrastructure has direct implications for education, as "rural schools were characterized by inadequate ICT infrastructure, unreliable electricity, limited internet connectivity, insufficient digital devices, and a shortage of locally relevant digital learning materials" (Digital Learning and Equity Study, 2026).

Yet despite these formidable constraints, Ethiopia has positioned itself as an emerging digital hub in the Horn of Africa. The government has articulated an ambitious vision through its Digital Education Strategy and Implementation Plan (2023–2028) , which aims to "guide the formation of a new generation of Ethiopian youth who are equipped with advanced skills that make them competent in the 21st century's digital environment" (Ministry of Education, 2023). The strategy is anchored in four pillars, digital infrastructure and services, digital capabilities and skills, an enabling policy environment, and digital content and platforms—and is explicitly aligned with SDG 4.

This juxtaposition, between a failing education system and an ambitious digital strategy; between deep infrastructural deficits and a vision of technological leapfrogging; between the realities of rural poverty and the aspirations of a digital hub, constitutes what this paper terms the Ethiopian EdTech paradox. It is a paradox that demands urgent scholarly attention, not least because Ethiopia's experience offers critical lessons for other low-income countries navigating similar tensions.

1.3 Problematising the Narrative: Critiquing the Pervasive "Magic Bullet" Discourse

The Ethiopian EdTech paradox is rendered more acute by a pervasive discourse that this paper critically interrogates: techno-solutionism. Techno-solutionism refers to "the belief that many of society's ills can and should be solved by technology" (Selwyn, 2025; Goshu, 2025). In education, this manifests as "the idea that digital technologies are essential for creating high-quality educational environments" (Selwyn, 2023, as cited in Notion, n.d.). As Linis-Dinco (2025) observes, "Technology's celebrated integration into education often masks deep inequalities and the profit-driven ties between the state and capital". EdTech providers, she argues, "have gone as far as to hype up their products and describe them as revolutionary," yet such characterisations are "nothing more than a marketing and public relations terminology" that has been "revolutionary for the financial relationships between the state and the capital, highlighting the relentless drive for profit rather than a genuine educational revolution".

The critique of techno-solutionism is not a rejection of technology per se. Rather, it is a call to recognize that "technology is a tool and must not be seen as an end in itself but as a means to facilitate broader educational and social objectives" (Linis-Dinco, 2025). It is an

insistence that "addressing the educational digital divide requires nuanced and strategic interventions" and a "communal move beyond techno-solutionism". In the context of low- and middle-income countries, this critique is particularly urgent. As scholars have noted, "for many developing countries, the cost of digital devices and the Internet is prohibitively high for a large portion of the population, particularly in rural areas and amongst marginalised communities" (Linis-Dinco, 2025). This "economic barrier does more than widen the gap between the rich and the working class. In fact, it strikes at the very heart of educational equity".

The Ethiopian context exemplifies the dangers of techno-solutionist thinking. The Digital Education Strategy (2023–2028), while commendable in its ambition, risks being interpreted through a techno-solutionist lens that prioritizes hardware procurement and platform deployment over the deeper structural reforms necessary for sustainable educational improvement. The strategy's emphasis on creating "an enabling infrastructure and connectivity for digital education" (Ministry of Education, 2023) is necessary but insufficient. As the EdTech Hub (2025) cautions, "effective EdTech implementation in low-resource schools starts with understanding local challenges and aligning with government priorities," and sustainability requires that "technology is used strategically, sustainably, and in ways that truly support teaching and learning". Similarly, a framework for educational technology adoption in developing countries must incorporate "education-specific factors and local contexts" beyond mere technological access (ETADC Framework, 2025).

II. Review of Literature

The theoretical framework for this paper is constructed through a critical synthesis of four interconnected bodies of literature: the critical philosophy of technology, human capital theory, infrastructure studies, institutional theory, and education in emergencies scholarship. This framework is designed to move beyond simplistic models of technology adoption, such as the Technology Acceptance Model (TAM) or the Diffusion of Innovations (DOI) theory, towards a multi-layered socio-technical and political economy analysis that is appropriate for the complex realities of low-resource, fragile, and post-conflict contexts. The framework proceeds in four parts: first, a critique of technological determinism grounded in Feenberg's Critical Theory of Technology; second, the articulation of a Structural Determinants Framework (SDF) synthesising human capital, infrastructure, and institutional perspectives; third, the introduction of the 3-P Alignment Model (People, Partnerships, Policy) as an analytical lens for sustainable scaling; and fourth, a situating of this framework within the literature on Education in Emergencies (EiE) to account for the geopolitical and post-conflict dimensions often marginalised in mainstream EdTech scholarship.

2.1 Beyond Technological Determinism: A Critical Review of Why Technological Diffusion Theories Fail in Low-Connectivity Economies

The dominant paradigms for understanding technology adoption in education—most notably the Technology Acceptance Model (TAM) (Davis, 1989) and Rogers' Diffusion of Innovations (DOI) theory (Rogers, 2003)—have exerted considerable influence over EdTech policy and practice in developing countries. These theoretical models emphasize users' perceptions of usefulness and ease of use, as well as the innovation characteristics that influence diffusion, and have been extensively applied to understand and predict technology integration within educational environments (Scherer et al., 2019; Venkatesh et al., 2003). Yet, as a growing body of critical scholarship has demonstrated, these frameworks are

fundamentally inadequate for understanding the dynamics of EdTech in low-connectivity economies.

The limitations of these models are threefold. First, they are methodologically individualist, focusing on the attitudes and behaviours of individual users while abstracting from the structural conditions; infrastructural, economic, political, and institutional that shape the possibilities for technology use (Selwyn, 2010, 2016). Second, they are decontextualizing, treating technology adoption as a linear, predictable process that unfolds similarly across different settings, irrespective of local material conditions, power relations, or cultural contexts (McGarr, 2019). Third, they are technologically determinist in their implicit assumption that technology itself drives change, obscuring the social, political, and economic forces that shape both technological development and its outcomes (Wilson, 2002).

As Wilson (2002) argued in her critical discourse analysis of the international ICT and development agenda, "assumptions of technological determinism and a view of technology as a neutral tool for development underlie the ICT and development discourse". This framing, she contends, allows "the complex political factors influencing poverty and inequality at local, national and international levels to be hidden, or at least go largely unquestioned". In the context of education policy, technological determinism manifests as the belief that "technology is the autonomous driver of educational change" (Kim, 2026), a discourse that frames digital innovation as "a neutral and inevitable force in educational reform" while marginalising critical questions about equity, power, and structural inequality.

Similarly, Johnson (1999) provided a trenchant critique of technologically mediated education as it is "widely prescribed for developing countries". He concluded that "the constraints of technological mediation, and its destructive impact on teaching, show its inability to provide for adequate educational development (which is necessarily grounded in a concrete human relationship in a real not virtual, dynamic social and cultural context)". Johnson's work anticipates the central concern of this paper: that the wholesale adoption of technological solutions in contexts of profound structural inequality risks not only failing to improve educational outcomes but actively undermining the relational and contextual foundations of quality education.

To move beyond technological determinism, this paper draws on Andrew Feenberg's Critical Theory of Technology (Feenberg, 1991, 1999, 2002). Feenberg's framework offers a powerful alternative to both technological determinism and instrumentalism by insisting that technology is socially shaped—that is, technologies embody the values, interests, and power relations of the societies in which they are designed and deployed, but they also remain sites of democratic contestation and potential transformation (Feenberg, 2002). As Feenberg (2002) argues, the "technical code" of any technology reflects the biases and interests of dominant groups; however, these codes can be challenged and democratised through social mobilisation and critical intervention.

2.2 The Structural Determinants Framework (SDF): Synthesising Human Capital, Infrastructure, and Institutional Perspectives

Building on the critique of technological determinism, this paper proposes a Structural Determinants Framework (SDF) that synthesises three distinct but interrelated theoretical traditions: human capital theory, infrastructure studies, and institutional theory. This synthesis is necessary because the sustainability of EdTech in low-resource contexts cannot be

explained by any single factor; rather, it is shaped by the complex interplay of human, material, and institutional conditions.

Human Capital Theory: Teacher Agency, Digital Literacy, and Student Preparedness

Human capital theory, originating in the work of Schultz (1961) and Becker (1964), posits that investments in education and training enhance individuals' productive capacities and, by extension, contribute to economic growth and social development. While the theory has been subject to extensive critique, particularly for its economistic assumptions and its neglect of structural inequalities; it remains a valuable lens for understanding the role of skills, knowledge, and competencies in the effective use of educational technology.

In the EdTech context, human capital refers to the digital literacy, pedagogical knowledge, and adaptive capacities of teachers, as well as the foundational literacy, numeracy, and digital skills of students. As research on the education-technology-economy nexus has demonstrated, "countries that invest in human capital and digital transformation demonstrate higher productivity, stronger innovation capacity, and more diversified economic structures" (Education-Technology-Economy Nexus Study, 2026). Conversely, the absence of these capacities constitutes a critical constraint on EdTech effectiveness. Studies have consistently found that "basic literacy and numeracy are foundational but not sufficient" for effective technology integration, and that "further support is required to develop basic digital skills and technology integration in teaching and learning" (Mashilo & Shekgola, 2024).

In the Ethiopian context, the human capital dimension is particularly acute. As noted in the introduction, teacher training in digital pedagogy is inadequate, and many teachers lack the confidence and competence to integrate technology meaningfully into their practice. Moreover, the low levels of foundational literacy and numeracy among students, evidenced by the persistently low pass rates in national examinations, mean that even well-designed EdTech interventions may fail to achieve their intended outcomes if learners lack the basic skills to engage with digital content. This paper therefore treats teacher agency, digital literacy, and student preparedness as critical structural determinants that mediate the relationship between EdTech deployment and educational outcomes.

Infrastructure Studies: The Materiality of Connectivity, Energy, and Hardware Maintenance

Infrastructure studies, as a distinct field of inquiry, emerged from science and technology studies (STS) and have been particularly influential in understanding the material, political, and social dimensions of technological systems (Star, 1999; Bowker & Star, 1999; Larkin, 2013). Infrastructure, in this tradition, is not merely a technical backdrop but an active mediator of social relations and possibilities (Costa et al., 2026). As Costa and colleagues (2026) demonstrate in their study of teacher technology appropriation in Brazil, "infrastructure appears to operate as an active mediator that shapes, but does not determine, pedagogical possibilities". Their research identified three qualitatively distinct "techno-pedagogical ecosystems"; Survival, Limited Adequacy, and Competition—each characterised by different infrastructural configurations that produced different patterns of teacher adaptation and pedagogical practice. Crucially, they found a "functional inversion where stable connectivity was perceived by teachers as a more critical conversion factor than equipment quantity".

This finding has profound implications for the Ethiopian context, where internet penetration stands at just 19.4% (Health Care Professionals Study, 2025), and where rural

schools are characterised by "inadequate ICT infrastructure, unreliable electricity, limited internet connectivity, insufficient digital devices, and a shortage of locally relevant digital learning materials" (Digital Learning and Equity Study, 2026). In such settings, the materiality of connectivity, energy, and hardware maintenance is not a peripheral concern but a fundamental structural determinant that shapes what is possible in educational practice.

Infrastructure studies also draw attention to the maintenance and repair of technological systems, a dimension that is frequently overlooked in EdTech policy and practice (Jackson, 2014). In low-resource contexts, where devices are often donated or procured through development aid, the absence of sustainable maintenance and repair systems means that hardware quickly becomes obsolete or non-functional, rendering investments in EdTech ineffective. This paper therefore treats infrastructural reliability and maintainability as critical determinants of EdTech sustainability.

Institutional Logics: The Gap between Policy Formulation and Implementation

Institutional theory, and more specifically the concept of institutional logics (Thornton & Ocasio, 1999; Friedland & Alford, 1991), provides a lens for understanding the gap between policy formulation and implementation in educational systems. Institutional logics are the "belief systems and associated practices" that shape how actors interpret and respond to their environment (Thornton et al., 2012). In the education sector, multiple and often competing logics; bureaucratic, professional, market, and community-based—coexist and create tensions that shape policy outcomes.

As Tamir (2026) demonstrates in his analysis of grading policy in higher education, "institutional theory, in particular, is used to explain the gap between formal expectations and actual practices, emphasising the role of middle-level academic leaders in navigating competing pressures". Similarly, Kanju and Masabo (2025) employ new institutionalism to examine "the implications of institutional politics in the implementation of higher education policy reforms" reveals how institutional structures and political dynamics mediate the translation of policy into practice.

2.3 The Ethiopian Digital Education Ecosystem – Context, Policy, and Emergent Actors

a. Demographic Imperatives: Quantifying the "Youth Bulge" and the Demand-Supply Gap in Secondary and Tertiary Education

Ethiopia's demographic profile presents both an extraordinary opportunity and a profound challenge for the education system. With an estimated population of 135.5 million in 2025 and a median age of just 19.1 years, the country is among the youngest in the world (Worldometer, 2025, as cited in University of Cambridge, 2025). Over 70 per cent of the population under the age of 30, with approximately 31.5 million people, constitutes about 30 per cent of the total population between the ages of 15 and 29 (Ethiopian Statistical Service, 2021, as cited in University of Cambridge, 2025). This "youth bulge" positions Ethiopia to reap a substantial demographic dividend, provided that the education system can equip this generation with the skills necessary for productive participation in the economy.

Yet the education system is failing to meet this demand. The 2025 Grade 12 national examination, the primary gateway to higher education, saw 581,905 students sit for the test, of which only 48,929, or 8.4 per cent, achieved the minimum passing score of 50 per cent (Addis Standard, 2025a). This figure represents a sharp decline from 2022, when 896,520 students took the examination (Addis Standard, 2025a). The 8.4 per cent pass rate, while a modest

improvement from the previous year's 5.4 per cent and the 3.3 per cent recorded in 2023, nonetheless "paints a consistent picture of a profound systemic fracture that extends far beyond the classroom" (Addis Standard, 2025b, para. 4). As one analysis observed, " over a third of all schools in the country could not produce a single passing student" (Addis Standard, 2025b, para. 6).

The crisis is compounded by resource allocation patterns that favour a minority of learners at the expense of the majority. Ethiopia allocates approximately 3.7 per cent of its gross domestic product (GDP) to education, significantly below the international benchmark of 6 per cent recommended by the United Nations Educational, Scientific and Cultural Organization (UNESCO) (Ethiopian Business Review, 2025; UNICEF, 2025). The proportion of the national budget allocated to education has been decreasing over time, dropping from 16.7 per cent in 2023/24 to 12 per cent in 2024/25 (UNICEF, 2025). Within this constrained budget, primary and secondary schools, which serve the vast majority of learners, often receive a limited share of resources (Ethiopian Business Review, 2025).

The consequences are stark: as of 2025, more than nine million children across Ethiopia are out of school due to conflict, displacement, and natural disasters (Addis Standard, 2025c; UNICEF, 2025). Over 6,000 schools remain closed, and more than 10,000 have been damaged or destroyed (Addis Standard, 2025c). The highest numbers of out-of-school children are concentrated in the Amhara (4.4 million), Oromia (3.2 million), and Tigray (1.2 million) regions (Addis Standard, 2025c). This demand-supply gap creates a paradoxical situation: a rapidly growing youth population with escalating educational aspirations confronting a contracting and increasingly selective education system.

b. Policy Infrastructure: The Digital Education Strategy (2023–2028) and Its Four Pillars

In response to these challenges, the Ethiopian Ministry of Education developed the Digital Education Strategy and Implementation Plan (2023–2028), a five-year initiative designed to guide the deployment of digital technologies across the education sector. The strategy aims to tackle long-standing challenges in access, equity, and quality through the strategic integration of technology, with the overarching goal of forming "a new generation of Ethiopian youth who are equipped with advanced skills that make them competent in the 21st century's digital environment" (Ministry of Education, Ethiopia, 2023, p. 4).

The strategy is organized around eight building blocks and nine strategic objectives. Key priorities include: curriculum-aligned content and platforms; national strategies and cybersecurity; Education Management Information System (EMIS) 2.0 data systems; EdTech ecosystem growth; research centres of excellence; teacher digital-competency certification; and learner digital skills across all levels (Ministry of Education, Ethiopia, 2023). The strategy explicitly stresses financing, leadership, inclusion, and partnerships as cross-cutting enablers (Ministry of Education, Ethiopia, 2023). It is complemented by the e-Learning for Strengthening Higher Education (e-SHE) initiative, a multi-stakeholder project owned by the Ministry of Education that aims to boost the relevance, quality, access, and resilience of higher education through the rollout of learning management systems across 50 public universities (University World News, 2025).

However, a critical analysis reveals significant alignment gaps between the strategy's ambitions and implementation realities. First, the strategy's emphasis on infrastructure presupposes the existence of reliable electricity and connectivity, conditions that are absent in

much of rural Ethiopia. While mobile broadband coverage now reaches 94 per cent of the population technically, only 25 per cent of Ethiopians are regular internet users, and 79 per cent of the population remains unconnected due to limited infrastructure and low digital literacy (UNESCO, 2025). The urban-rural divide is stark: 42 per cent of the urban population uses the internet, compared to just 9 per cent in rural areas (Internet Society, 2025). Second, the teacher digital-competency certification framework, while commendable, requires substantial investment in pre-service and in-service training that is not yet adequately funded. Third, the strategy's focus on higher education and technical and vocational education and training (TVET) institutions may inadvertently divert resources away from the primary and secondary levels where the most acute crises exist. Fourth, the strategy's implementation relies heavily on partnerships with private sector actors, raising questions about accountability, equity, and the risk of commercial interests overshadowing educational objectives.

c. Mapping the Startup Ecosystem: Emergent Innovations and "Glocalized" Solutions

Despite these structural constraints, a nascent but dynamic EdTech startup ecosystem has emerged in Ethiopia, concentrated primarily in Addis Ababa. These enterprises are developing locally grounded solutions that attempt to navigate the infrastructural realities of low-connectivity and low-resource contexts.

GlobeDock Academy: AI-Powered Offline-First Learning

The most prominent example is GlobeDock Academy, an EdTech company that provides an AI-powered, offline-first digital learning solution designed to improve the quality and accessibility of secondary education across Ethiopia (UNESCO, 2026). The platform serves learners in Grades 7 to 12, with a strong focus on underserved areas and vulnerable groups, including girls (UNESCO, 2026). Since its launch in 2023, the platform has engaged hundreds of thousands of learners nationwide; one source indicates that it has enabled over 500,000 students to access the national curriculum even with limited internet data (GlobeDock Academy, 2026).

The platform's key innovation lies in its offline-first architecture: content is migrated to mobile apps with offline access enabled through downloadable lessons and study notes, allowing learners to access educational materials even without internet connectivity (GlobeDock Academy, 2025a, 2025b). Content is produced via a proprietary AI-agentic system that automates approximately 70 per cent of over 5,000 curriculum-aligned lessons (UNESCO, 2026). The platform has also developed a GlobeDock Teach Hub in partnership with UNICEF, providing digital training and classroom tools to support teachers (UNESCO, 2026).

GlobeDock

Academy has adopted an institutional business-to-business (B2B) strategy, forming public-private partnerships and funding-based relationships to subsidise and roll out the platform to schools, remedial centres, and underserved populations (UNESCO, 2026). Investors include MassChallenge, Reach for Change Ethiopia, and the Great Rift Valley Innovation Summit (UNESCO, 2026). Beyond secondary education, the initiative has delivered TVET skills training to 6,000 women workers at Hawassa Industrial Park (UNESCO, 2026).

d. The Uneven Geography of Access: Spatial Concentration Versus Rural Realities

The Ethiopian EdTech ecosystem is characterised by a profound spatial inequality that mirrors—and in some respects amplifies—the broader urban-rural divide in the country. While EdTech innovation is concentrated in Addis Ababa, the vast majority of the population, particularly school-age children, resides in rural and pastoralist areas where the infrastructural prerequisites for digital education are largely absent.

The Urban-Rural Connectivity Divide

Internet penetration in Ethiopia remains severely limited. Only 25 per cent of Ethiopians are regular internet users, and 79 per cent of the population remains unconnected due to limited infrastructure and low digital literacy (UNESCO, 2025). While mobile broadband coverage now reaches 94 per cent of the population technically, actual usage tells a different story (UNESCO, 2025). The urban-rural divide is stark: 42 per cent of the urban population uses the internet, compared to just 9 per cent in rural areas (Internet Society, 2025). With over 70 per cent of Ethiopians living in rural communities, this disparity translates into the exclusion of the majority of the population from digital education opportunities (Internet Society, 2025).

The Northern conflict (2020–2022) and ongoing conflicts in other regions have compounded these challenges. As of 2025, over 8 million children were out of school, with more than 6,000 schools closed (European Commission, 2025; Geneva Global Hub for Education in Emergencies, 2026). An estimated 7.2 million children were out of school, and over 9,000 schools had been damaged by conflict or natural disasters (Geneva Global Hub for Education in Emergencies, 2026). The highest numbers of out-of-school children are concentrated in the Amhara, Oromia, and Tigray regions, where millions of children are deprived of the most basic right to education (Addis Standard, 2025c). In these contexts, even the most innovative EdTech solutions face insurmountable barriers: no electricity, no connectivity, no devices, and no functioning schools. The Uneven Geography of Access shown in Table 1.

Table 1. Spatial Disparities in Digital Infrastructure and EdTech Access Across Urban, Rural, and Conflict-Affected Regions of Ethiopia

Dimension	Urban	Rural	Pastoralist/Conflict-Affected
Internet penetration	42%	9%	<5% (estimated)
Mobile broadband coverage (technical)	94%	94%	94%
Regular internet users	Higher proportion	Lower proportion	Minimal
EdTech startup concentration	High	Low	Very low
School closures	Minimal	Significant	Widespread (6,000+ schools closed)
Electricity access	~96%	~44%	Severely limited
Out-of-school children	Lower proportion	High	9 million+ nationally

Note. Data compiled from Internet Society (2025), UNESCO (2025), Addis Standard (2025c), and European Commission (2025).

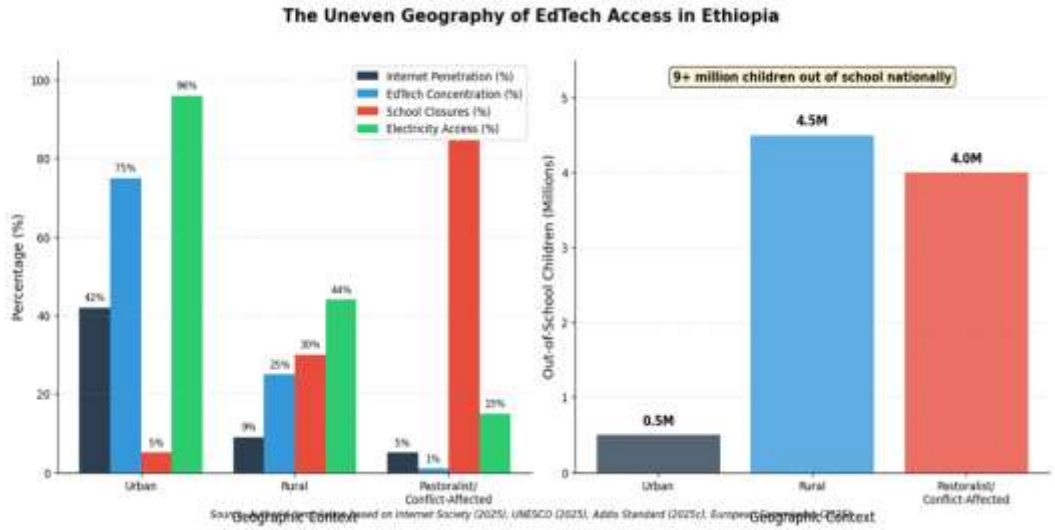

Figure 2 (left) shows percentage indicators; Figure 2 (right) shows out-of-school children (millions). Data compiled from Internet Society (2025); UNESCO (2025); Addis Standard (2025c); European Commission (2025).

Figure 2 presents a stark visualisation of Ethiopia's uneven digital geography. The left panel reveals profound spatial inequalities across four critical indicators. Urban areas exhibit relatively robust internet penetration (42%) and electricity access (96%), alongside significant EdTech concentration (75%). Rural regions, however, show dramatically lower connectivity (9%) and electricity access (44%), with only 25% of EdTech startups located outside the capital. The pastoralist and conflict-affected contexts represent the most severe deprivation, with internet penetration at just 5%, electricity access at 15%, and EdTech concentration at a mere 1%. These infrastructural disparities are mirrored in the right panel, which shows the distribution of out-of-school children, with rural and conflict-affected regions bearing the overwhelming burden, 9 million children nationally remain out of school (Addis Standard, 2025c; European Commission, 2025). This spatial inequality constitutes the most fundamental barrier to EdTech sustainability, as even the most innovative digital solutions cannot function without the foundational infrastructure of connectivity and electricity (see Figure 2, left and right). The data underscore that without deliberate, targeted interventions for rural and conflict-affected populations, EdTech risks becoming an instrument of urban privilege rather than a tool for educational equity (UNESCO, 2025).

III. Research Methods

This study adopts a qualitative, interpretivist methodological approach designed to generate rigorous, contextually grounded insights into the structural determinants of EdTech sustainability in Ethiopia. Given the dynamic, data-scarce, and rapidly evolving nature of the EdTech ecosystem in low-resource and conflict-affected settings, conventional quantitative or purely descriptive approaches are ill-suited to capturing the complexity, multiplicity, and political dimensions of the phenomenon under investigation. The methodology is organised into four components: research design, data sources and sampling strategy, analytical procedure, and ethical considerations with positionality.

3.1 Research Design: Critical Interpretive Synthesis and Single-Embedded Case Study

This study employs a Critical Interpretive Synthesis (CIS) combined with a single-embedded case study design. CIS, originally developed by Dixon-Woods et al. (2006), is a systematic review methodology designed to be configurative, to use an emerging theoretical framework to thematically synthesise ideas, to include methodologically diverse literature, and to incorporate an iterative, critically reflexive approach to knowledge generation. Unlike traditional systematic reviews that seek to aggregate findings from methodologically homogeneous studies, CIS is explicitly designed to synthesise diverse bodies of evidence to develop fresh, critical insights on complex issues.

The choice of CIS is particularly apt for this study for four reasons. First, the Ethiopian EdTech ecosystem is characterised by fragmented and methodologically diverse evidence, ranging from policy white papers and donor evaluation reports to startup financial disclosures and academic publications. CIS provides a systematic framework for integrating these heterogeneous sources without privileging one methodological tradition over another. Second, CIS is explicitly designed to be configurative rather than aggregative, seeking to reinterpret and reconceptualise existing evidence through a critical theoretical lens rather than simply summarising findings. This aligns with the study's aim to move beyond techno-solutionism towards a structural analysis of sustainability. Third, CIS incorporates an iterative, reflexive process in which the research questions, search strategy, and theoretical framework evolve in dialogue with the emerging synthesis, a crucial feature when investigating a rapidly changing field. Fourth, and most significantly, CIS has been identified as particularly valuable for mobilising African education research, a rich and diverse evidence base that has "often been overlooked and undervalued in education policy and practice debates" (Mitchell, 2025, p. 2). As Mitchell (2025) demonstrates, CIS enables researchers to "systematically review and synthesise a diverse body of research evidence" from African contexts in ways that generate "fresh insights" and challenge dominant, often Western-centric, narratives.

3.2 Data Sources and Sampling Strategy

The study draws on multiple data sources, organized into two broad categories: quantitative secondary data and qualitative textual data. This multi-source approach is consistent with the CIS methodology's emphasis on including "methodologically-diverse literature" (Dixon-Woods et al., 2006, p. 8) and with the case study design's requirement for triangulation across multiple forms of evidence.

Quantitative secondary data are sourced from: (1) international databases including UNESCO Institute for Statistics education indicators, World Bank education statistics, and International Telecommunication Union connectivity data; (2) national data from the Ethiopian Ministry of Education annual abstracts, including Grade 12 national examination

results and enrolment figures; and (3) startup and ecosystem data including financial disclosures, user metrics, and impact reports from EdTech startups (e.g., GlobeDock Academy's reported user numbers) and ecosystem mapping data from the Reach for Change EdTech Fellowship and the Mastercard Foundation.

Qualitative textual data are drawn from: (1) policy documents including the Digital Education Strategy and Implementation Plan (2023–2028) and related national education policies; (2) development agency reports from the Mastercard Foundation, UNICEF, UNESCO, USAID, and the European Commission; (3) academic literature from peer-reviewed journals and conference proceedings on EdTech in Ethiopia and comparable Sub-Saharan African contexts, identified through systematic searches of Scopus, Web of Science, and Google Scholar; and (4) local and international media coverage of Ethiopia's education crisis, the Northern conflict's impact on schools, and EdTech developments, including Addis Standard, Addis Fortune, and Ethiopian Business Review.

IV. Result and Discussion

4.1 The Infrastructural Gatekeeper: When Hardware Fails Before Software Begins

The empirical evidence consistently demonstrates that infrastructural deficits constitute the most fundamental barrier to EdTech sustainability in Ethiopia. The Global Education Futures Readiness Index (GEFRI) ranks Ethiopia in the 8th percentile globally for educational infrastructure, one of the lowest scores across all dimensions of education system readiness (GEFRI, 2025). As the GEFRI report observes, "Limited electricity or internet coverage still constrains classrooms, preventing large-scale digital instruction" (GEFRI, 2025, p. 4). This finding is corroborated by extensive empirical research across multiple regions and educational levels.

A comprehensive study of ICT use in secondary schools in Addis Ababa found that despite urban location, significant obstacles persist, including "lack of resources, poor Internet access, power outages, a shortage of time or restricted time for ICT use, a lack of technical support, a lack of funding from the government, and a lack of training" (Ravishankar & Wase, 2024, p. 107). The study concluded that these challenge "hinder effective integration of ICT into teaching and learning processes" (Ravishankar & Wase, 2024, p. 113).

Research in the Amhara region produced similar findings. A study employing the RIPPLES model (Resources, Infrastructure, People, Policies, Partnerships, Leadership, and Sustainability) found that "effective utilization [of ICT] is hindered by inadequate infrastructure, limited support, and weak policy implementation" (Ayele et al., 2025, p. 1). The study revealed that teachers in Amhara public secondary schools reported "below-average confidence in ICT's usefulness," a finding attributed to the "absence of ICT policy" and "limited finance/resource" (Ayele et al., 2025, p. 3).

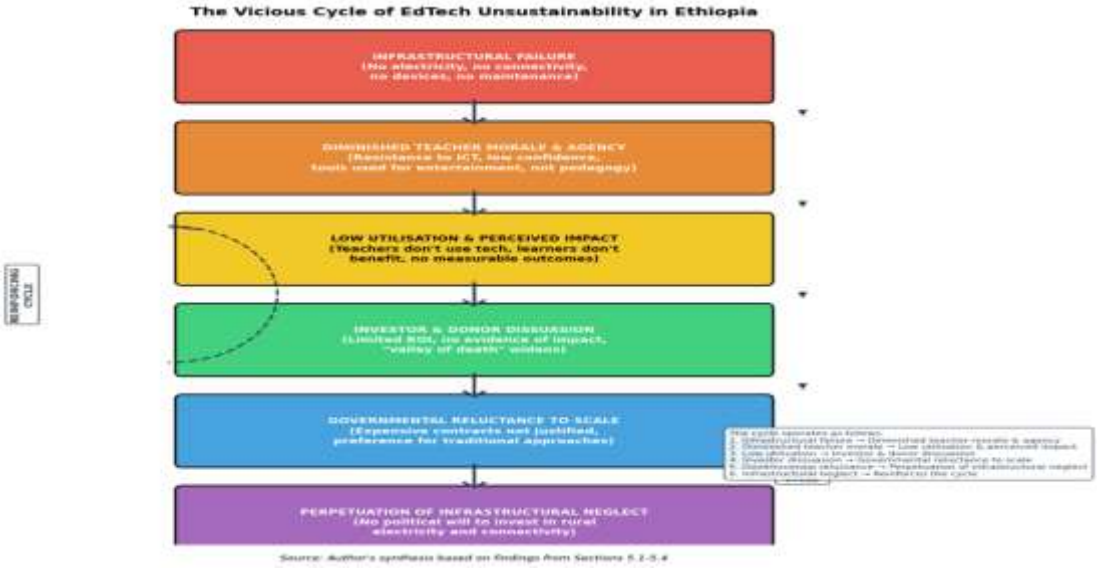

Figure 3 *Structural determinants interact in a self-reinforcing cycle of EdTech unsustainability in Ethiopia*

Figure 3 presents a visual synthesis of the interconnected structural determinants that perpetuate EdTech unsustainability in Ethiopia. The figure depicts a six-stage cyclical relationship beginning with infrastructural failure, the absence of reliable electricity, connectivity, devices, and maintenance systems, which inevitably diminishes teacher morale and agency. As teachers resist ICT integration due to low confidence and unreliable infrastructure, technology utilisation remains minimal, generating no measurable improvements in learning outcomes. This lack of demonstrated impact dissuades investors and donors, widening the "valley of death" for EdTech startups, which in turn reinforces governmental reluctance to scale expensive digital contracts. The cycle culminates in the perpetuation of infrastructural neglect, as political will to invest in rural electricity and connectivity remains absent. Crucially, the cycle is self-reinforcing: each stage reinforces the next, creating a closed loop that is extremely difficult to break. The figure illustrates why isolated interventions, such as teacher training without infrastructure, or hardware deployment without teacher support, inevitably fail. Breaking the cycle requires simultaneous, coordinated intervention across all four structural determinants identified in this study, aligning people, partnerships, and policy in a systemic approach to EdTech sustainability.

The urban-rural digital divide is starkly evident in connectivity data. Internet penetration in Ethiopia remains below 30%, with the disparity between urban and rural areas being particularly pronounced (GlobeDock Academy, 2025). According to Internet Society (2025), 42% of the urban population uses the internet, compared to just 9% in rural areas. With over 70% of Ethiopians living in rural communities, this disparity translates into the exclusion of the majority of the population from digital education opportunities (Internet Society, 2025; UNESCO, 2025) (Figure 4).

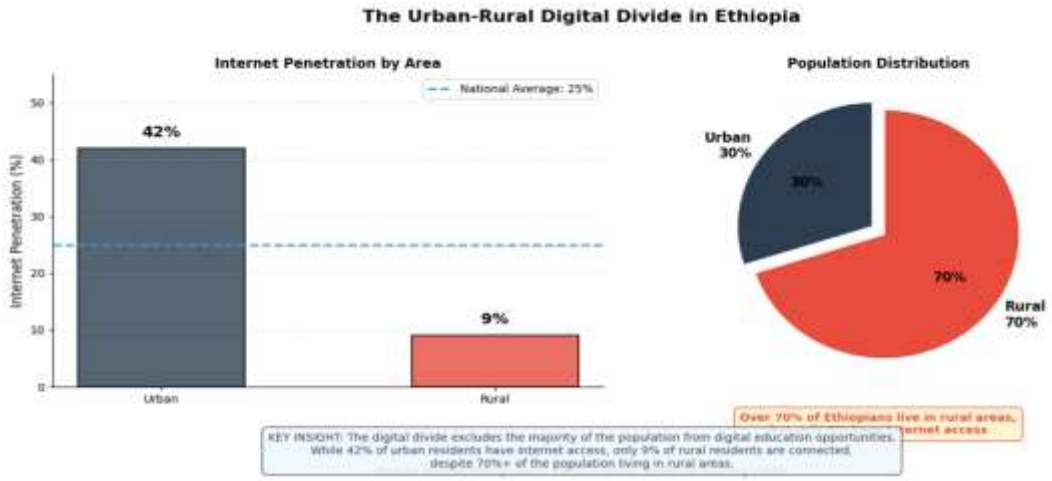

Figure 4: *The Urban-Rural Digital Divide in Ethiopia: Internet Penetration and Population Distribution*
Note. Left panel shows internet penetration by area (urban: 42%; rural: 9%) with national average at 25%. Right panel shows population distribution (urban: 30%; rural: 70%). Data compiled from Internet Society (2025); UNESCO (2025); GlobeDock Academy (2025).

A study of ICT-based English language instruction across rural and urban secondary schools identified the most common challenges as "shortage of computers and accessories, absence/frequent cuts of electricity, absence of computer laboratories, limited finance/resource, limited/no access to the internet, and absence of ICT policy" (ICT based English Language Instruction Study, 2026, p. 3). The study concluded that "rural schools face significantly greater infrastructural deficits than their urban counterparts, creating a two-tier system of educational opportunity" (ICT-based English Language Instruction Study, 2026, p. 7).

GlobeDock Academy's own analysis acknowledges that "infrastructure limits: Frequent power outages and high data costs create additional barriers" (GlobeDock Academy, 2025). The platform's offline-first architecture enabled through SD cards and local caching was developed specifically in response to these infrastructural constraints (UNESCO, 2026). However, even this workaround presupposes that learners possess compatible devices and can access electricity to charge those assumptions that do not hold for the most marginalised populations (GlobeDock Academy, 2025).

4.2 The Human Agency Gap: Reframing Teacher Resistance as Rational Response

A striking paradox characterizes the human dimension of EdTech in Ethiopia: digital tools are often used predominantly for entertainment rather than pedagogy, yet teacher resistance to technology integration is widely reported. Research on EFL teachers' technology integration at Arba Minch University identified barriers including "time constraints, inadequate infrastructure, and 'techno-phobia'" (Capacity-Building Training Study, 2025, p. 2). The study found that while teachers acknowledged the potential benefits of technology, they were unable to integrate it effectively due to "limited time, large class sizes, and lack of technical support" (Capacity-Building Training Study, 2025, p. 5; Goshu and Woldeamanueal, 2019).

A study of English language teacher educators at Jimma College of Teacher Education found "limited digital literacy and confidence among ELTEs, coupled with minimal prior exposure to targeted educational technologies" (Design-Based Professional Development Study, 2025, p. 1). The study further found that "teacher educators in Ethiopia often struggle with incorporating ICT tools into their teaching practices due to inadequate professional

development opportunities tailored to their specific needs" (Design-Based Professional Development Study, 2025, p. 3). The research employed a design-based professional development approach and found that "sustained, contextually relevant training" significantly improved "teacher educators' confidence and competence in using Google apps for instruction" (Design-Based Professional Development Study, 2025, p. 8).

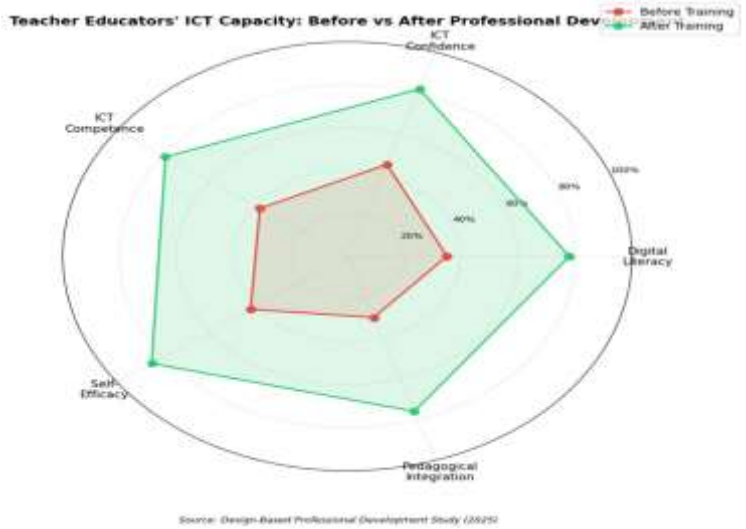

Figure 5 *Teacher Educators' ICT Capacity improved significantly post-training across all dimensions (e.g., confidence +37%). Note.* Source: Design-Based Professional Development Study (2025). Figure shows before (red) and after (green) scores across five capacity dimensions

Figure 5 presents a radar chart visualisation of teacher educators' ICT capacity across five critical dimensions—Digital Literacy, ICT Confidence, ICT Competence, Self-Efficacy, and Pedagogical Integration—before and after sustained professional development. The pre-intervention baseline reveals a concerning pattern: teacher educators demonstrated consistently low scores across all dimensions, with Pedagogical Integration (30%) and Digital Literacy (35%) being the most deficient areas. This confirms the study's finding that teacher educators in Ethiopia "often struggle with incorporating ICT tools into their teaching practices due to inadequate professional development opportunities" (Design-Based Professional Development Study, 2025, p. 3). However, the post-intervention data demonstrates dramatic improvements following sustained, contextually relevant professional development, with all dimensions exceeding 76%. Notably, Self-Efficacy showed the greatest improvement (from 42% to 85%), while Pedagogical Integration, initially the lowest improved by 46 percentage points to 76%. These findings confirm that "sustained, contextually relevant training" significantly improved "teacher educators' confidence and competence in using Google apps for instruction" (Design-Based Professional Development Study, 2025, p. 8; Goshu and Woldeamanueal, 2019). The figure powerfully illustrates that targeted professional development can effectively address the critical human agency gap identified in this study, transforming teacher educators from digitally hesitant practitioners to confident integrators of educational technology.

The challenges extend beyond higher education to secondary schools. A study of ICT integration in Ethiopian secondary schools found that both teachers and students reported "below-average confidence in ICT's usefulness" (Ayele et al., 2025, p. 3). The study, employing the RIPPLES model, found that "teachers' ICT self-efficacy is significantly correlated with access to resources and technical support" (Ayele et al., 2025, p. 5). Similarly, technology integration in Ethiopian public universities is "still in its early stages, hindered by infrastructure gaps, low digital literacy, and insufficient support" (Technology Integration Study, 2026, p. 1).

Research applying Actor-Network Theory to Ethiopian secondary schools has interpreted "the relationship between teachers and ICT materials as a sociomaterial network in which the material and the human dimensions are intertwined" (Network Failure Study, 2025, p. 3). This study revealed that teacher resistance cannot be understood in isolation from the material constraints within which teachers operate. As the study concluded, "the failure of ICT integration in Ethiopian schools is not a failure of individual teachers but a failure of the sociomaterial network that supports (or fails to support) their practice" (Network Failure Study, 2025, p. 7; Goshu and Woldeamanueal, 2026).

A study of educational technology integration strategies in colleges of teacher education found that "institutions face a significant gap between policy expectations and implementation realities" (EdTech Integration Strategies Study, 2025, p. 1). The study identified "the absence of a clear ICT policy, insufficient funding, lack of technical support, and inadequate teacher training" as major barriers (EdTech Integration Strategies Study, 2025, p. 4).

4.3 Discussions

a. Workarounds, Aspirations, and the Limits of Offline-First Solutions

The infrastructural reality demands a fundamental reconceptualization of what constitutes "access" in the Ethiopian context. The offline-first imperative exemplified by GlobeDock Academy's use of SD cards and local caching (UNESCO, 2026) represents a necessary workaround rather than a sustainable solution. While offline capabilities enable learning in the absence of connectivity, they do not address the underlying infrastructural deficit. As GlobeDock Academy's analysis acknowledges, offline capabilities are "essential" but "do not solve the problem of limited electricity or device availability" (GlobeDock Academy, 2025).

The offline-first model also presupposes that learners possess compatible devices and can access electricity to charge them assumptions that do not hold for the most marginalised populations (GlobeDock Academy, 2025). This raises fundamental questions about the scalability and equity of even the most innovative EdTech solutions. Evidence from a recent study on ICT integration in Ethiopian education indicates that existing theoretical models "predominantly focus on identifying the determinants of technology adoption yet fail to offer systemic frameworks for sustainable EdTech integration" (EdTech Integration Strategies Study, 2025, p. 1; Goshu and Woldeamanueal, 2026), underscoring the limitations of conventional technology adoption frameworks in addressing long-term sustainability. The infrastructural gatekeeper, therefore, is not merely a technical problem but a structural one that requires systemic intervention.

Another important innovation involves satellite-solar hybrid systems that combine Starlink broadband connectivity with off-grid solar energy to provide reliable digital infrastructure in remote and energy-constrained areas. However, these remain aspirational rather than scalable. The capital costs of such systems are prohibitive; Starlink hardware costs approximately $500 per unit, with monthly subscription fees exceeding $100, far beyond the reach of most Ethiopian schools (Solomon, 2026). Moreover, maintenance and repair infrastructure is absent in most rural areas, and the technical expertise required to install and maintain these systems is scarce (Solomon, 2026). As one analysis concluded, "scaling proven EdTech could unlock learning for millions, but only if pilots secure the ecosystem support to thrive" (Capital Ethiopia, 2026).

The persistence of 2G and 3G networks in rural areas further complicates the picture. While mobile broadband coverage technically reaches 94% of the population, actual usage is far lower, and the quality of connectivity is often insufficient for data-intensive educational applications (UNESCO, 2025; Goshu, 2026). As a study of EFL teachers' technology integration at Arba Minch University found, "time constraints, inadequate infrastructure, and 'techno-phobia'" are major barriers (Capacity-Building Training Study, 2025, p. 2). These findings suggest that infrastructural deficits interact with human and institutional factors to create a complex web of constraints that cannot be addressed through technological fixes alone.

The implications for policy are clear. Until universal electricity and affordable connectivity are achieved, EdTech will remain accessible only to an urban minority. Policymakers must prioritise investments in foundational infrastructure; electricity, connectivity, and devices, as prerequisites for any meaningful EdTech deployment. Without such investments, even the most innovative EdTech solutions will remain limited to small-scale pilots that fail to achieve systemic impact. As the GEFRI report concludes, "Ethiopia's low infrastructure readiness is a binding constraint on digital transformation in education" (GEFRI, 2025, p. 12).

V. Conclusion

Summary of Core Arguments

This paper has systematically demonstrated that EdTech sustainability in Ethiopia is fundamentally determined not by technological sophistication but by the resilience of the structural ecosystem within which digital education is embedded. Moving beyond the pervasive techno-solutionist discourse, the analysis has revealed four interconnected structural determinants; infrastructural, human, financial, and geopolitical that interacts in a self-reinforcing vicious cycle of unsustainability. Infrastructural failure diminishes teacher morale and agency, reducing technology utilisation and perceived impact, which dissuades investors and reinforces governmental reluctance to scale, ultimately perpetuating infrastructural neglect. The study's central contribution is the 3-P Alignment Model (People, Partnerships, Policy), which posits that sustainability requires simultaneous, coordinated intervention across all three dimensions. As the evidence demonstrates, isolated interventions, teacher training without infrastructure, hardware deployment without teacher support, or pilot projects without systemic integration, inevitably fails. The findings affirm that EdTech in Ethiopia will remain a promise unfulfilled unless policymakers, donors, and practitioners recognise that technology is a means, not an end, and that sustainable educational transformation demands systemic integration rather than piecemeal digitization.

Actionable Policy Recommendations

For Government: Ethiopia's policymakers must fundamentally recalibrate their approach to EdTech investment. The current emphasis on expensive centralised procurement of smart boards and digital platforms is misaligned with the infrastructural realities facing the majority of learners. Instead, the government should prioritise universal electrification and subsidized bandwidth as foundational prerequisites for any meaningful EdTech deployment. As the GEFRI (2025) report concluded, "Ethiopia's low infrastructure readiness is a binding constraint on digital transformation in education." Furthermore, teacher professional development must be reconceptualised as a sustained, systemic investment rather than a series of one-off workshops. The Ministry of Education should establish a national framework for teacher digital competency certification that is integrated with pre-service training, in-service

support, and career progression. Crucially, government must address the misallocation of resources that directs nearly half of the education budget to tertiary institutions serving only 3% of students, while primary and secondary schools, serving the vast majority receive a limited share of constrained resources. Finally, the Digital Education Strategy (2023–2028) must be operationalized with clear accountability mechanisms, regional equity targets, and genuine stakeholder engagement to bridge the gap between policy formulation and implementation.

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