



## Addressing ICT Infrastructure Challenges in Nepal: Through Sustainable Digital Learning Solutions

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### Abstract

**Background:** Information and Communication Technology (ICT) is a critical catalyst for achieving Sustainable Development Goal 4 (Quality Education) and modernizing pedagogical frameworks. While the Government of Nepal has introduced significant policy initiatives including the ICT in Education Master Plan and the Digital Nepal Framework the translation of these policies into rural classroom realities remains inconsistent.

**Objectives:** This study examines the core infrastructural barriers affecting ICT adoption in rural Nepal. It specifically aims to assess the current status of digital resources, analyze the impact of infrastructure reliability on learning, and identify the "sustainment gap" that hinders long-term functional continuity.

**Methodology:** A quantitative research design was employed, utilizing a survey-based approach to collect primary data from 145 respondents (students and teachers) in rural Nepalese schools. Data analysis included descriptive statistics, Spearman's correlation analysis, and reliability testing (Cronbach's Alpha = 0.798).

**Findings:** The results indicate that while basic hardware is present, its effectiveness is severely limited by a lack of "hygiene factors." Major challenges include difficulty in maintenance and repair (81.3%), unreliable electricity and internet (77.9%), and a shortage of trained ICT personnel (66.2%). Correlation analysis confirms a significant positive relationship between infrastructure reliability and digital learning effectiveness. The study highlights a shift from the "first-level" digital divide (physical access) to a "second-level" divide (quality and usability).

**Conclusion:** The study concludes that ICT integration in Nepal fails not due to a lack of initial investment, but due to a lack of sustainability planning. To bridge the rural-urban divide policy must shift from mere hardware provision to creating inclusive digital ecosystems supported by solar power, offline learning platforms, and localized technical support.

**Keywords:** ICT in Education, Rural Nepal, Digital Divide, Infrastructure Reliability, Sustainable Development Goal 4

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### 1. Introduction

#### 1.1. Background

Information and Communication Technology (ICT) has become a key driver of modern education, enabling improved access to learning resources, interactive teaching methods, and enhanced student engagement. Globally, ICT is recognized as an essential tool for achieving inclusive and equitable quality education under Sustainable Development Goal 4. (UNESCO's ICT Competency Framework for Teachers, 18 October 2023)

In developing countries, ICT plays a critical role in reducing educational disparities and expanding learning opportunities,

particularly in remote and underserved regions (bank, 2020-03-25).

In Nepal, the government has taken important steps to promote the use of Information and Communication Technology (ICT) in education. Key initiatives such as the ICT in Education Master Plan (2013–2017) and the Digital Nepal Framework (2019) were introduced to improve school infrastructure, enhance digital skills, and encourage the use of technology in teaching and learning.

These policies aim to modernize education by integrating digital tools into classrooms and making learning more interactive and accessible. However, the implementation of ICT is not consistent across the country. Urban schools have benefited more from these initiatives, while many rural schools still face challenges such as lack of internet access, insufficient equipment, and limited technical support. As a result, the overall adoption of ICT in education remains uneven, with rural areas lagging behind

### 1.2. Motivation

The COVID-19 pandemic highlighted the importance of ICT in ensuring continuity of education. During school closures, digital learning became essential, yet many students in rural Nepal were unable to participate effectively due to lack of access to devices, unreliable internet connectivity, and unstable electricity supply ( UNICEF, July 2022) <sup>[2]</sup>

This situation revealed a critical issue: the availability of ICT infrastructure alone does not ensure effective utilization. Sustainable implementation supported by reliable power, connectivity, and technical support is equally important for meaningful integration of ICT in education.

### 1.3. Problem Statement

Despite policy-level commitments and increasing investment in ICT infrastructure, Nepal continues to face significant challenges in effective ICT integration. Previous studies have identified several persistent barriers, including poor internet connectivity, unreliable electricity supply, limited maintenance systems, and shortage of trained ICT personnel. These challenges often result in underutilization of ICT resources and contribute to a widening digital divide between urban and rural education systems. As a result, ICT investments fail to achieve their intended educational outcomes, particularly in resource-constrained environments.

### 1.4. Research Objectives

This study aims to address these challenges through the following objectives:

- To assess the current status of ICT infrastructure in rural schools
- To identify key infrastructural barriers affecting ICT adoption
- To analyze the impact of these challenges on digital learning
- To propose sustainable and scalable digital learning solutions

### 1.5. Contributions

This paper makes the following contributions:

- Provides empirical evidence on ICT infrastructure challenges in rural Nepal
- Highlights sustainability issues beyond infrastructure availability

- Proposes a context-specific sustainable digital learning framework

## 2. Literature Review

### 2.1. ICT Infrastructure in Education

ICT infrastructure is widely recognized as a foundational requirement for effective digital learning. It includes access to reliable electricity, internet connectivity, hardware devices, and technical support systems. Studies in developing countries have shown that inadequate infrastructure remains one of the primary barriers to ICT adoption in education (bank, 2020-03-25).

In rural and remote regions, infrastructure challenges are more pronounced due to geographical constraints and limited investment. The success of ICT integration depends not only on infrastructure availability but also on its reliability and sustainability (Trucano, 2005.) <sup>[4]</sup>

Similarly, the national ICT policies often fail to translate into effective implementation due to weak infrastructural support and lack of institutional capacity. (Kozma, 2005/10/31) <sup>[5]</sup>

### 2.2. ICT Infrastructure and Materials

Infrastructure is no longer just about "having computers"; it is now defined by connectivity, accessibility, and maintenance.

The "Second-Level" Digital Divide: Literature distinguishes between the "first-level" divide (physical access to hardware) and the "second-level" divide (the quality of that access and the ability to use it effectively). In many regions, the "first-level" gap is closing, but the "second-level" remains wide due to poor internet stability and lack of technical support (Hes, Jan 29, 2026)

#### 2.2.1. Infrastructure Beyond Hardware: Essential infrastructure now includes:

- Stable Power & High-Speed Wi-Fi: These are the most critical "hygiene factors for ICT integration for teacher skill ", (Okeke, 2023) <sup>[7]</sup>
- "Radical infrastructure: Building beyond the failures of past imaginaries" This article explores the societal and human elements of infrastructure, arguing for "care ethics" in digital networks, shifting focus from pure market efficiency to inclusive digital ecosystems (Cath, 2024/11/01) <sup>[8]</sup>

### 2.3. ICT Challenges in the Nepalese Context

In Nepal, several studies have examined barriers to ICT integration in education.

Unreliable electricity supply and absence of maintenance mechanisms lead to frequent breakdown of ICT facilities (Karki, April 2019) <sup>[9]</sup>

These findings indicate that ICT challenges in Nepal are not limited to infrastructure availability but extend to issues of sustainability, maintenance, and human capacity.

### 2.4. Sustainable ICT Solutions in Education

Information and Communication Technology (ICT) is a fundamental driver for achieving the SDGs within educational frameworks. The digital tools possess the "great potential" to strengthen global sustainability awareness by facilitating interactive learning environments. This shift moves ICT from a simple pedagogical aid to an essential component of a sustainability-based curriculum (Azis, July

17, 2025) [11]

To address infrastructural challenges, researchers have proposed various sustainable ICT solutions. These include the use of solar-powered systems to overcome electricity shortages, offline digital learning platforms to address connectivity issues, and community-based technical support models for maintenance (Trucano, 2005.) [4]

(UNESCO, 18 October 2023) [1] emphasizes the importance of context-specific solutions that consider local constraints and resource availability.

Similarly, (bank, 2020-03-25) suggests that blended

approaches combining online and offline learning can improve accessibility in low-resource environments.

However, while these solutions have been explored globally, their application in Nepal remains limited and under-researched, particularly in rural school settings.

**2.5. The Role and Potential of ICT**

The efficient utilization of digital tools enhances student motivation, fosters dynamic classroom environments, and revitalizes teacher enthusiasm through the acquisition of modern technical skills (Joshi, October 2024) [10]

**Table1:** Comparison of ICT Infrastructural Dimensions and Challenges

Dimension	Traditional View (First-Level)	Modern/Evolving View (Second-Level & Radical)	Key Challenges (Developing/Nepal Context)
Defining Concept	Focused on "having computers" and physical hardware acquisition.	Defined by connectivity, accessibility, usability, and long-term maintenance.	Pronounced gap in rural/remote regions due to geographical constraints.
Primary Infrastructure	Hardware devices (PCs, Laptops).	High-speed Wi-Fi, stable power, and technical support systems.	Inadequate funding and limited investment in non-hardware "hygiene factors."
The Digital Divide	Physical access gap (the "first-level" divide) which is currently closing.	Quality of access and the ability to use tools effectively (the "second-level" divide).	Poor internet stability and a lack of institutional capacity for support.
Integration Success	Viewed as a result of availability (presence of tools).	Dependent on the reliability and sustainability of the infrastructure.	Weak infrastructural support leading to the failure of national policy implementation.
Core Philosophy	Market efficiency and pure technological rollout.	"Care ethics" in digital networks; shifting toward inclusive digital ecosystems.	Disconnect between comprehensive policy and practical, human-centered implementation.

**2.6. Research Gap**

Based on the reviewed literature, the following gaps are identified:

- Limited focus on sustainability of ICT infrastructure in rural Nepal
- Lack of integration between infrastructure challenges and practical solutions
- Insufficient emphasis on long-term functionality and maintenance systems
- Absence of context-specific frameworks for resource-constrained environments

This study addresses these gaps by combining empirical analysis of ICT infrastructure challenges with the development of sustainable digital learning solutions tailored to rural Nepal.

**3. Methodology**

**3.1. Research Design**

This study adopts a quantitative research design to examine ICT infrastructure challenges and their impact on digital learning in rural Nepal. A survey-based approach was used to collect primary data from respondents, allowing statistical analysis of infrastructure availability, challenges, and usage patterns. The quantitative approach enables objective measurement of relationships between ICT infrastructure variables and their influence on educational outcomes.

**3.2. Study Area and Population**

The study focuses on rural schools in Nepal, where ICT implementation faces significant infrastructural constraints. Respondents include both students and teachers, providing perspectives from ICT users and facilitators within the education system.

A total of 145 respondents participated in the study, ensuring adequate representation for statistical analysis.

**3.3. Data Collection**

Primary data were collected using a structured questionnaire designed to capture:

- Availability of ICT infrastructure (computers, internet, electricity)
- Reliability and usability of ICT resources
- Challenges faced in ICT implementation
- Perception of digital learning effectiveness

The questionnaire included both closed-ended and Likert-scale questions to facilitate quantitative analysis.

Data collection was conducted through a combination of online and field-based surveys, ensuring participation from diverse geographical locations.

**3.4. Data Processing and Analysis**

The collected data were coded and analyzed using statistical techniques. The analysis included:

- Descriptive statistics (frequency and percentage) to summarize responses
- Correlation analysis to examine relationships between variables
- Reliability testing using Cronbach’s Alpha

The reliability test yielded a Cronbach’s Alpha value of 0.798, indicating acceptable internal consistency of the survey instrument.

**3.5. Variables and Measurement**

**Table 2:** The study considers the following key variables:

Variable Type	Variables
Independent Variables	Electricity availability, Internet connectivity, ICT equipment, technical support
Dependent Variable	ICT usage in education
Mediating Factors	Digital literacy, maintenance systems

Each variable was measured using Likert-scale responses to assess perception and effectiveness.

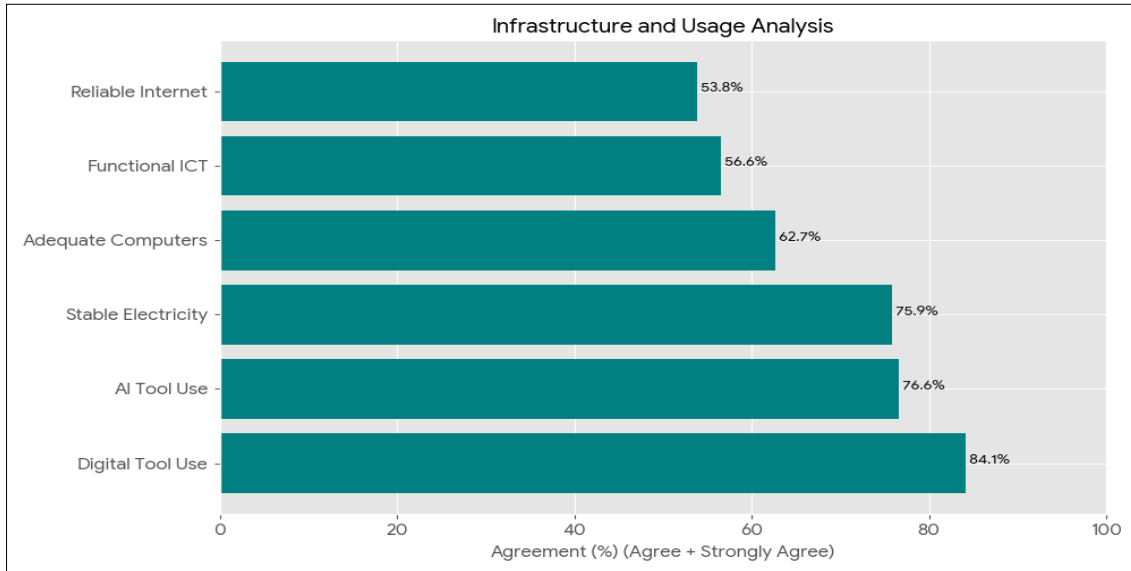
**3.6. Ethical Considerations**

Participation in the study was voluntary, and respondents were informed about the purpose of the research. Confidentiality and anonymity of responses were maintained throughout the study.

**4. Results and Analysis**

**4.1. Descriptive Analysis of ICT Infrastructure**

The descriptive analysis provides an overview of ICT infrastructure availability and usability in rural schools. The results indicate that while basic ICT resources are present to some extent, their reliability remains a major concern.



**Fig 1:** ICT Infrastructure Availability and Usage Analysis

A majority of respondents reported access to computers and basic ICT tools. However, only about 53.8% indicated having reliable internet connectivity, and certain proportion highlighted issues related to unstable electricity supply. These findings suggest that infrastructure availability does

not necessarily translate into effective usability.

**4.2. Key Challenges in ICT Implementation**

The study identified several major challenges affecting ICT integration in rural education.

**Table 3:** Major ICT Infrastructure Challenges

Challenge	Percentage of Respondents (%)
Difficulty in maintenance and repair	81.3%
Unreliable electricity and internet	77.9%
Lack of trained ICT personnel	66.2%

The results show that maintenance and technical support are the most critical issues, followed by infrastructure reliability. The shortage of trained personnel further limits effective ICT utilization. These findings highlight that the primary barrier is not access to ICT resources, but their long-term functionality and support systems.

**4.3. ICT Usage and Digital Learning**

Despite infrastructural challenges, ICT usage in education

shows a moderate level of adoption. Many respondents reported using ICT tools for basic learning activities such as accessing digital content and communication.

However, the effectiveness of ICT usage is significantly influenced by infrastructure reliability. Frequent disruptions in electricity and internet connectivity reduce consistency in digital learning practices.

#### 4.4. Correlation Analysis

			Correlations				
			ICT_Infrastructure	ICT_Usage	Barriers_Challenges	Digital_Literacy	Opportunities
Spearman's rho	ICT_Infrastructure	Correlation Coefficient	1.000	.418***	-.074	.302***	.033
		Sig. (2-tailed)	.	<.001	.377	<.001	.696
		N	145	145	144	145	145
	ICT_Usage	Correlation Coefficient	.418***	1.000	-.120	.352***	.071
		Sig. (2-tailed)	<.001	.	.152	<.001	.395
		N	145	145	144	145	145
	Barriers_Challenges	Correlation Coefficient	-.074	-.120	1.000	.198*	.405***
		Sig. (2-tailed)	.377	.152	.	.017	<.001
		N	144	144	144	144	144
	Digital_Literacy	Correlation Coefficient	.302***	.352***	.198*	1.000	.515***
		Sig. (2-tailed)	<.001	<.001	.017	.	<.001
		N	145	145	144	145	145
	Opportunities	Correlation Coefficient	.033	.071	.405***	.515***	1.000
		Sig. (2-tailed)	.696	.395	<.001	<.001	.
		N	145	145	144	145	145

\*\*\*. Correlation is significant at the 0.001 level (2-tailed).  
\*. Correlation is significant at the 0.05 level (2-tailed).

Fig 2: The Spearman’s Correlation Analysis

Correlation analysis was conducted to examine the relationship between ICT infrastructure factors and ICT usage.

The results indicate a positive relationship between infrastructure reliability and ICT usage, suggesting that improved infrastructure directly enhances digital learning effectiveness. Additionally, digital literacy shows a positive association with ICT usage, indicating the importance of user capacity in technology adoption.

#### 4.5. Key Findings

The analysis reveals the following key insights:

- ICT infrastructure is partially available but not reliable
- Maintenance and technical support are the most critical challenges
- ICT usage exists but is limited by infrastructural constraints
- Infrastructure reliability and digital literacy are key drivers of ICT effectiveness

### 5. Discussion

#### 5.1. Interpretation of Key Findings

This study reveals that ICT infrastructure in rural Nepal is partially available but lacks reliability and sustainability, which significantly affects its effective use in education. Although a considerable number of schools possess basic ICT resources, issues such as unreliable electricity, poor internet connectivity, and lack of maintenance systems limit their functionality.

The finding that maintenance and technical support (81.3%) is the most critical challenge suggests that ICT initiatives often focus on deployment rather than long-term usability. This supports the argument by Trucano (2015) that ICT projects in developing countries frequently fail due to lack of sustainability planning.

Similarly, the high percentage of respondents reporting

electricity and connectivity issues (77.9%) aligns with global findings that infrastructure reliability is a major barrier in rural ICT implementation (World Bank, 2020) [3].

#### 5.2. Comparison with Existing Studies

The results of this study are consistent with previous research conducted in Nepal and other developing countries. Bhatta (2018) and Karki (2020) also identified poor connectivity and lack of technical support as key barriers to ICT adoption. Furthermore, UNESCO (2021) highlights that ICT integration requires not only infrastructure but also trained personnel and institutional support. The finding that 66.2% of respondents reported a shortage of trained ICT personnel reinforces this perspective.

However, unlike previous studies that mainly focus on identifying challenges, this study emphasizes the importance of sustainability and long-term functionality, providing a more practical and implementation-oriented perspective.

#### 5.3. Implications for Policy and Practice

The findings of this study have several important implications:

- ICT policies should shift from infrastructure provision to sustainability-focused implementation
- Investment should prioritize reliable electricity solutions, such as solar power in rural areas
- Schools should adopt offline digital learning tools to overcome connectivity limitations
- There is a need to develop local technical support systems for maintenance and repair
- Continuous teacher training programs should be implemented to improve ICT competency

These measures can help ensure that ICT infrastructure remains functional and effective over time.

#### 5.4. Sustainability Perspective

A key contribution of this study is the emphasis on sustainability in ICT implementation. The findings indicate that without proper maintenance, technical support, and reliable infrastructure, ICT investments may fail to deliver long-term benefits.

Sustainable ICT solutions such as renewable energy sources, localized support systems, and context-specific learning platforms are essential for improving digital learning outcomes in resource-constrained environments.

#### 5.5. Limitations of the Study

This study has some limitations:

- The sample size is limited to 145 respondents, which may not fully represent all regions of Nepal
- The study focuses on rural areas, limiting comparison with urban settings
- The analysis is primarily based on self-reported data, which may introduce bias
- The study does not include longitudinal data, limiting analysis of long-term trends

Future studies can address these limitations by using larger datasets, comparative analysis, and advanced statistical models.

#### 6. Conclusion

This study examined ICT infrastructure challenges in rural Nepal and their impact on digital learning. The findings reveal that while basic ICT resources are available in many schools, their effectiveness is significantly limited by issues of reliability and sustainability. Key challenges include unreliable electricity and internet connectivity, lack of maintenance and technical support systems, and shortage of trained ICT personnel.

The results indicate that ICT integration in education is not solely dependent on infrastructure availability, but also on its long-term functionality and usability. Without sustainable support mechanisms, ICT resources remain underutilized and fail to deliver expected educational outcomes.

To address these challenges, the study highlights the importance of adopting sustainable and context-specific solutions, such as alternative energy sources, offline digital learning platforms, and localized technical support systems. These approaches can enhance the reliability and effectiveness of ICT in resource-constrained environments.

Overall, this study contributes to bridging the gap between ICT infrastructure limitations and practical implementation strategies, offering insights for improving ICT-enabled education in rural Nepal.

#### 7. Future Work

Future research can build upon this study in several directions:

- Conduct large-scale studies covering diverse geographical regions of Nepal
- Perform comparative analysis between rural and urban ICT implementation
- Apply advanced statistical or modeling techniques to examine causal relationships
- Evaluate the effectiveness of pilot sustainable ICT solutions in real school settings
- Explore integration of emerging technologies such as AI-based learning tools and satellite internet

These directions can further strengthen understanding of ICT adoption and support the development of more effective digital education strategies.

#### References

1. UNESCO. UNESCO's ICT Competency Framework for Teachers. Paris: UNESCO; 2023 Oct 18.
2. UNICEF. [Digital Learning and Transformation of Education Strategy or similar report]. New York: UNICEF; 2022 Jul.
3. World Bank. Remote Learning and COVID-19. Washington, DC: World Bank; 2020 Mar 25.
4. Trucano M. Knowledge Maps: ICT in Education. Washington, DC: infoDev/World Bank; 2005.
5. Kozma RB. National policies that connect ICT-based education reform to economic and social development. *Human Technology*. 2005;1(2):117-56.
6. Hes T. Bridging the digital divide: Why connectivity alone is not enough. *DevelopmentAid*. 2026 Jan 29.
7. Okeke CA. Infrastructural development and development administration: A retrospective. *Journal of Foresight and Thought Leadership*. 2023.
8. Cath BP, Paris BS, West SM. Radical infrastructure: Building beyond the failures of past imaginaries for networked communication. *New Media & Society*. 2024;27.
9. Karki H. A brief history of public education, ICT and ICT in public education in Nepal. *Deerwalk Journal of Computer Science and Information Technology*. 2019 Apr:78-103.
10. Joshi BM, Acharya U, Khatiwada SP. Policy versus Reality: Challenges of Implementing ICT in Higher Education in Nepal. *Pragyaratna*. 2024 Oct.
11. Azis RN, Rahmi W, Nasar I, Bito GS. Educating for Sustainability: The Impact of ICT on Promoting Sustainable Development Goals in Education. *Ruteng, Indonesia: ResearchGate*; 2025 Jul 17

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