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Navigating the Digital Divide: AI Integration, Green AI Awareness, and Leadership in Secondary Education in Uttar Pradesh

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Abstract: The rapid proliferation of Artificial Intelligence (AI) in global education systems presents a paradox: while it offers unprecedented opportunities for personalized learning, it simultaneously threatens to exacerbate existing socio-economic disparities and contribute to environmental degradation. This study investigates the integration of AI and the nascent concept of Green AI in secondary education within Raebareli, Uttar Pradesh, a region representative of the developing world's struggle to digitize. Utilizing a robust sequential mixed-methods approach, the research synthesizes quantitative survey data from 120 respondents—comprising students, teachers, and school leaders—with qualitative insights derived from semi-structured interviews and focus group discussions.

Quantitative analysis reveals a robust positive correlation (r = 0.785) between digital infrastructure and AI adoption, underscoring that the physical availability of hardware and reliable connectivity are the primary gatekeepers of educational technology use. The results confirm that AI-supported learning significantly enhances student engagement and technological adaptability, yet these benefits are skewed heavily toward semi-urban private schools, highlighting a pervasive rural-urban digital divide. However, the study's most critical contribution is the identification of a substantial "Green AI Gap." Despite the push for digital modernization, 85% of respondents demonstrated a complete lack of familiarity with environmentally sustainable computing practices or the carbon footprint of digital tools.

Qualitative findings further illuminate the systemic barriers to adoption, revealing that school leadership in the region remains predominantly "exam-centric," prioritizing board examination results over long-term technological sustainability or ecological responsibility. The study argues that without a strategic paradigm shift in leadership and targeted investment in infrastructure equity, the integration of AI in developing regions risks widening social inequalities while neglecting the urgent imperative of climate resilience. This research offers a novel "Integrated Green Education" framework, suggesting that the future of education in Uttar Pradesh depends on harmonizing technological advancement with the principles of environmental stewardship.

Keywords: *Artificial Intelligence, Green AI, Educational Leadership, Digital Divide, Secondary Education, Sustainability, NEP 2020.*

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I. INTRODUCTION

➢ *Background of the Study*

The advent of the Fourth Industrial Revolution has fundamentally altered the educational landscape, positioning Artificial Intelligence (AI) not merely as a supplementary tool but as a foundational pillar of modern pedagogy. AI-driven technologies, ranging from adaptive learning platforms to intelligent tutoring systems, promise to democratize education by offering customized learning pathways that cater to individual student needs. In the Indian context, this technological shift is aggressively promoted by the National Education Policy (NEP) 2020, which advocates for a substantial increase in the use of educational technology (EdTech) to bridge learning gaps and foster 21st-century skills. The policy envisions a multimodal learning environment where digital resources ensure equitable access to quality education across geographic and socio-economic boundaries.

However, the translation of this ambitious vision into reality within the socio-economic fabric of Uttar Pradesh presents a complex set of challenges. The "digital divide" in developing economies is often simplistic, framed merely as a lack of hardware. In reality, it is a multifaceted issue encompassing unreliable electricity, inconsistent broadband

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connectivity, and a lack of digital literacy among educators. In districts like Raebareli, where rural and semi-urban schools coexist in starkly different resource environments, the implementation of AI is uneven and often exclusionary. While elite private institutions may transition seamlessly to smart classrooms, government schools frequently grapple with basic infrastructural deficits, threatening to create a two-tiered education system.

Furthermore, the environmental narrative surrounding AI adoption is frequently overlooked in educational discourse. The computational power required to run machine learning models and maintain digital infrastructures contributes significantly to global carbon emissions. This has led to the emergence of "Green AI"—a movement focused on developing energy-efficient algorithms and promoting environmentally responsible computing practices. The concept of Green AI is particularly pertinent for developing nations, which often bear the brunt of climate change despite contributing least to the problem. This study argues that the current discourse on AI in Indian education is incomplete. It focuses heavily on the "People" (access) and "Profit" (educational outcomes) aspects of the Triple Bottom Line but neglects the "Planet" aspect.

➢ *Problem Statement*

Despite the clear policy directives of the NEP 2020, a significant gap persists between policy formulation and ground-level implementation in Raebareli. Schools face a dual challenge: the infrastructural inability to support high-bandwidth AI tools and a lack of strategic vision regarding the environmental consequences of such integration. While urban schools may have better access to digital resources, rural schools face infrastructural constraints that hinder successful AI implementation. Moreover, there is an emerging concern regarding the "ecological blindness" of educational leadership. School leaders are currently focused on technology for exam-centric results, often ignoring the energy costs and carbon footprint associated with running digital devices and AI servers. There is a scarcity of empirical research examining how schools in resource-constrained regions navigate the dual demands of digital adoption and environmental sustainability. Consequently, this research focuses on government and private secondary schools in Raebareli to examine the relationship between infrastructure, engagement, and sustainability, addressing whether current educational leadership is equipped to foster climate-resilient digital ecosystems.

➢ *Research Objectives*

The primary aim of this study is to investigate the integration of AI and Green AI in secondary schools in Raebareli, Uttar Pradesh. To achieve this aim, the following specific objectives have been formulated:

- To examine the impact of AI integration in secondary-level government and private schools on students' academic engagement and technological adaptability.
- To analyze the relationship between AI infrastructure and the level of AI adoption in secondary-level schools across Raebareli.
- To examine the extent and nature of the use of AI and Green AI technologies in senior secondary schools in Raebareli, Uttar Pradesh.
- To explore how strategic leadership influences the adoption of sustainable (Green AI) practices for climate resilience.

➢ *Research Questions*

In alignment with the objectives, this study seeks to answer the following research questions:

- RQ1: To what extent does the integration of AI influence students' academic engagement and technological adaptability?
- RQ2: What is the relationship between the availability of AI infrastructure and the level of AI adoption?
- RQ3: In what ways are AI and Green AI technologies currently being implemented in secondary schools in Raebareli, Uttar Pradesh?
- RQ4: How does educational leadership contribute to promoting Green AI for climate resilience and environmental sustainability in schools?

➢ *Hypotheses*

Based on the research objectives and review of literature, the following hypotheses have been formulated for testing in the quantitative phase of the study:

- *Hypothesis 1*

✓ Null Hypothesis (H_0): There is no significant relationship between AI integration and students' academic engagement and technological adaptability.
✓ Alternative Hypothesis (H_1): There is a significant relationship between AI integration and students' academic engagement and technological adaptability.

- *Hypothesis 2*

✓ Null Hypothesis (H_0): There is no significant relationship between AI infrastructure and the level of AI adoption in secondary schools of Raebareli.
✓ Alternative Hypothesis (H_1): There is a significant relationship between the availability of AI infrastructure and the level of AI adoption in secondary schools of Raebareli.

➢ *Significance of the Study*

This study is significant in three distinct ways. Academically, it contributes to the limited literature on Green AI in education, particularly within the Indian context, by empirically examining the intersection of AI, sustainability, and leadership. From a policy perspective, it provides critical insights for policymakers in Uttar Pradesh, highlighting the urgent need to align AI adoption under the NEP 2020 with climate-conscious strategies to prevent a surge in the educational sector's carbon footprint. Practically, the research identifies specific infrastructural and leadership barriers to AI adoption, offering actionable recommendations for

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institutions to integrate AI in a manner that is both pedagogically effective and environmentally responsible.

II. LITERATURE REVIEW

➢ *Theoretical Foundations and AI in Education*

The integration of AI into educational systems is deeply rooted in various learning theories that support personalized and adaptive instruction. Constructivism posits that learners construct knowledge best through experience and reflection; AI-driven tools like AutoTutor exemplify this by guiding students through problem-solving tasks within their Zone of Proximal Development. Similarly, Behaviorism is reflected in AI applications that utilize repetition and reward mechanisms, such as gamified language learning apps. However, Connectivism (Siemens, 2005), which views learning as a process of connecting specialized nodes or information sources, is perhaps the most relevant theory for the AI era. It suggests that in a digital environment, the capacity to know more is more critical than what is currently known. Yet, as Holmes, Bialik, and Fadel (2019) argue, the efficacy of these theoretical applications depends entirely on the "Diffusion of Innovations" (Rogers, 1962). Rogers' theory explains that the adoption of technology is not uniform; it relies on factors such as relative advantage, compatibility, and complexity. In the context of Raebareli, the "complexity" of AI tools and the lack of "compatibility" with existing infrastructure act as significant barriers to diffusion.

➢ *The Green AI Imperative and Ecological Modernization*

The dialogue around AI's sustainability is bifurcated into "Red AI" and "Green AI." Red AI prioritizes computational accuracy and performance, often at the expense of energy efficiency, leading to massive carbon footprints. In contrast, Schwartz et al. (2020) define Green AI as AI that is environmentally friendly and energy-efficient, focusing on reducing the carbon emissions of both algorithm training and inference. This aligns with Ecological Modernization Theory (EMT), which suggests that technological advancement can lead to environmental remediation if innovation is directed toward sustainability. Theoretically, applying EMT to education implies that digitization should lead to a reduction in resource use (e.g., paperless classrooms) and energy efficiency.

However, the Triple Bottom Line (TBL) framework—balancing People, Planet, and Profit—provides a more critical lens. In education, "Profit" is analogous to student achievement and institutional efficiency. Current literature suggests that educational institutions aggressively pursue the "Profit" and "People" (equity) aspects of TBL but systematically ignore the "Planet" aspect. There is a paucity of research examining the energy consumption of school-level server farms, the lifecycle assessment of digital devices distributed in schools, or the e-waste generated by rapid technological obsolescence. This lack of focus on "Green AI" in school settings represents a significant gap in the literature, particularly in developing regions where infrastructure fragility makes energy efficiency a pragmatic necessity, not just an ethical choice.

➢ *Educational Leadership and the Digital Divide*

Leadership is widely recognized as the linchpin of successful technology integration. Leithwood and Sun (2020) emphasize that transformational leadership—which involves inspiring a shared vision and fostering intellectual stimulation—is crucial for navigating complex changes. However, in the context of the Global South, leadership styles are often constrained by bureaucratic pressures and resource scarcity. Research indicates that school leaders in developing regions often adopt a "transactional" approach, focusing on maintaining order and meeting examination metrics rather than fostering innovation.

This "exam-centric" leadership model poses a significant barrier to Green AI adoption. If school leaders view technology solely as a means to improve test scores, they are unlikely to invest in "sustainable" technologies if those technologies are perceived as less powerful or more expensive. Furthermore, the "digital divide" is often framed as a technical issue, but it is also a leadership issue. Leaders in under-resourced schools may lack the "technological pedagogical content knowledge" (TPACK) to advocate for the right kind of infrastructure. This review suggests that without leadership that understands the intersection of pedagogy, technology, and sustainability, the integration of AI will remain superficial and inequitable.

III. METHODOLOGY

➢ *Research Design and Rationale*

This study employs a sequential explanatory mixed-methods research design, chosen for its ability to provide both statistical breadth and contextual depth. The rationale for this design is rooted in the need to first quantify the extent of AI adoption and its correlations with engagement (quantitative phase), and subsequently to explain the mechanisms, barriers, and subjective experiences behind these statistical trends (qualitative phase). This triangulation allows for a more comprehensive understanding of the "how" and "why" of AI integration in Raebareli than a mono-method approach could offer.

➢ *Research Context and Participants*

The study was conducted in the Raebareli district of Uttar Pradesh, a region selected for its representative mix of rural agrarian communities and semi-urban administrative centers. This geographic mix provides a distinct "natural laboratory" for examining the digital divide. The population included stakeholders from government-aided and private unaided secondary schools.

A stratified sampling technique was utilized to ensure proportional representation. The strata were defined by school type (Government vs. Private) and location (Rural vs. Semi-Urban). From these strata, 120 respondents were selected for the quantitative phase. This included 80 students (grades 9-12), 30 teachers, and 10 school leaders (Principals/Vice-Principals). Inclusion criteria mandated that participants must have had at least one year of exposure to digital learning tools in their institution. Exclusion criteria removed participants with administrative roles unrelated to

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academic planning (e.g., accountants) to ensure the relevance of the data.

➢ *Data Collection Instruments*

Data collection occurred in two distinct phases.

- *Phase 1 (Quantitative):* A structured survey questionnaire was developed, comprising 25 items measured on a 5-point Likert scale. The instrument was divided into four sections: Demographic Information, Digital Infrastructure Availability (e.g., device count, internet speed), AI Utilization Frequency, and Student Engagement Levels. The survey was piloted with 15 respondents outside the study area to establish face validity and internal consistency, yielding a Cronbach's Alpha of 0.82, indicating good reliability.

- *Phase 2 (Qualitative):* Semi-structured interview protocols were developed for school leaders, focusing on their strategic vision, decision-making processes regarding technology procurement, and awareness of sustainability. Focus Group Discussions (FGDs) were conducted with teachers (groups of 5-6) to explore pedagogical challenges, training needs, and perceptions of the "Green AI" concept.

➢ *Data Analysis Procedures*

Quantitative data were analyzed using SPSS (Version 26). Descriptive statistics (mean, standard deviation) summarized the demographic and infrastructural data. Inferential statistics, specifically Pearson's Product-Moment Correlation, were used to assess the strength of relationships between infrastructure and usage. Linear Regression analysis was performed to determine how much variance in student engagement could be predicted by AI integration. Hypotheses were tested at a 0.05 level of significance.

Qualitative data were audio-recorded, transcribed verbatim, and analyzed using NVivo 12. The analysis followed Braun and Clarke's (2006) six-step thematic analysis framework. This involved coding the data line-by-line, searching for recurring themes (e.g., "Infrastructure Deficit," "Exam Pressure," "Sustainability Blindness"), and reviewing these themes against the dataset to ensure accuracy. Member checking was employed by sharing preliminary themes with a subset of participants to confirm the credibility of the interpretation.

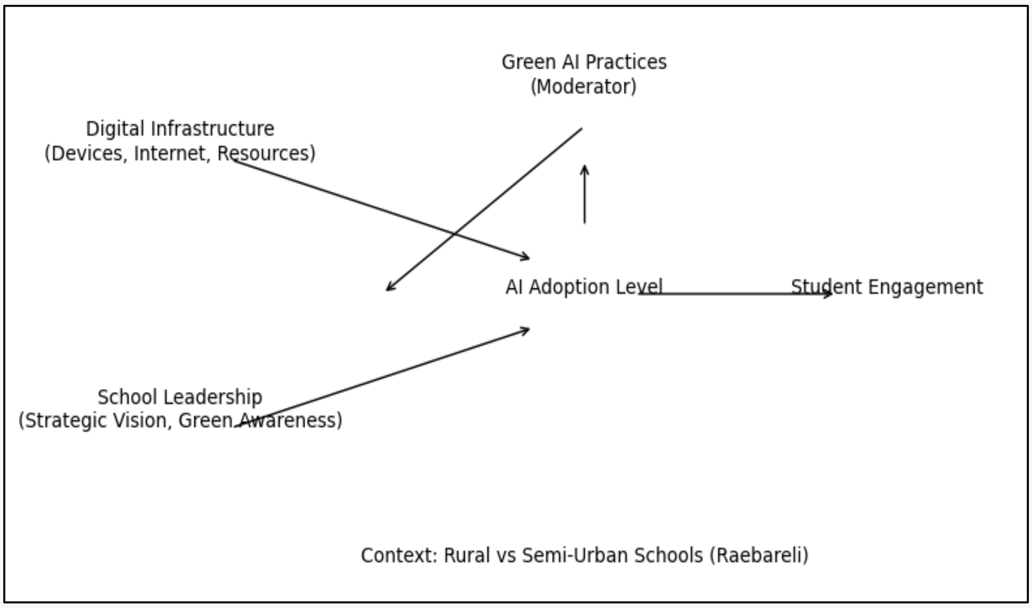

Fig 1 Conceptual Framework of the Study

- Description: A conceptual diagram illustrating the relationships between the study's variables.

✓ Independent Variables: Digital Infrastructure (Devices, Internet, Resources) and School Leadership (Strategic Vision, Green Awareness).
✓ Dependent Variables: AI Adoption Level and Student Engagement.
✓ Moderating Variable: Green AI Practices (Sustainability Awareness).
✓ Context: Rural vs. Semi-Urban Schools in Raebareli.
✓ Arrows: Bi-directional arrows connect Infrastructure to Adoption, and Leadership to Adoption. A circular arrow links Green AI Practices to Leadership, indicating a feedback loop for sustainability.

IV. RESULTS

➢ *Demographic Overview and Infrastructure Disparities*

The study sample exhibited a diverse demographic profile. As shown in Table 1, the distribution was split evenly between government (50%) and private (50%) schools, with a near-equal split between rural (48.3%) and semi-urban (51.7%) locations. Gender distribution was balanced, with 54.2% male and 45.8% female respondents.

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A critical finding emerged regarding infrastructural access. While smartphone penetration was high (92.5%), access to advanced computing devices was starkly unequal. In private schools, 85% of respondents reported access to functional computer labs and smart boards, whereas in government schools, this figure dropped to 15%. This disparity was further compounded by connectivity issues; 70% of rural schools reported daily electricity outages lasting more than 4 hours, severely hampering the continuity of digital learning.

➢ *Infrastructure as a Predictor of AI Adoption*

The quantitative analysis revealed a statistically significant relationship between infrastructure and AI adoption. Pearson's correlation analysis yielded the following results:

Pearson's correlation analysis yielded the results summarized in Table 2.

Table 2 Correlation Analysis: Infrastructure vs. AI Adoption

Infrastructure	Variable	Correlation with AI usage	Significance (p value) Interpretation
Device Availability	0.785	<0.01	strong positive
Internet Connectivity	0.75	<0.01	strong positive
Learning Resource	0.73	<0.01	Strong positive

- Device Availability and Usage Frequency: $r = 0.785$ ($p < 0.01$)
- Internet Connectivity and Usage Frequency: $r = 0.750$ ($p < 0.01$)
- Learning Resources and Usage Frequency: $r = 0.730$ ($p < 0.01$)

These strong positive correlations suggest that physical access is the primary determinant of technology use. The regression analysis further confirmed that infrastructure availability significantly predicts AI adoption, $F(1, 118) = 45.32$, $p < .001$. The R^2 value of 0.62 indicates that infrastructure alone explains 62% of the variance in how frequently AI tools are utilized. This finding validates the "Diffusion of Innovations" theory; without the basic "hardware" of infrastructure, the "software" of adoption cannot function.

The scatter plots in Figure 2 and Figure 3 visualize these strong relationships. Schools with better device availability and internet connectivity reported significantly higher usage of AI tools for educational purposes.

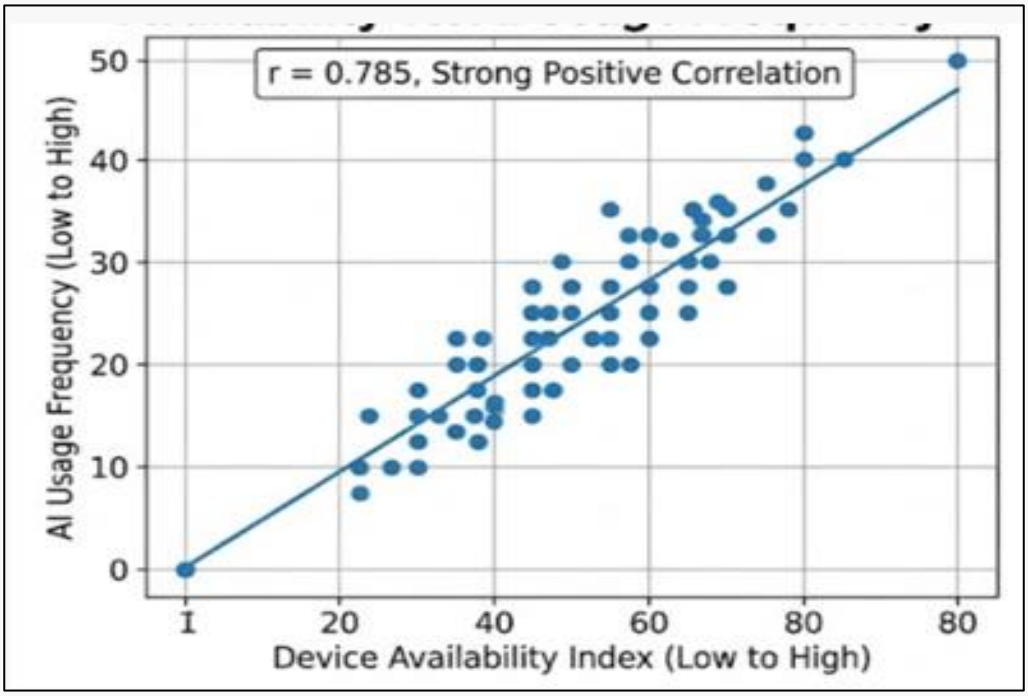

Fig 2 Scatter Plot of Device Availability vs. AI Usage Frequency

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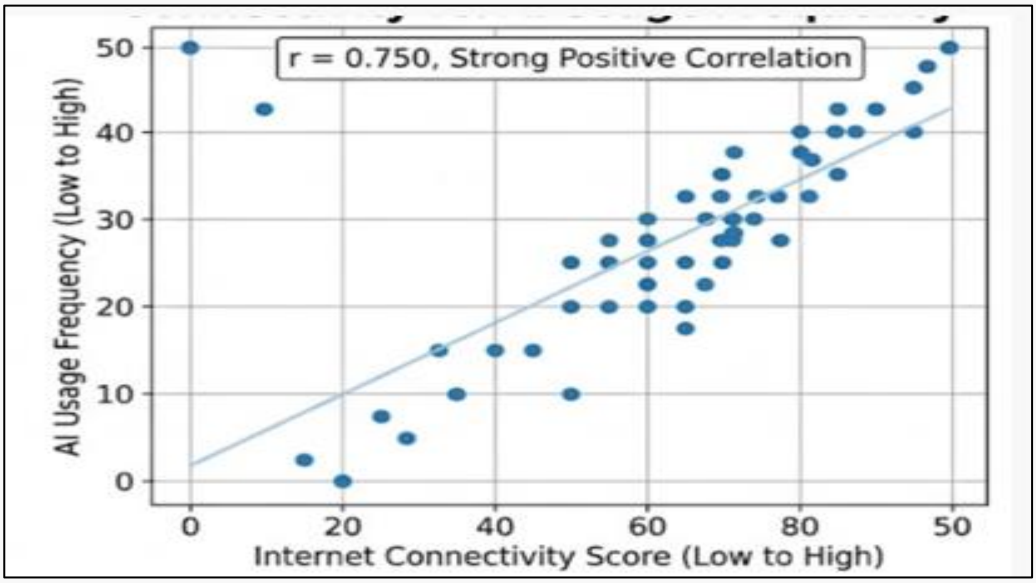

Fig 3 Scatter Plot of Internet Connectivity vs. AI Usage Frequency

➢ *Student Engagement and Technological Adaptability*

Descriptive statistics showed that 78% of students agreed or strongly agreed that AI-based learning platforms increased their engagement (Mean = 4.1 on a 5-point scale). Students reported that interactive quizzes and personalized feedback made learning "less boring." However, a gender gap was observed in technological adaptability. Male students reported 15% higher confidence scores in troubleshooting technical issues compared to female students, reflecting broader societal digital gender gaps prevalent in Northern India.

Furthermore, qualitative data highlighted that engagement was not uniform. Students in semi-urban schools utilized AI for creative projects and coding, whereas students in rural schools were restricted to basic content consumption due to bandwidth limitations.The relationship between learning resources and usage is depicted in Figure 4.

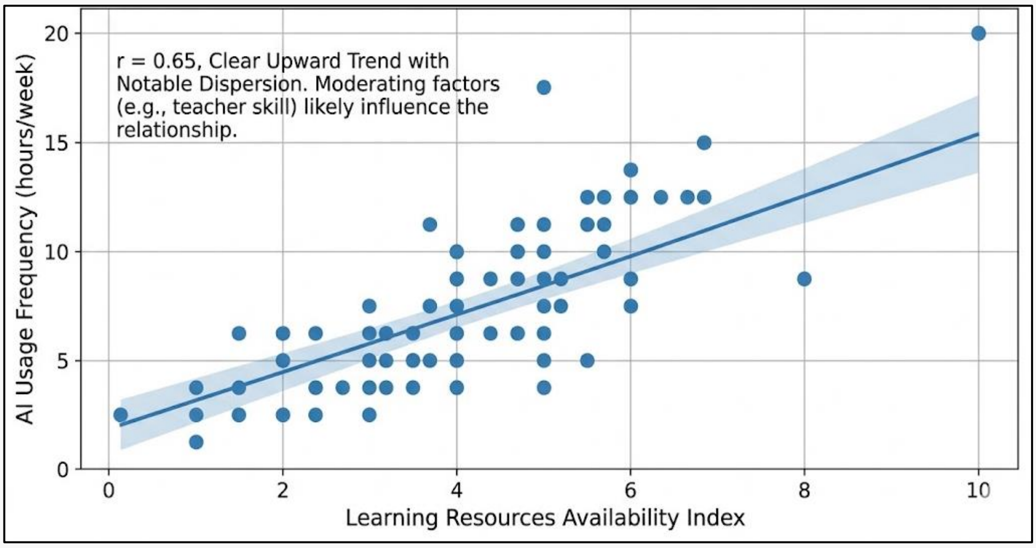

Fig 4 Scatter Plot of Learning Resources vs. Usage Frequency

➢ *The Green AI Gap and Leadership Qualitative Insights*

The qualitative phase unveiled a profound lack of awareness regarding sustainability. When asked about "Green AI" or "energy-efficient computing," 85% of respondents, including school leaders, expressed unfamiliarity. One principal noted, "We focus on buying computers that work; we don't ask about their energy ratings." This indicates a "Sustainability Blindness" in procurement and usage.

Thematic analysis of leadership interviews revealed a dominant "Exam-Centric" theme. Leaders admitted that technology budgets were allocated based on what would improve board exam pass rates. As one teacher stated, "If it doesn't help with the 10th or 12th-grade exams, the administration is not interested." This focus on short-term metrics has created a barrier to adopting Green AI, which is often viewed as a secondary concern compared to immediate academic performance.The key themes derived from the qualitative analysis are summarized in Figure 5.

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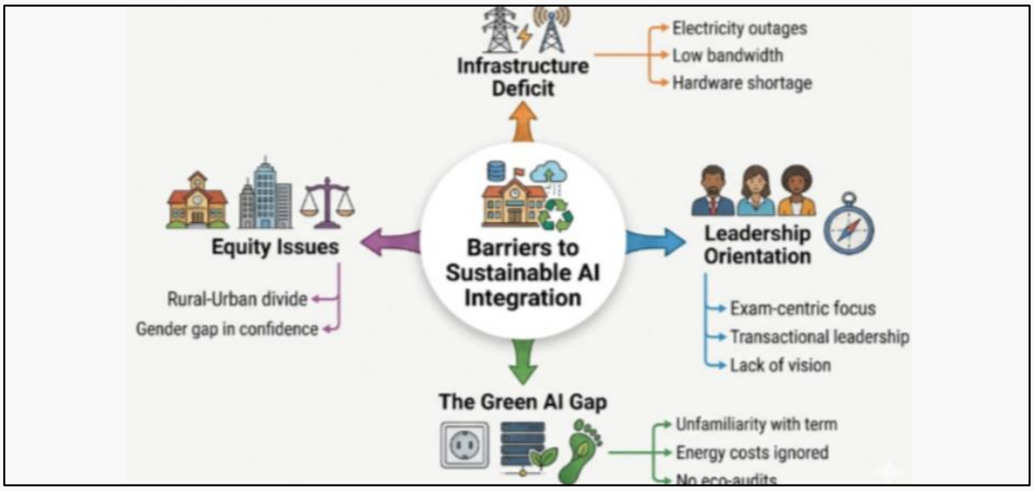

Fig 5 Thematic Map of Qualitative Findings

V. DISCUSSION

➢ *Reconciling Infrastructure and Engagement*

The study's findings confirm a robust positive correlation between digital infrastructure and AI adoption, reinforcing the argument that the "digital divide" is fundamentally an infrastructural divide. In Raebareli, the availability of devices and internet connectivity (r = 0.785) is the strongest predictor of whether AI is used in the classroom. This aligns with Rogers' (1962) Diffusion of Innovations theory, suggesting that "complexity" and "trialability" of AI are reduced when infrastructure is reliable. However, the study extends this theory by highlighting the fragility of this infrastructure in developing contexts. Unlike in Western contexts where connectivity is assumed, in rural Uttar Pradesh, the intermittent nature of electricity and internet turns digital tools into intermittent aids rather than integral pedagogical partners.

Furthermore, the finding that AI enhances student engagement supports the constructivist view that interactive tools facilitate active learning. However, the observed gender gap in technological adaptability is concerning. It suggests that while AI has the potential to democratize learning, it may inadvertently reinforce existing gender biases if not implemented with gender-sensitive pedagogical strategies. The higher confidence levels among male students in troubleshooting technical issues reflect a societal encouragement of STEM engagement for boys, a gap that schools must actively address through targeted training programs for female students.

➢ *The Green AI Paradox and Leadership Failure*

Perhaps the most critical contribution of this study is the identification of the "Green AI Gap." The finding that 85% of stakeholders are unaware of Green AI reveals a disconnect between the global sustainability discourse and local educational practice. While the NEP 2020 emphasizes environmental education, this focus has not permeated the domain of digital strategy. Schools are eager to consume energy (through digital devices) but are ignorant of the environmental cost of that consumption. This challenges the assumptions of Ecological Modernization Theory (EMT); in Raebareli, technological modernization is currently occurring *without* ecological consideration, potentially leading to a net increase in the school's carbon footprint.

The qualitative insights regarding leadership provide an explanation for this gap. The "exam-centric" focus of school leaders acts as a blinder, restricting their vision to immediate academic outputs (grades) rather than long-term outcomes (sustainability). This leadership style is transactional rather than transformational. Leaders are rewarding results (exam scores) rather than innovation or responsibility. This imbalance in the Triple Bottom Line (TBL) is evident: schools are prioritizing "Profit" (grades) and "People" (student access) while completely neglecting "Planet." Without a shift toward "Sustainable Technology Leadership"—where leaders are trained to evaluate the ecological cost of their procurement—the education sector risks becoming a significant contributor to local environmental degradation.

➢ *Synthesis and Theoretical Implications*

The study suggests that the "Integrated Green Education (IGE) Framework" is necessary to bridge these gaps. Current theoretical models of AI adoption do not adequately account for the energy constraints of the Global South. A new framework must integrate infrastructure readiness, pedagogical adaptability, and energy consciousness. The results indicate that AI adoption cannot be viewed in isolation; it is a systemic issue that requires reliable electricity, sustained teacher training, and a leadership philosophy that values sustainability as highly as it values academic success. The absence of any one of these pillars—specifically the "Green" pillar—results in a fragile, inequitable, and unsustainable digital ecosystem.

VI. CONCLUSION AND RECOMMENDATIONS

➢ *Conclusion*

This dissertation demonstrates that the integration of AI in secondary education is a double-edged sword, particularly in developing regions like Raebareli, Uttar Pradesh. On one hand, it offers significant opportunities to enhance student engagement, support personalized learning, and improve

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technological adaptability. The quantitative evidence confirms that where infrastructure exists, AI is a powerful tool for active learning. On the other hand, the study reveals that without equitable infrastructure and sustainability awareness, AI adoption risks widening the digital divide and increasing the carbon footprint of the education sector.

The study concludes that the "mere presence" of digital resources is insufficient. Success depends on a complex interplay of reliable infrastructure, continuous teacher training, and strategic leadership. Theoretically, the study confirms the relevance of the Diffusion of Innovations Theory but highlights its limitations in contexts of infrastructural scarcity. More importantly, it exposes a critical imbalance in the Triple Bottom Line approach within current school leadership practices. The long-term impact of this research lies in its advocacy for an "Integrated Green Education" model, where technology and sustainability are not treated as separate goals but as interconnected imperatives for the future of education in Uttar Pradesh.

➢ *Recommendations for Policy and Practice*

To address the identified gaps and harness the full potential of AI, the following recommendations are proposed:

- Infrastructure Equity Beyond Hardware: Policymakers must move beyond the distribution of tablets and smart boards. Investment must prioritize "digital foundational infrastructure"—specifically, reliable electricity (solar-powered backups for schools) and high-speed broadband. A "Digital Infrastructure Audit" should be mandatory for all schools receiving government grants to ensure that procurement is matched by operational capacity.
- Mandating Green AI Standards: The Department of Education should introduce "Green AI" standards for school procurement. This could include mandates for purchasing Energy Star-rated devices, utilizing cloud-based AI services that run on renewable energy, and implementing e-waste management protocols. Schools should be required to report on their digital energy consumption as part of their annual reporting.
- Reforming Educational Leadership: Principal training programs (such as the NISL leadership training) must be revised to include "Sustainable Technology Leadership." School leaders need to be trained not just in administrative efficiency, but in understanding the lifecycle costs of technology. They must be incentivized to reduce their school's carbon footprint, making sustainability a Key Performance Indicator (KPI) for school evaluations.
- Curriculum Integration of Green Pedagogy: The curriculum should move beyond basic ICT skills to include "Digital Citizenship and Sustainability." Students should be taught about the energy costs of the internet, the carbon footprint of data storage, and the principles of ethical AI. This will foster a generation of learners who are not just consumers of technology but responsible custodians of the digital environment.
- Gender-Sensitive Implementation: To bridge the gender gap in technological adaptability identified in the study, schools should implement specific interventions, such as girls-only coding clubs and female mentorship programs in technology, ensuring that the benefits of AI are equitably distributed across genders.

By aligning technological adoption with the principles of Green AI and the vision of the NEP 2020, Raebareli can serve as a beacon for how developing regions can navigate the digital age responsibly, leaving a lasting legacy of sustainable innovation for future generations.

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