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Transformative Education for Sustainable Futures: Exploring Green ICT Awareness and Practices among Higher Education Students

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Abstract

This research aims to explore the awareness, practices, motivational factors, and barriers of green information and communication technology (ICT) among higher education students at Central University, Delhi, relating to India's national education policy 2020 and the United Nations' sustainable development goals. A descriptive survey research design was used; data were collected using a structured questionnaire from 195 students. The questionnaire aimed to evaluate practitioners' green ICT awareness, practices, motivations, and barriers. Descriptive and non-parametric inferential statistics, such as the Mann–Whitney U and Kruskal–Wallis tests, were employed. Students' understanding of green ICT was moderate, but their actual involvement in green ICT practices was lower, indicating an awareness–practice gap. Females scored higher on green ICT awareness, while males scored higher on sustainable ICT behaviors. Peer pressure and institutional requirements were the main drivers for adoption, and the primary barriers were a lack of training, education, and green products. This study addresses a significant research gap by providing empirical evidence on green ICT awareness, practices, and the awareness–practice gap among higher education students in India, a context underexplored in existing literature. It uniquely investigates gender-based disparities (higher awareness among females, higher practice among males). It identifies peer influence and institutional mandates as primary drivers, offering novel insights for aligning institutional strategies with India's national education policy (NEP) 2020 and the UN sustainable development goals (SDGs). Results are based on self-report data from a single university. Further wider, longitudinal, and multimethod studies are recommended. The results guide educators and policymakers to develop interventions that reduce the awareness–practice gap and promote sustainable ICT practices.

Keywords: Green ICT, sustainable development, higher education, student awareness, gender differences, national education policy 2020, sustainable development goals

Introduction

Confronted with mounting environmental challenges – from climate change to resource depletion and waste generation – higher education institutions are increasingly expected to be enablers of transformation towards sustainability. An HEI's role as knowledge and innovation steward is central in providing future professionals with sustainability competencies and technological literacy (Barnett-Itzhaki et al., 2025; Molina et al., 2023). In this perspective, the green ICT (the strategic use of ICT for carbon emission reduction, for e-waste minimization, for electric consumption optimisation and natural resources conservation) is becoming one of the most suitable pathways through which sustainability can be embedded in educational systems (Amiri et al., 2025; Suryawanshi and Narkhede, 2015).

Integrating green ICT awareness and uptake in higher education supports both campus eco-efficiency itself, whilst intersecting with the United Nations' Sustainable Development Goals too. Especially relevant are SDG 4 (Quality Education) and SDG 12 (Responsible Consumption and Production). SDG 4 also highlights the importance of everybody having access to tertiary education that is of high quality and that is equally accessible to all and of developing technical and ICT skills that are needed in society (SDG Targets 4.3 and 4.4; UNESCO, 2020) (Abdullahi et al., 2024; Kızıloğlu and Karaboğa, 2024). Furthermore, SDG 4.7 explicitly requires the integration of sustainable development and sustainable lifestyles into national curricula, as well as teacher education, driving the significance of green ICT as content and a means for transformative pedagogy (United Nations, n.d.; UNESCO, 2024). At the same time, SDG 12 asks organisations to support sustainable consumption and production patterns that green ICT promotes when it decreases resource use in the digital world.

India's National Education Policy (NEP) 2020, introduced by the Ministry of Education, Government of India, provides a comprehensive framework for transforming higher education through multidisciplinary learning, digital integration, sustainability, and experiential pedagogy. There is a strong and timely opportunity to mainstream sustainability in the education system. Acknowledging the benefits of India's demographic dividend, NEP 2020 aligns with SDG 4, which seeks to provide inclusive and equitable quality education for all while encouraging a multidisciplinary approach, critical thinking, and digital literacy (Ministry of Education, 2020). The policy also specifically promotes environmental sustainability through green schools and campuses, eco-clubs and ICT for pedagogical innovation (Velempini, 2025; Yang et al., 2025). Technology-enabled learning and the National Education Technology Forum under NEP 2020 provide an opportunity to incorporate green ICT into curriculum development and campus operations (Ministry of Education, 2020).

Thus, the convergence of global (SDGs), national (NEP 2020), and technological agendas underscores the urgency of understanding how higher education students engage with green ICT—both in terms of awareness and practice. While research on sustainability integration in curricula is growing, empirical studies specifically addressing student knowledge and behaviour toward green ICT remain limited, particularly within Indian HEIs (Manchanda et al., 2025; Unuigbe and Zulu, 2023). This knowledge gap is critical because students—as both beneficiaries and agents of educational change—are pivotal to achieving transformative education. Accordingly, the present study seeks to explore how university students perceive and practise green ICT and to identify motivations and barriers influencing adoption. By doing so, it aims to contribute to the scholarship on sustainable competencies in HEIs, as well as inform policymakers and educators seeking to operationalise NEP 2020 and achieve SDG targets via green ICT integration.

In particular, the paper aims at studying students' knowledge and understanding of green ICT, like reducing power and paper consumption, responsible e-waste handling and informed digital behaviour. It also examines real green ICT adoption and practice, such as the use of energy-saving options, e-waste disposal, and responsible usage of ICT (McCarthy et al., 2024; Oduor and Franklin, 2024; Yadav et al., 2023). It also studies both the drivers—such as environmental concern, institutional promotion and peer influence—and the barriers –such as infrastructure unavailability and lack of awareness –that influence the adoption of green ICT (Dalvi-Esfahani and Nilashi, 2022; Lee et al., 2022; Oduor and Franklin, 2024; Papagiannidis and Marikyan, 2021). These results are discussed in the contexts of NEP 2020, SDG 4 (Quality Education), and SDG 12 (Responsible Consumption and Production) and have positive implications for curriculum design, institution policy, and pedagogical innovation.

By shedding light on how the next generation of graduates approach green ICT, this research contributes to the Education for Sustainable Development (ESD) literature by providing empirical knowledge on the digital dimension of sustainability in higher education. It responds to UNESCO's teaching to educate learners with knowledge, skills, and values necessary for sustainable development (El-Halwagy, 2024; Milkova et al., 2025; Molina et al., 2023) and it is a direct response to NEP 2020 for the integration of digital tools, sustainability, and a multidisciplinary approach in higher learning.

Ultimately, transformative education for sustainable futures relies on the use of technology not just as a conduit for content but as a sustainable practice in its own right. With its focus on orienting students' attitudes and actions towards green ICT, this study aims to impact institutional practices, teacher training and curriculum development to align with national policy and global sustainability agendas.

Literature Review

Prior studies suggest that demographic variables such as gender and age influence sustainability awareness and technology-related behaviours. However, findings remain inconsistent regarding green ICT adoption in higher education. This indicates the need to examine whether differences in awareness and practices exist among student subgroups and whether awareness necessarily translates into sustainable ICT behaviour. Furthermore, behavioural and institutional theories highlight that awareness alone may be insufficient to drive sustainable practices unless supported by social influence, institutional norms, and enabling structures. On this basis, the present study examines variations in green ICT awareness and practices across demographic categories and explores the relationship between awareness, behavioural adoption, and contextual motivators and barriers.

The following research questions guided the study:

1. What is the level of awareness and familiarity among university students with green ICT concepts and practices?
2. How much do students participate in green ICT practices?
3. Are there significant differences in green ICT awareness and practices based on demographic factors such as gender and age?
4. What are the primary motivations for students to adopt green ICT?
5. What barriers and challenges prevent the adoption of green ICT in educational institutions?

Materials and Methods

Research Design

This study employed a descriptive survey design to investigate university students' awareness, perceptions, practices, motivations, and barriers in relation to green information and communication technologies (green ICT). A quantitative approach was deemed appropriate, as it allowed the systematic collection and analysis of data from a relatively large sample to identify patterns and differences across demographic groups (Asencio et al., 2017; Hernandez et al., 2016).

Participants

The target population comprised students enrolled at Central University, Delhi (India). Using convenience sampling, 195 students voluntarily participated in the study by completing an online questionnaire. The sample consisted of (see Table 1) 57.9% females (n = 113) and 42.1% males (n = 82). Most participants were relatively young, with 75.4% (n = 147) between 20–25 years of age, while the remainder were aged 26–30 (21%), 31–35 (2.6%), and above 35 (1%). Regarding educational background, the largest group held a Bachelor's degree in Teacher Education (52.8%), followed by a Diploma in Teacher Education (24.1%), with smaller proportions holding master's or doctoral qualifications. Notably, 65.6% of participants reported no prior participation in green ICT-related workshops or awareness programmes, suggesting limited formal exposure to sustainability-focused ICT initiatives.

The demographic variables of gender, age, and educational background were selected for analysis based on prior literature indicating their influence on technology adoption and environmental behaviours (e.g., Papagiannidis & Marikyan, 2021; Zhao et al., 2024). Gender differences in environmental concern and technology use have been extensively documented, while age and educational exposure shape sustainability skills and ICT-related decision-making. Including these variables allows for a more detailed understanding of how green ICT awareness and practices vary across student subgroups within higher education. The concentration on students from teacher education programmes at Central University, Delhi, was intentional. This group represents future educators who are pivotal to implementing pedagogical shifts envisioned by NEP 2020. Central University was selected as a representative large public university in India's capital, where policy awareness is likely pronounced, providing a relevant context to study the intersection of policy, education, and sustainable technology practices.

Instrumentation

The research instrument was a structured questionnaire developed to measure students' awareness, practices, motivations, and barriers regarding green ICT. The construction and validation process involved the following steps:

Item Development

The initial pool of items was generated through a comprehensive review of the literature on green ICT, sustainability in education, and ICT behaviour change (El-Halwagy, 2024; Jäggle et al., 2024; Murugesan, 2008; Molla and Abareshi, 2012).

- The Awareness and Familiarity scale included nine items (3-point Likert scale) covering concepts such as energy efficiency, e-waste, cloud computing, and virtualization.
- The Practices and Behaviour scale included four items that measure sustainable ICT practices, such as using energy-saving settings, considering environmental impact when buying devices, and responsibly disposing of ICT equipment.

- Multiple-response items were created to identify students' motivations for adopting green ICT (such as peer influence, cost savings, and institutional requirements) and the barriers to adoption (like lack of training, limited green product availability, and cultural resistance).

Table 1 Demographic Information

Characteristics	Count	Count	Column N %
Gender	Male	82	42.1%
	Female	113	57.9%
Age	20-25	147	75.4%
	26-30	41	21.0%
	31-35	5	2.6%
	35+	2	1.0%
Educational Background	Diploma in Teacher Education	47	24.1%
	Bachelor Course	8	4.1%
	Bachelor in Teacher Education	103	52.8%
	Master Course	10	5.1%
	Master in Teacher Education	22	11.3%
	Ph.D.	5	2.6%
Have you ever participated in events or workshops focused on green ICT awareness?	Yes	67	34.4%
	No	128	65.6%

Content Validity

Content validity was confirmed through expert review by faculty members specialising in ICT, sustainability, and education from Jamia Millia Islamia and the University of Delhi. Experts assessed the items for relevance, clarity, and consistency with the study objectives. Based on their feedback, some items were reworded for better contextual clarity, while redundant items were removed.

Pilot Testing

A pilot study with ten university students (not included in the final sample) was conducted to check for item clarity, ease of administration, and approximate completion time. Feedback from participants indicated high clarity and face validity. Minor revisions, such as simplifying technical terms and reordering questions, were incorporated before final administration.

Construct Validity

To assess construct validity, Exploratory Factor Analysis (EFA) was conducted using Principal Component Analysis (PCA) with Varimax rotation. The analysis yielded the following results:

- Kaiser-Meyer-Olkin (KMO) = 0.918, indicating superb sampling adequacy (Kaiser, 1974).
- Bartlett's Test of Sphericity was significant ($\chi^2 = 1456.322$, df = 171, $p < .001$), confirming the data were suitable for factor analysis.
- Items loaded cleanly on the expected factors (Awareness vs. Practices), supporting construct validity of the scales.

Data Collection Procedure

The questionnaire was shared through official student networks and university social media groups. To maximise participation, the survey link was sent out multiple times over three weeks. Respondents completed the survey voluntarily, without any incentives.

Data Analysis

Data were analysed using both descriptive and inferential statistics with the help of SPSS software version 31 and Python for image generation. Specifically:

- First, descriptive statistics (means, standard deviations, skewness, and kurtosis) were calculated to summarise participants' awareness, familiarity, and practices.
- Later, after determining that the distribution did not follow a normal pattern through the Kolmogorov-Smirnov and Shapiro-Wilk tests, it was confirmed that the data for key variables did not meet the assumption of normality ($p < .05$). Therefore, non-parametric inferential tests were used.
    - Mann–Whitney U tests were applied to examine gender-based differences in awareness and practices.
    - Kruskal–Wallis tests were employed to analyse variations across age groups.
    - Spearman's rho correlations were performed to examine links between awareness, practices, and demographic variables (age, gender).
- Frequency and percentage analyses were used to identify key motivators and barriers to green ICT adoption.

This set of statistical techniques offered both a broad overview of trends and an analysis of statistically significant differences and correlations.

Results

RQ1: Level of awareness and familiarity with green ICT

Descriptive statistics were calculated for nine items measuring participants' familiarity and awareness of various green ICT concepts and practices. As shown in Table 2, the mean scores across all items ranged from 1.89 to 2.24 (on a 3-point Likert scale), suggesting that participants generally reported being "somewhat familiar" with most aspects of green ICT.

Specifically, respondents showed the greatest familiarity with international or national initiatives promoting green ICT (mean = 2.24, SD = 0.70) and with ICT equipment disposal procedures (mean = 2.22, SD = 0.72). They also had relatively high familiarity with initiatives in the workplace or community encouraging green ICT practices (mean = 2.16, SD = 0.74), with the concept of green ICT itself (mean = 2.09, SD = 0.75), and with the energy-saving benefits of cloud computing (mean = 2.03, SD = 0.77).

Conversely, participants showed the lowest familiarity with the concept of virtualisation and its environmental benefits (mean = 1.89, SD = 0.73), as well as with the concept of e-waste (mean = 1.92, SD = 0.70). Awareness of energy-saving benefits related to cloud computing (mean = 1.95, SD = 0.80) and energy-efficient hardware (mean = 2.04, SD = 0.78) was also moderate.

The distributions for all items were roughly symmetric, as shown by skewness values near zero. However, all items displayed negative kurtosis, indicating relatively flat distributions with responses spread across options instead of being highly concentrated at a single point.

Table 2 Descriptive Statistics of Green ICT Awareness and Familiarity

Items	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Item 1	2.09	.754	-.154	.174	-1.222	.346
Item 2	1.92	.699	.113	.174	-.936	.346
Item 3	2.24	.700	-.362	.174	-.921	.346
Item 4	2.16	.739	-.262	.174	-1.131	.346
Item 5	1.89	.728	.168	.174	-1.091	.346
Item 6	2.04	.782	-.063	.174	-1.360	.346
Item 7	2.03	.773	-.053	.174	-1.318	.346
Item 8	2.22	.723	-.361	.174	-1.026	.346
Item 9	1.95	.798	.093	.174	-1.421	.346

RQ2: Extent of participation in green ict practices

Table 3 shows descriptive statistics for four items that assess participants' engagement with sustainable ICT practices and environmentally responsible behaviors. The items were rated on a 3-point Likert scale, indicating the frequency or extent of each practice. Respondents reported the highest engagement with using energy-saving settings on electronic devices (mean = 2.29, SD = 0.63), suggesting this is an occasionally adopted green ICT behavior within the sample. Similarly, consideration of the environmental impact when purchasing electronic devices was also relatively high (mean = 2.09, SD = 0.71), indicating a moderate level of environmental awareness when acquiring new ICT equipment. The average score for considering the environmental impact of e-waste when disposing of ICT equipment (mean = 2.05, SD = 0.75) was slightly lower, implying that while participants are somewhat mindful of proper e-waste disposal, there is still room for improvement in this area. Notably, familiarity with energy-efficient computing practices was the lowest among the measured items (mean = 1.82, SD = 0.67), highlighting a possible gap in technical knowledge or everyday use of energy-saving strategies beyond simple device settings. Skewness values for all items were near zero, indicating roughly symmetrical response distributions. Negative kurtosis values across items suggest responses were moderately dispersed, with no extreme clustering, reflecting variability in the adoption and awareness of green ICT practices within the sample.

Table 3 Green ICT Practices and Behaviour

Items	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
Item 1	1.82	.669	.223	.174	-.779	.346
Item 2	2.05	.748	-.075	.174	-1.202	.346
Item 3	2.09	.712	-.135	.174	-1.010	.346
Item 4	2.29	.626	-.298	.174	-.644	.346

RQ3: Demographic differences in awareness and practices

To examine gender differences in green ICT awareness and practices, group statistics and Mann-Whitney U tests were conducted (see Table 4). Female participants reported significantly higher levels of awareness and familiarity with green ICT (mean = 19.08, SD = 4.09) compared to their male counterparts (mean = 17.78, SD = 3.80). The Mann-Whitney U test showed that this difference is statistically significant (U = 5612, p = 0.012). This suggests that, within this sample, females have a greater overall awareness and understanding of green ICT concepts and initiatives. Conversely, male participants showed significantly higher engagement in green ICT practices and behaviours (mean = 10.99, SD = 1.82) relative to female participants (mean = 10.25, SD = 1.88), with the Mann-Whitney U test confirming this difference (U = 3578, p = 0.006). This finding indicates that, although females have higher awareness, males are more likely to report engaging in sustainable ICT practices.

Table 4 Mann-Whitney U Test Results Comparing Green ICT Awareness, Familiarity, and Practices Based on Gender

Scale	Gender	Mean	Std. Deviation	Std. Error Mean	U Mann-Whitney	p
Green ICT Awareness and Familiarity	Male	17.78	3.80	.42	5,612	.012
	Female	19.08	4.09	.38		
Green ICT Practices and Behaviour	Male	10.99	1.82	.20	3578	.006
	Female	10.25	1.88	.18		

The Kruskal-Wallis test in Table 5 revealed no statistically significant difference in awareness and familiarity scores across age groups (H = 2.501, p = 0.475). This means that participants' awareness of green ICT concepts and initiatives was relatively consistent, regardless of age. Similarly, the Kruskal-Wallis test found no significant differences in green ICT practice scores among the different age groups (H = 1.733, p = 0.630). This suggests that engagement in green ICT practices does not significantly vary with age within this sample.

Table 5 Kruskal-Wallis Test Results for Green ICT Awareness, Familiarity, and Practices Across Age Groups

Scale	Age group	Mean	Standard deviation	Standard error of mean	Kruskal-Wallis H	p-value
Green ICT awareness and familiarity	20–25	18.28	4.16	0.34	2.501	0.475
	26–30	19.34	3.37	0.53		
	31–35	18.80	4.82	2.15		
	35+	20.00	1.41	1.00		
Green ICT practices and behaviour	20–25	10.61	1.90	0.16	1.733	0.630
	26–30	10.49	1.86	0.29		
	31–35	10.00	2.12	0.95		
	35+	10.00	1.41	1.00		

Spearman's rho correlation was conducted to examine the relationships among green ICT awareness, practices, and selected demographic variables (age and gender). The Spearman's rho correlation results are presented in Figure 1. A significant negative correlation was found between green ICT awareness and practice (ρ = -0.398, p < 0.001), suggesting that higher levels of awareness were associated with lower reported practice of green ICT behaviours. This inverse relationship may indicate a gap between knowledge and implementation, a phenomenon observed in sustainability-related behaviour change literature.

Regarding demographic variables, green ICT awareness and familiarity were not significantly linked to Age (ρ = 0.108, p = 0.131), suggesting that awareness levels are fairly consistent across different age groups within the sample. However, a weak yet statistically significant positive correlation was observed between awareness and gender (ρ = 0.181, p = 0.011), indicating that gender is somewhat associated with awareness levels. This finding implies that females reported slightly higher awareness levels than males.

Practice was also not significantly related to age (ρ = -0.077, p = 0.286), showing no meaningful link between age and green ICT behaviour. Since the p-value is above the usual cutoff of 0.05, we conclude that age does not have a significant effect on Green ICT practices in this sample. However, practice was negatively related to gender (ρ = -0.199, p = 0.005), indicating that males reported higher engagement in green ICT practices compared to females, even though females showed higher awareness. Because the correlation is significant at the 0.01 level (2-tailed), this gender difference in Green ICT practices is unlikely to be due to chance.

These findings reveal a complex relationship between awareness, behavior, and demographic traits. Notably, the gap between awareness and practice—where individuals with higher awareness participate less in green ICT activities—requires further research into barriers to behavior change, such as institutional support, resource access, or perceived effectiveness.

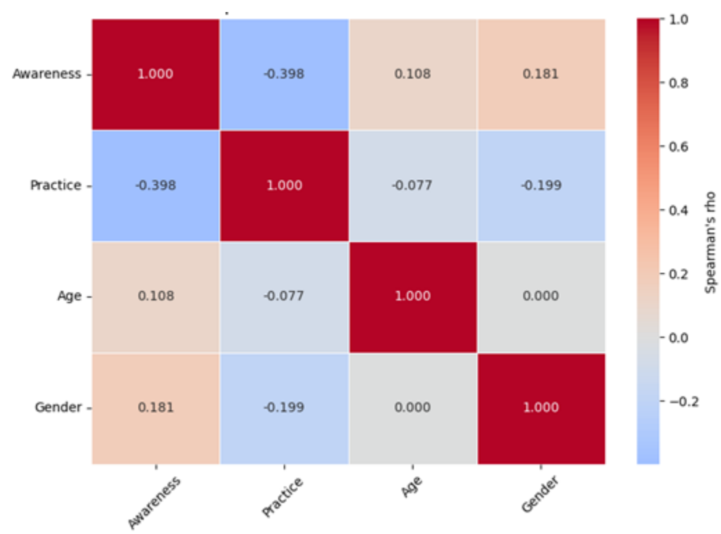

Figure 1 Spearman's rho Correlation Matrix

RQ4: Motivations for adopting green ICT

The dimension of "motivations for adoption" examines the factors that influence individuals and institutions to adopt green ICT practices, as well as the core reasons for rejection. This analysis draws on findings from Tables 6 through 9, which include both single and multiple-response items from a sample of 195 respondents.

The main factors influencing the adoption of green ICT (see table 6) show that peer influence is the most significant, with 36.9% of respondents citing "friends" as a key factor. This indicates that social influence and peer behaviour may play a pivotal role in shaping individual environmental practices in educational settings. Likewise, institutional requirements were also a major motivator (32.8%), suggesting that top-down policies and mandates within educational institutions have a substantial impact on technology use and environmental responsibility. Cost considerations (19.5%) also stand out, reflecting the practical nature of decision-making, where financial incentives or savings support sustainable behaviour. Legal frameworks (5.6%) and environmental concern (1.5%) were less frequently mentioned, which might point to a lack of regulatory enforcement or limited environmental awareness among some participants. Notably, a small portion of respondents (0.5%) reported either a lack of adoption or unfamiliarity with green ICT, highlighting an awareness gap that could be addressed through targeted education and training.

Table 6 Factors Contributing to Green ICT Adoption

Factor	Percent
Friends	36.9%
Institutional Requirement	32.8%
Cost	19.5%
Laws	5.6%
Environment	1.5%
Family	0.5%
Self-Responsibility	0.5%
Eco-Friendly	0.5%
No Adoption	0.5%
Students	0.5%
Society	0.5%
I don’t know what is green ICT	0.5%
Total	**100.0%**

Most respondents (54.9%) consider energy consumption (see table 7) in their use of electronic devices, though they lack detailed knowledge. An additional 29.7% actively monitor energy use, showing a growing awareness and proactive behavior aligned with sustainability goals. However, 15.4% admit they do not pay attention to energy use, indicating a group that may need further education or motivation to adopt energy-conscious habits.

Table 7 Consideration of Energy Consumption in Use of Electronic Devices

Response Option	Percent
Yes, but I’m not sure about the specifics	54.9%
Yes, I actively monitor it.	29.7%
No, I don’t pay attention to it.	15.4%
Total	**100.0%**

Table 8 presents the multiple-response analysis; respondents listed several reasons for adopting green ICT, with the most common being that it extends device lifespan (25.3% of responses; 43.0% of cases). This aligns with both environmental and economic advantages, as prolonging hardware life reduces e-waste and replacement costs. Environmental friendliness was also an important motivator, with 23.5% of responses (39.9% of cases) citing carbon footprint reduction as a key factor. Ease of communication and output (22.6%) and cost savings (19.5%) highlight the practical and operational benefits of green ICT. The motivation to enhance a positive external image (9.1%) was the least cited, indicating that intrinsic or utility-based motivations tend to be more influential than reputation concerns in the educational setting.

Table 8 Reasons for Adopting the Green Approach (Multiple Responses)

Reason for Adopting the Green Approach	% of Responses	% of Cases
It increases the devices' lifetime	25.3%	43.0%
Ease of producing output or speeding up communication (e.g., email vs paper submission)	22.6%	38.3%
Cost reduction (e.g., electricity, paper, new equipment, transportation, etc.)	19.5%	33.2%
It leads to a positive image in the eyes of others	9.1%	15.5%
It leads to reducing carbon footprint and is environmentally friendly	23.5%	39.9%
Total	**100.0%**	**169.9%**

RQ5: Barriers to green ICT adoption

Table 9 depicts the understanding that rejection is crucial to interpreting adoption. The most cited reason for not adopting Green ICT was a lack of knowledge or awareness (37.2% of responses; 58.2% of cases). This finding signals a critical need for awareness campaigns, capacity building, and curriculum integration to foster a deeper understanding of sustainable ICT practices. Other significant barriers included a lack of clear guidelines or standards (23.4%), the limited availability of green products (14.5%), and a perception that existing equipment is sufficient (10.9%). These responses reflect both structural limitations and attitudinal resistance, highlighting the importance of not only education but also institutional support, resource access, and policy clarity.

Table 9 Reasons for Rejecting the Green ICT Approach (Multiple Responses)

Reason for Rejecting the Green ICT Approach	% of Responses	% of Cases
Lack of green ICT knowledge/awareness	37.2%	58.2%
Ignorance about the consequences of not using green ICT	14.1%	22.2%
Limited number of green products	14.5%	22.7%
Old equipment is still functioning, so there is no need to invest in green ICT.	10.9%	17.0%
Lack of clear guidelines and standards	23.4%	36.6%
Total	**100.0%**	**156.7%**

The data presented in Table 10 identifies key institutional, cultural, and policy-related barriers hindering the adoption of Green ICT practices in educational settings.

1. Lack of Education and Training as the Most Significant Barrier

The most commonly cited barrier, with 14.7% of responses (46.2% of cases), is the lack of education or training from institutions. This highlights a significant gap in institutional readiness and the need for professional development programs. The absence of structured educational initiatives on Green ICT suggests that many students, faculty, and staff may not fully understand sustainable technology practices, their benefits, or how to implement them effectively. This finding supports the earlier observation that awareness and knowledge gaps are key factors in the rejection of Green ICT (see Table 9).

2. Behavioural and Cultural Obstacles

A significant proportion of respondents identified behavioural and cultural barriers, including:

- Lack of motivation among faculty/staff/students (12.1%; 38.2% of cases)
- Lack of participation from necessary stakeholders (11.7%; 37.0%)
- Environmentally unconcerned institutional culture (11.0%; 34.7%)

These responses reflect the importance of institutional culture and individual engagement in driving change. Without widespread commitment and internal motivation, policy changes or infrastructural improvements may be limited in effect. A disengaged or indifferent culture can even impede well-funded initiatives.

3. Perception and policy gaps

Interestingly, 11.4% of responses (35.8% of cases) indicated that the environmental impacts of ICT are not considered significant. This perception creates a major conceptual barrier: if sustainability in ICT is not seen as a priority, it is unlikely to receive attention in planning or budgeting. This further emphasizes the need for awareness campaigns and curriculum integration to foster a shared understanding of ICT's environmental footprint. Regarding governance, the lack of government regulation (11.2%) and weak procurement practices (9.2%) suggest that external frameworks and institutional policies are either underdeveloped or poorly enforced. Without clear national or institutional guidelines, decisions about procurement, disposal, and energy use may not prioritise sustainability.

4. Funding and Research Constraints

Despite the increasing global focus on sustainability, funding limitations continue to be a major obstacle, with 9.9% of responses (31.2% of cases) pointing to insufficient support from top management. Additionally, inadequate research and development (RandD) activities were mentioned by 9.0% of respondents (28.3%), highlighting a lack of innovation and adaptation of green ICT solutions within educational institutions.

Table 10 Barriers and Challenges to Adopting Green ICT in Educational Institutions (Multiple Responses)

Barriers and Challenges	% of Responses	% of Cases
Lack of adequate funding and support from top management	9.9%	31.2%
Lack of participation from necessary students/staff/faculties	11.7%	37.0%
Environmentally unconcerned institutional culture	11.0%	34.7%
Lack of education or training from institutes	14.7%	46.2%
ICTs' environmental impacts are not considered significant.	11.4%	35.8%
Lack of motivation among faculty/staff/students at institutes	12.1%	38.2%
Lack of government regulation	11.2%	35.3%
Lack of good procurement practices at educational institutes	9.2%	28.9%
Inadequate research and development activities	9.0%	28.3%
Total	**100.0%**	**315.6%**

Discussion

The discussion interprets the key findings structured around the research questions. Concerning RQ1 and RQ2, students demonstrated moderate awareness but lower engagement in green ICT practices, revealing a distinct awareness–practice gap. Addressing RQ3, significant gender differences emerged, with females reporting higher awareness and males reporting higher practice. No significant variations were found across age groups. Regarding RQ4 and RQ5, the primary motivations for adoption were peer influence and institutional requirements, while the chief barriers were a lack of training, education, and accessible green products. The following sections expand on these findings and their implications.

The findings of this study show a complex relationship between awareness and practice of green ICT among higher education students. While female students exhibited significantly higher awareness of green ICT concepts, male students reported greater participation in sustainable ICT practices. This contradictory awareness–practice gap reflects the broader sustainability literature, which indicates that knowledge alone does not always lead to action due to structural, cultural, and motivational barriers (Alfirević et al., 2025; Irabor et al., 2025; Milkova et al., 2025).

The negative correlation between awareness and practice supports previous research highlighting the so-called "value–action gap" in sustainability behaviours. For example, Grunwald et al. (2025) and Salahange et al. (2024) found that despite strong environmental awareness, students often lack the institutional support and technical know-how to effectively implement sustainable ICT practices. Likewise, Cabasan (2024), Kızıloğlu and Karaboğa (2024), and Zhao et al. (2024) showed that awareness is necessary but not enough without enabling factors such as infrastructure, training, and incentives.

The present study also found that peer influence and institutional requirements were more powerful drivers of green ICT adoption than intrinsic environmental concern. This supports previous research by Abdallah et al. (2024), Arhavbarien et al. (2024), and Primandaru et al. (2023), who suggested that students are more likely to adopt sustainable ICT behaviours when they perceive social endorsement and institutional mandates. Conversely, environmental concern played only a minor role, aligning with findings by Clark and Doll (2024), Manchanda et al. (2025), and McCarthy et al. (2024), which indicate that sustainability adoption in higher education is often motivated by practical or social reasons rather than deep ecological values.

Furthermore, the barriers identified—lack of education, inadequate training, cultural indifference, and limited availability of green products—align with earlier studies in both Indian and global contexts (Baroudi and Haidar, 2025; Hermannsson et al., 2023; Manchanda et al., 2025). These barriers reveal systemic gaps in curriculum integration, policy enforcement, and institutional leadership that hinder turning awareness into action.

Conclusion

This study examined green ICT awareness, practices, motivations, and barriers among higher education students in India, relating the findings to the national education policy 2020 and the sustainable development goals. The main conclusion is the existence of a significant awareness–practice gap, emphasising that knowledge does not automatically lead to sustainable behaviour. Notably, the gender disparity, in which females exhibited higher awareness but males demonstrated more practice, merits further investigation into the social and behavioural factors influencing Green ICT adoption.

The findings offer clear practical implications. For educators and policymakers aiming to operationalise NEP 2020 and SDG 4 and 12, interventions must move beyond raising awareness to enabling practice. This can be achieved by integrating green ICT modules into the curriculum, providing hands-on training, strengthening institutional sustainability mandates, and ensuring access to green technologies. By bridging the gap between awareness and action, higher education institutions can better equip students to become proactive agents of sustainable digital transformation.

Limitations and Future Research

Several limitations should be recognized. First, the study used a convenience sampling method at a single institution (Central University, Delhi), which may limit how well the findings apply to other higher education settings. Second, relying on self-reported survey data introduces the risk of social desirability bias, as students might exaggerate their awareness or practices related to green ICT. Third, the cross-sectional design limits the ability to draw causal conclusions; longitudinal studies would be needed to see how awareness and practices change over time and in response to institutional efforts. Finally, the small percentage of participants with prior experience in Green ICT workshops (34.4%) suggests limited practical exposure, which could have affected both awareness and reported behaviors.

Future research should explore multiple directions to overcome these limitations. Conducting studies across various universities in India and internationally would enable comparative analysis of green ICT adoption within different institutional and cultural contexts. Long-term research can evaluate how policy changes, training programs, and curriculum integration influence students' sustainability practices over time. Additionally, using mixed-methods approaches that include qualitative interviews or focus groups could offer more in-depth understanding of the social, cultural, and psychological factors behind the awareness–practice gap. Finally, intervention studies assessing the effectiveness of structured training, peer-led initiatives, and policy enforcement could provide practical insights for policymakers and educators.

The Discussion section analyzes and interprets the study's results in relation to existing knowledge, exploring the significance and implications of the findings. It compares the results with previous studies, cites relevant references, and addresses strengths, weaknesses, and unexpected outcomes. Authors may discuss study limitations, propose explanations or hypotheses, and suggest directions for future research. This section ties the key findings back to the research questions or objectives stated in the Introduction.

Declarations

Ethics Statement: All procedures involving human participants in this study were conducted in accordance with the ethical standards of the institutional and/or national research committee.

Informed Consent: All individual participants in the study gave informed consent. Participation was voluntary, and participants were informed about the research's purpose, the voluntary nature of their involvement, the confidentiality of their data, and their right to withdraw at any time without penalty.

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