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Digitalization of Agricultural Education in Northern India: Accessibility, Use and Effectiveness

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SUMMARY

This study investigates the availability, awareness, and utilization of ICT (Information and Communication Technology) infrastructure and software tools among agricultural students in Northern India. The research is based on a comprehensive primary survey conducted among students enrolled in State Agricultural Universities (SAUs). We computed indices for ICT awareness, availability, and usage and categorized students into low, medium, and high ICT usage groups for further analysis. Additionally, we examined the adoption of various e-resources tailored to the field of agriculture, such as Agridaksh and Agropedia. Our findings reveal a direct correlation between ICT awareness and availability with its actual usage among students. Several factors including educational level, gender, social background, family context, and ICT awareness were found to influence ICT usage among students. Analysis of student perceptions regarding the effectiveness of ICT resources in various academic activities indicates that over 75 percent of students consider ICT use in the learning process as a time-saving measure. Furthermore, nearly 66 percent agree that ICT enhances efficiency and accuracy in their work. More than half of the students reported improved understanding of concepts, enhanced academic performance, increased placement and employment opportunities, and greater prospects for higher education through the utilization of various ICT resources. However, students perceived a relatively lower impact of ICT resources on placement and employment creation. These results underscore the potential of digital tools in agricultural education and emphasize the need to bridge the existing gap in access, awareness, and usage of ICT tools in State Agricultural Universities in Northern India.

Keywords: Digitalization; Agricultural education; ICT use; ICT awareness; ICT adoption; ICT effectiveness; Social media.

1. INTRODUCTION

The digitalization of agricultural higher education involves the utilization of Information and Communication Technology (ICT) for teaching, learning, and research processes. ICT has precipitated a rapid transformation in educational systems worldwide over the past two decades. It plays a significant role in granting access to high-quality educational resources, enabling remote learning, and mitigating constraints of time and place in education (Talebian *et al.*, 2014).

The role of ICT has become particularly pivotal in various fields, including education, in response to the new normal ushered in by the COVID-19 pandemic. The Government of India has undertaken various initiatives under the National Mission on Education through Information and Communication Technology (NMEICT) program to harness the potential of ICT in teaching and learning. These initiatives encompass open online courses, high-quality educational channels through Direct to Home (DTH), a virtual repository of learning resources with a single-window search facility, open-source audio-video tutorials, virtual labs, promotion of open-source software in educational institutions, and the provision of embedded systems and robotics for teacher and student training (GoI, 2022).

Similar endeavors are evident in the field of agricultural education, where several initiatives have

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been launched to promote the use of ICT for effective learning processes. India's National Agricultural Research System (NARS) ranks among the world's largest systems, encompassing a robust network consisting of the Indian Council of Agricultural Research (ICAR) and State Agricultural Universities (SAUs). The country boasts a resilient Agricultural Education (AE) network comprising 66 Deemed Universities, three Central Agricultural Universities, and four Central Universities with Agriculture Faculties.

AE stands apart from other streams of education by virtue of its dual emphasis on scientific learning and hands-on field experience in agricultural production, management, and research. Consequently, both laboratory and fieldwork constitute integral components of higher AE. The AE programs and curricula encompass diverse disciplines of biological and social sciences, focusing on the delivery of professional courses for mastery in agricultural production and research. As such, similar to other professional higher education programs, the scope for offline or remote learning programs in agriculture is limited.

Recognizing the need for digitalization in agricultural education, the National Agricultural Research and Education System (NARES) of India has accorded significant importance to ICT infrastructure development and human resource enhancement. ICT infrastructure and its applications received due attention through the National Agricultural Innovation Project (NAIP), initiated by ICAR in 2006 and executed over six years. Under NAIP, efforts were made to bolster ICT infrastructure and its application in various ICAR research institutes and SAUs. As part of this endeavor, e-courses covering diverse agricultural disciplines were designed, alongside strengthening digital libraries and information management systems. Through NAIP and other ICAR initiatives, access to various information and knowledge-sharing platforms, including CeRA (Consortium for e-resources in agriculture), WebOpac, Union Catalogue, institutional repositories, digital archiving, information portals, e-courses, and e-publishing, was initiated for NARES (NAIP, 2014; Pateria, 2014).

This momentum has continued through the National Agricultural Higher Education Project (NAHEP), launched in 2017, which aptly recognizes the significance of ICTs in AE for enhancing international competitiveness (Kumar P *et al.*, 2019; NAHEP, 2019).

Currently, digital integration in agricultural higher education in India primarily involves course delivery, the development of online course materials, accessing learning resources, and distance education (Rathore *et al.*, 2020). The integration of ICT into teaching and learning activities has gained further impetus in the wake of the COVID-19 pandemic. The digitalization efforts by the Indian Council of Agricultural Research (ICAR) in agricultural education paved the way for the transition to online education during the pandemic, thereby mitigating the adverse effects of the crisis on the learning process.

However, a recent study by Muthuprasad *et al.* (2021) revealed that despite the flexibility and convenience offered by online learning, both students and instructors at agricultural universities in India reported technological constraints during the COVID-19 period.

The use of ICT and online education has the potential to complement traditional learning methods, especially in light of the increasing number of students in higher education institutions (Herath and Hewagamage, 2015; Kozlova and Pikhart, 2021). It is pertinent to assess how well agricultural universities have equipped themselves to integrate a potential hybrid model of education. Additionally, an examination of the patterns of ICT usage among students, along with their perceived advantages and limitations, would provide valuable insights.

Against this backdrop, this study seeks to shed light on the status of ICT infrastructure, the availability, awareness, and usage of ICT tools (both hardware and software), with a special emphasis on resources developed within the NARS. This study focuses on their availability to students pursuing higher education in agriculture in Northern India. Furthermore, it explores the utilization of various social media platforms for academic learning among students and examines the perceived impact of ICT usage on various aspects of academic learning. It's important to note that this study specifically considers digitalization efforts in SAUs, as empirical evidence for a comparative study with other disciplines is not available.

2. METHODOLOGY

2.1 Data Collection

The study was conducted across five State Agricultural Universities in the Northern states of India, specifically in Haryana, Himachal Pradesh, Punjab, Uttarakhand, and Uttar Pradesh. Data were gathered from undergraduate and postgraduate students enrolled in 12 universities specializing in agricultural and animal husbandry education within the selected states during the academic year 2016-17. The selection of students focused on those in their third year of undergraduate studies and first year of postgraduate studies, as they were expected to possess substantial exposure to both academic and research domains. The total number of students in the sample was 2,734, as detailed in Table 1.

Table 1. State-wise details of number of student respondents

State	Sample size
Haryana	415
Himachal Pradesh	519
Punjab	483
Uttarakhand	367
Uttar Pradesh	950
Total	**2,734**

In addition to students, administrative staff and instructors were included in the respondent group to assess the availability of ICT infrastructure. The study operated under a time constraint, and there was uncertainty regarding the response rate, especially from administrative officers. Given that a significant proportion of undergraduate students came from rural backgrounds with unclear access to facilities for participating in an online survey, personal visits were conducted to collect data from a broader sample of stakeholders. Furthermore, the online survey format might have biased responses, as it was accessible only to students with internet access and mobile phones or computers.

The various ICT tools were broadly categorized into:

i) Hard tools, encompassing the physical infrastructure of ICT, including desktops, laptops, projectors, interactive boards, tablets, etc.

ii) Soft tools, representing the software component of ICT initiatives, which included e-resources tailored for agricultural education, such as Agropedia (an online knowledge repository in agriculture), CeRA (Consortium of e Resources in Agriculture), digital repositories like e-prints@cmfri, e-granth, KrishPrabha, and KrishiKosh, e-learning platforms like e-krishishikha, e-learn agriculture, e-Journals, Agridaksh (an expert system), and provisions for statistical software like SAS, among others.

A pre tested structured questionnaire was employed to collect information on students' basic profiles, the availability, awareness, and usage patterns of ICT materials and resources at universities, the use of social media for learning, the availability and utilization of ICT soft initiatives in agricultural education, and the perceived impact of ICTs on various aspects of agricultural education. Percentage analysis was employed to represent the distribution of student respondents based on their basic profiles. Further details regarding the methodology are provided in the subsequent subsections.

2.2 Indices for ICT availability, ICT awareness and ICT use

While there exist various reports, research papers, and literature discussing ICT awareness, adoption, and its impact on diverse aspects of society, there is a dearth of specific "ICT awareness index," "ICT use index," and "ICT availability index" that are widely recognized or established, akin to some other indices like the Human Development Index. International organizations such as the International Telecommunication Union (ITU), World Bank, World Economic Forum, and UNESCO regularly publish reports and statistics on global ICT development, including indicators related to ICT awareness and access. These reports provide insights into the state of ICT readiness and adoption in various countries. However, none of these reports observe any index measuring the availability, awareness, or use of ICT. Nevertheless, similar indices were employed by Kumar V *et al.* (2019) to investigate the extent of utilization of different ICT tools by teachers in Agricultural Universities and by Shashidhara (2020) to examine the use of ICTs by extension personnel in disseminating agricultural information in North Eastern Karnataka.

In our survey, we recorded the availability and awareness of individual ICT tools as binary variables, denoted by 'yes' or 'no' responses, with corresponding scores of one or zero. The ICT resources considered for computing the indices are presented in the first

column of Table 3. The frequency of usage of different ICT resources was measured on a five-point scale, with scores assigned as follows: Daily (4), Weekly (3), Monthly (2), Occasionally (1), and Never (0), as detailed in Table 4. To quantitatively and systematically assess these responses, we developed three types of indices: the ICT Use Index, the ICT Availability Index, and the ICT Awareness Index for each student, calculated using Equations 1-3.

$ICT\ use\ Index = \frac{\sum_i^n \sum_{j=1}^m U_i C_j}{\sum_i^n \sum_{j=1}^m Max(C_j)} * 100$	(1)
$ICT\ awareness\ Index = \frac{\sum_{i=1}^n A_i}{\sum_i^n i} * 100$	(2)
$ICT\ availability\ Index = \frac{\sum_{i=1}^n B_i}{\sum_i^n i} * 100$	(3)

In the equations provided above, the variables U, A, and B correspond to the states of utilization, awareness, and accessibility, respectively, with "Yes" represented as 1 and "No" as 0. Additionally, the variable C signifies the weighting assigned to the utilization categories, ranging from 0 to 4. Here, 'i' serves as the index for specific ICT tools, while 'j' acts as the index for utilization categories, encompassing 'never,' 'occasional,' 'monthly,' 'weekly,' and 'daily.' The variables 'n' and 'm' denote the maximum count of ICT tools and utilization categories, respectively, with the highest attainable value for any index set at 100.

2.3 Computation of ICT use categories

Stratification process serves a dual purpose: it reduces variability within each stratum and ensures proportional representation when needed. Moreover, stratification can unveil hidden patterns, trends, or disparities that might remain unnoticed when analyzing data as a whole. The analysis of stratified data can lead to more informed decision-making and the ability to tailor strategies to address specific segments identified through this stratification.

In this study, students were classified into three categories based on their ICT use index values: low, medium, and high. To establish the boundaries of these categories, we employed the Cumulative Square Root Frequency method (CSRF), a valuable technique for handling skewed distributions (Dalenius and Hodges, 1959). CSRF achieves this by dividing the cumulative function of the square root of frequencies into equal intervals.

To determine the stratum boundaries, we divided the ICT use index data (as defined in Equation 1) into distinct class intervals. For each class interval, we calculated the frequencies, square root of frequencies, and cumulative square root frequencies. These calculations allowed us to define the upper limits for the three required categories (low, medium, and high) using Equation 4.

$C_i = Y_{i-1} + \left(\frac{(Y_i - Y_{i-1})}{\sqrt{f}}\right) * \left\{\left(S_k / 3\right) * i - S_{i-1}\right\}$	(4)

Where,

C_i = Upper limit of the ith category, i: 1, 2, 3 for low, medium and high respectively

Y_i = Upper limit of the class in which C_i lies

Y_{i-1} = Lower limit of the class in which C_i lies

S_k = Cumulative square root frequency value

$\sqrt{f}$ = Square root of the frequency of the ith class in which Lies

S_{i-1} = CSRF of the preceding class in which $C_i\left(S_k/3\right)$ lies

$Y_i - Y_{i-1}$ = Width of the class in which in which $C_i\left(S_k/3\right)$ lies

Since the data needs to be classified into three strata (low, medium and high), the cumulative square root frequency of last class was divided by 3 to get the cumulative square root value for each stratum. These values were used for identifying the upper limit of the identified strata.

2.4 Use of social media for learning among students

In addition to the utilization of ICT tools at universities and colleges, the adoption of social media platforms for educational purposes has gained popularity among students. This trend is primarily driven by the widespread availability of convenient and

flexible ICT access through devices like smartphones and tablets. We examined the usage patterns of various social media platforms, including Facebook, WhatsApp, Google Groups, Wiki, Twitter, Blog, Google+, News, and other platforms, among students for learning purposes. The extent of social media use for academic activities was evaluated on a five-point scale, ranging from "Daily" to "Never."

2.5 Availability and use of ICT soft initiatives in agricultural education

Numerous e-resources and online knowledge repositories have been made accessible within agricultural universities through various ICT initiatives by ICAR. Prominent initiatives include Agropedia, CeRA, and other digital repositories. Additionally, online platforms such as MOOCs (Massive Open Online Courses) and Coursera offer learning opportunities to students. This study assessed the availability of these ICT soft resources among students from different agricultural universities. Availability for each e-resource was determined using a binary response code (Yes/No), and the frequency of their usage was measured on a scale of "Daily," "Weekly," "Monthly," "Occasionally," and "Never"

2.6 Perceived impact of ICT use in agricultural education

Students' perceptions of the influence of ICT use on various aspects of learning, including time spent, information accuracy, and ease of learning, were gauged using a five-point continuum: "Strongly Disagree," "Disagree," "Neutral," "Agree," and "Strongly Agree." The distribution of students' responses for each e-resource was calculated in terms of percentages. To comprehend the perceived external factors affecting ICT adoption, students were asked to express their level of agreement on various factors categorized on a five-point scale ("Strongly Disagree," "Disagree," "Neutral," "Agree," "Strongly Agree"). To rank each factor, a weighted average score out of 100 was computed, with weights assigned based on proportional responses under each score. Furthermore, the effectiveness of ICT resources on different aspects of learning and its outcomes, such as concept development, academic performance, employment opportunities, and higher education prospects, were also evaluated.

2.7 Factors affecting ICT use among students

To analyze the socio-economic and external factors influencing the use of ICT tools among agricultural students, we employed both qualitative perception analysis and empirical methods. At the individual level, factors affecting ICT use were identified using an Ordinary Least Square (OLS) regression with the following functional form:

$$Y_i = \beta_0 + \beta_1 \boldsymbol{X}_i + \beta_2 T_i + \beta_3 A_i + \varepsilon_i$$

Where:

Y_i represents ICT tool use index for student i.

$\boldsymbol{X}_i$ includes Student specific characteristics, encompassing course, gender, caste, family background and access to scholarship.

T_i is a binary variable indicating whether individual student i received ICT training.

A_i represents the ICT tools awareness index for student i.

ε_i denotes the error term.

3. RESULTS AND DISCUSSION

3.1 Profile of respondents

The profile of student respondents from various states is detailed in Table 2. A majority of the students

Table 2. Profile of student respondents (%)

Variables	Possible Values	% of students
Course	Under-Graduation	63.24
	Post-Graduation	36.76
Gender	Male	57.39
	Female	42.61
Caste category	General	56.80
	Scheduled Caste	15.62
	Scheduled Tribe	2.19
	Other Backward Caste	25.38
Family background	Rural	60.31
	Urban	39.69
Scholarship	Yes	42.50
	No	57.50
Training received	Yes	19.39
	No	80.61
Possession of ICT resources	Mobile/Tablet	95.61
	PC/ Laptop	60.39
	Internet connectivity	82.77

were enrolled in undergraduate (UG) courses, accounting for 63.24 percent. The sample also displayed a higher representation of male students. Notably, 40 percent of the students hailed from urban backgrounds. Relatively few students had received training related to ICTs. The majority of students possessed personal ICT resources, such as mobile phones and tablets, with over 80 percent having internet connectivity. However, personal laptops or computers were available to only 60 percent of students.

3.2 Availability, awareness and use of ICT resources among students

The availability of different ICT resources across the State Agricultural Universities (SAUs) in Northern India exhibited wide variation. Students' positive reports on resource availability ranged from 18-91 percent. Notably, academic websites, computers, and projector facilities were widely available. However, the availability of E-Portfolio, Teleconference, Video conference, Digital report card system, and Virtual classroom facilities was limited. Interestingly, more than 75 percent of students were aware of commonly used ICT resources, such as computers, projectors, and academic websites, despite their limited availability. However, the utilization of ICT resources was relatively lower compared to their availability and awareness levels, which could have posed challenges for online learning during the pandemic, especially during lockdown months.

Table 3. Availability, awareness and use of ICT resources among students

SI No.	ICT item	% of students		
		Availability	Awareness	Use
1.	Interactive board	76.12	83.80	71.58
2.	Computer	89.32	91.62	85.37
3.	Projector	88.37	89.25	81.75
4.	Television	59.25	76.66	58.45
5.	Video conference	29.48	52.96	22.90
6.	Teleconference	21.98	40.05	17.92
7.	E-Portfolio	18.40	29.52	15.51
8.	Wi-Fi / LAN	69.93	75.90	63.57
9.	Digital report card system	21.58	41.44	19.90
10.	Virtual class rooms	33.65	49.12	30.21
11.	Academic websites	90.93	88.30	83.80

Source: Authors estimated based on primary survey (2016)

Table 4. Usage pattern of ICT resources among students

Item	% of students				
	Never	Occasionally	Monthly	Weekly	Daily
Interactive board	28.42	19.02	1.87	9.69	41.00
Computer	14.63	31.68	5.30	17.26	31.13
Projector	18.25	24.65	5.30	15.76	36.03
Television	44.15	25.38	3.11	7.50	19.86
Video conference	77.10	15.84	2.89	2.05	2.12
Teleconference	82.08	11.70	1.65	1.76	2.82
E-Portfolio	84.49	8.27	1.06	2.78	3.40
Wi-Fi / LAN	36.43	14.34	2.38	7.24	39.61
Digital report card system	80.10	12.77	2.34	1.39	3.40
Virtual class rooms	69.79	12.66	1.83	4.06	11.67
Academic websites	16.20	35.74	13.50	18.58	15.98

Source: Authors estimated based on primary survey (2016)

Our analysis of usage pattern of ICT resources by students showed that more than 50 per cent of students use interactive board and projector on regular basis (Daily or weekly) (Table 4). Only one-third of the respondents were regularly using academic websites of the respective SAUs for their learning. Though the identification of the specific reasons for this was beyond the per view of the study, it may be attributed to static content on the websites as reported by the students during the survey. Also, the analysis showed that a section of the students has never used common ICT resources like computers (15%), website (16%) and interactive board (28%). This may be because of limited availability of such facilities in their respective universities.

3.3 Categorization of students based on ICT use

The students were categorized into three categories based on their ICT resource use index, into low, medium and high category with class intervals '0 – 24', '24 – 44' and '44 - 100' respectively. Majority of the students remained under medium ICT resource use index category (Table 5). It was observed that proportion of students using ICT at different levels is directly proportional to the corresponding ICT availability index and ICT awareness index. Further, students were well aware of the ICT resources even when the availability of the same of limited. Fewer students were classified as 'High' ICT users, suggesting room

for improvement in ICT utilization through increased awareness and resource availability.

Table 5. Distribution of students in different ICT tools use category

ICT Use Category	ICT use Index class values	Students (%)	Mean ICT availability index	Mean ICT awareness index
Low	<24	34.75	34.66	44.22
Medium	24-44	43.09	47.75	56.81
High	>=44	22.17	60.99	66.85

Source: Authors estimated based on primary survey (2016)

3.4 Use of social media for academic learning among students

Social media is a set of applications on internet that provides users a platform to share any text or media to increase their networking. Table 6 shows the use of popular social media applications by the students. Even though News related and collective use of other websites are used by more than 90 per cent of students, WhatsApp is most widely daily used application by students.

Table 6. Use of social media for learning among the students

Items	Use (% of students)	Degree of usage (% of students)				
		Never	Occasionally	Monthly	Weekly	Daily
Face book	86.47	13.53	19.35	4.39	15.95	46.78
Whats App	89.17	10.83	13.90	2.41	8.08	64.78
Google Groups	55.71	44.29	20.52	4.02	10.39	20.78
Wiki	66.06	33.94	23.37	4.97	15.51	22.20
Twitter	23.52	76.48	11.12	3.07	4.75	4.57
Blog	18.51	81.49	7.90	2.23	4.54	3.84
Google+	65.76	34.24	23.37	7.79	11.92	22.68
News	90.09	9.91	14.67	3.29	12.00	60.13
Others	95.79	4.21	10.53	1.05	23.16	61.05

Source: Authors estimated based on primary survey (2016)

More than 75 per cent students were using ICT resources along with social media applications for research purpose, subject learning and for communication (Table 7). A smaller proportion of, 4 to 9 per cent of, students, were not using social media for academic purpose and 10-18 per cent students were neutral about use of social media for academic purpose and learning. On similar lines, Pandey *et al.* (2020) and Reddy *et al.* (2021) had also emphasized positive role of social media on higher agricultural education in terms of creation of social wealth. The analysis suggests that social media based academic material will directly benefit majority of students in learning and research.

Table 7. Purpose of using ICT resources among students of SAUs Northern India

Purpose of use	% of students				
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Research	3.44	2.56	11.49	44.62	37.89
Subject information	2.30	3.11	12.58	47.99	34.02
General knowledge	2.60	1.79	9.62	45.03	40.97
Presentation material	3.11	5.71	17.63	42.43	31.13
Communication	3.26	3.69	12.87	44.88	35.30

Source: Authors estimated based on primary survey (2016)

3.5 Availability and use of ICT soft initiatives among SAU students of Northern India

An analysis of the frequency of use of e-resources revealed that 41 percent of students were using E-Courses, with 48 percent reporting their availability. Approximately 52 percent of students regularly used e-literature. On the contrary, the use of ICT resources developed for agricultural education, such as Agropedia (18%) and Agridaksh (9%), was limited. These findings underscore the potential for enhancing the outreach of these initiatives through improved content and increased user awareness.

Table 8. Availability and usage of ICT soft initiatives in agricultural education (%)

Category	Soft initiatives	% of students	
		Availability	Use
Knowledge Repository	Agropedia	28.64	17.92
Expert System Tool	Agridaksh	19.02	8.89
Statistical Software	SAS	19.75	11.56
Literature Search	CERA, e-granth, e-Journals, e-prints@ cmfri, KrishiKosh, KrishPrabha	64.30	52.45
E-Course/ E-learning platforms	Coursera, e-krishishikha, e-learn agriculture, MOOCS	48.43	40.78

Source: Authors estimated based on primary survey (2016)

3.6 Factors affecting the use of ICT

Table 9 summarizes students' perceptions of factors affecting the use of ICT resources. Factors such as internet speed, availability of e-resources, operational knowledge of ICT tools, subscription to relevant journals and e-resources, and access to quality ICT tools were perceived as the most influential factors affecting ICT use among students. Some of the factors identified are comparable to the study by Singh *et al.*, (2021).

The regression analysis revealed several significant factors affecting ICT tool use among students, including course type, gender, caste, family background, and awareness of ICT (Table 10). ICT tool use index was higher among post-graduation students. This could be due to better awareness, access and higher use of ICT resources by PG students for research purposes. Across the gender categories, female students had higher index compared to their male counterparts indicating no gender bias towards female students in case of ICT use. Siddiq and Scherer (2019) has also reported higher level of ICT literacy among female students. ICT usage was found to be significantly lower in case of students belonging to marginal castes and rural areas. This may be due to lack of personal ICT resources which leads to and knowledge of ICT tools.

Table 9. Perceived factors affecting use of ICT among SAU students of Northern India

Factors	Response of student (%)					Weighted mean-factor score out of 5	Rank
	SD	D	N	A	SA		
Internet Speed	3.00	7.28	20.23	32.04	37.45	3.94	1
Availability of e-resources	3.26	6.69	23.45	40.89	25.71	3.79	2
Operational knowledge of ICT tools	2.56	5.67	26.96	43.93	20.89	3.75	3
Subscription of relevant Journals and e- resources	3.37	5.49	28.42	40.71	22.02	3.73	4
Access to quality ICT tools	2.01	5.63	30.1	42.57	19.68	3.72	5
Infrastructure facilities	2.60	8.38	25.79	42.9	20.34	3.7	6
Training on ICT tools	3.07	7.32	29.26	38.19	22.17	3.69	7
Organizational support and Policy	3.55	6.47	33.32	39.32	17.34	3.6	8
Complexity and initial time requirement for updating ICT skills	3.69	5.6	31.89	45.39	13.42	3.59	9
Heavy Workload necessitates use of ICT	3.77	9.91	32.99	36.43	16.9	3.53	10

Source: Authors estimated based on primary survey (2016)

Note: SD-Strongly disagree, D-Disagree, N-Neutral, A-Agree, SA-Strongly Agree

Table 10. Regression estimates of factors affecting the use of ICT tools among students

Independent variables	Coefficient	significance
Course (Base category =Graduation): Post-graduation	0.60	1.35**
Gender (Base=Male): Female	0.61	1.66***
Caste category (Base category =General): Other Backward Castes	0.82	-2.77***
Scheduled Caste	1.96	2.77
Scheduled Tribe	0.71	-2.59***
Background (Base category=Rural): Urban	0.61	1.44**
ICT awareness index	0.01	0.38***
Intercept	0.94	10.00***
Adjusted R squared	0.24	
N	2734	

Note: standard errors are given in parenthesis

*** and ** represent statistical significance at 1% and 5% levels respectively

3.7 Effect of ICT on student learning in the SAUs of Northern India

The students' perceptions regarding the impact of ICT on various academic activities, including research, subject knowledge updating, and receiving academic alerts, are presented in Fig. 1. A significant majority of students expressed agreement with the positive effects of ICT in terms of time-saving, enhanced accuracy, and improved ease of use. Specifically, more than 75 percent of students concurred that ICT contributes to time savings in academic tasks. Furthermore, nearly 66 percent of students acknowledged that ICT facilitates ease in their academic work and enhances accuracy.

To gauge the effectiveness of ICT, the surveyed students were asked to rate the degree of improvement in areas such as concept understanding, academic performance, job placement, employment opportunities, and prospects for higher education. These ratings

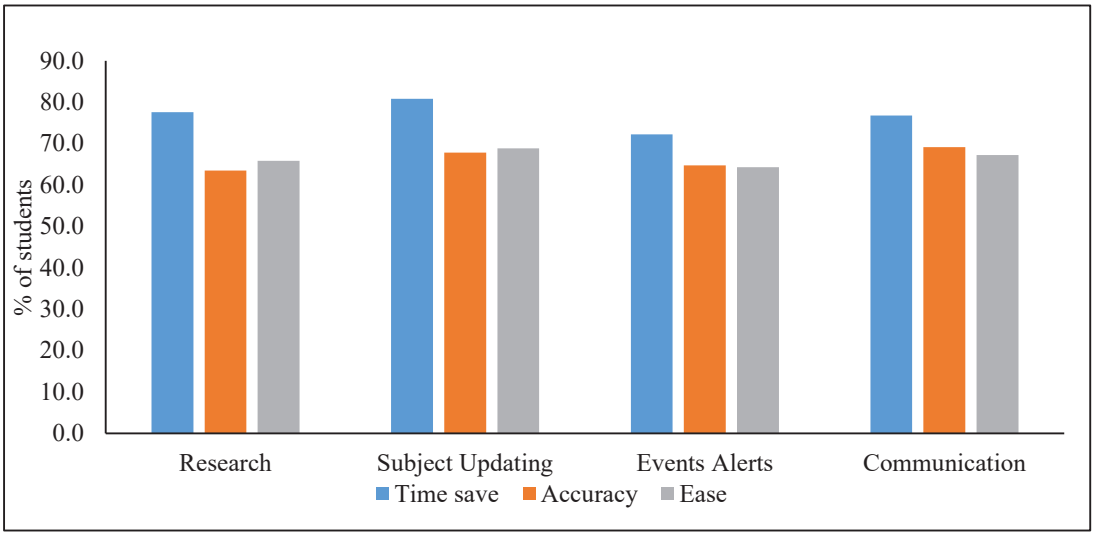

Fig. 1. Agreement of students (%) regarding impact of ICT resources

Source: Authors estimated based on survey primary survey (2016)

form the basis for heat map wherein movement from blue to red shade indicates increasing proportion of respondents under each category (Fig. 2). We observe that a majority of them attributed more than 50 per cent of positive effects to ICT use.

It is noteworthy that over 60 percent of the students pointed out the negative impacts of ICT, including health problems, reduced productivity due to excessive ICT usage, information overload on the internet, and a lack of socialization (Fig. 3).

Items	1-10	11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-100
Concept	7.86	4.9	2.89	2.63	4.28	10.02	9.18	17.89	18.54	12.00
Performance	7.24	6.51	3.26	4.43	5.41	8.34	10.61	17.34	19.75	11.85
Employment	16.28	2.6	3.22	3.51	4.28	7.06	9.62	13.79	15	14.08
Higher Education	8.67	4.21	1.9	2.6	2.63	6.4	7.57	10.5	17.15	18.11

Fig. 2. Heat map for showing extent of improvement (%) in various dimensions of education after using ICT

Source: Authors estimated based on primary survey (2016), Note: Blue - White – Red indicate transition from low to high

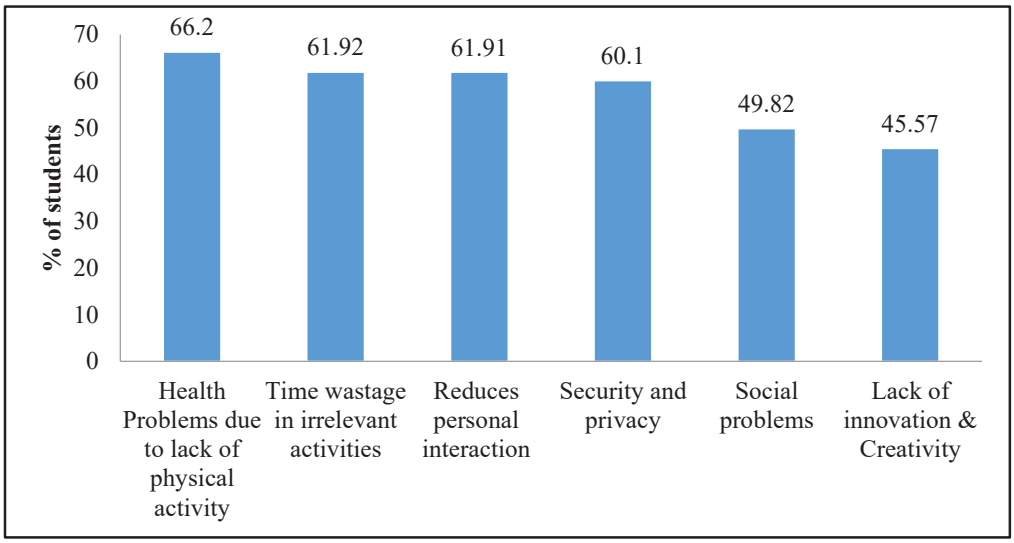

Fig. 3. Agreement of students (%) on negative impact of ICT

Source: Authors estimated based on primary survey (2016)

In nutshell, the analysis revealed that a limited number of students had received formal ICT training, the majority possessed personal ICT devices, including mobile phones and tablets. However, access to personal laptops or computers was less prevalent, being available to only 60 percent of students.

Regarding the availability, awareness, and use of ICT resources, our study uncovered varying degrees of access among students. Academic websites, computers, and projector facilities were relatively widespread. Conversely, e-Portfolio, teleconference, video conference, digital report card systems, and virtual classroom facilities exhibited limited availability. While students demonstrated good awareness of ICT resources, actual usage was somewhat lower, potentially posing challenges for online learning.

The distribution of students into three groups based on their ICT resource utilization: low, medium, and high users suggested a correlation between ICT usage and availability and awareness of resources. There is ample room for increasing ICT utilization among students through improved awareness and resource accessibility. Students' use of social media for academic purposes emerged as a notable trend, with WhatsApp being the most frequently used platform. Additionally, over 75 percent of students reported using social media for research, subject learning, and communication, underscoring the importance of social media in academic pursuits.

The analysis of ICT soft initiatives highlighted varying levels of use. E-courses and e-literature had the highest usage rates, while certain resources designed for agricultural education, such as Agropedia and Agridaksh, had lower utilization. This indicates the need for enhancing the reach and content of these initiatives.

Limitation of the study: The study has limitation of data pertaining to Northern India. Hence, some findings of the study may have regional applicability only. Besides, the data was collected during academic year 2016-17. Rapid transitions are observed in mobile and internet coverage since then. The study clearly concludes that despite the availability, access and use of ICT resources is limited. Further, the study identified the constraining factors which affect the utilization in spite of the availability.

4. CONCLUSIONS AND POLICY IMPLICATIONS

In this study, we conducted a comprehensive assessment of the utilization and impact of Information Communication Technology (ICT) tools and resources in agricultural education among students in Northern India. Our findings shed light on various aspects of ICT adoption and its consequences.

Our study provides valuable insights into the state of ICT adoption among agricultural students in Northern India. While there is a strong prevalence of personal ICT devices among students, more concerted efforts are warranted to bridge the gap between resource availability and actual utilization. Enhancing the accessibility and enriching the content of ICT resources, especially in the context of agricultural education, can substantially enhance students' learning experiences.

Moreover, the positive impact of ICT on academic activities, including time savings, heightened accuracy, and ease of use, underscores its paramount significance in contemporary education. However, it's imperative to acknowledge that students also perceive negative facets of ICT, such as health concerns and information overload, necessitating targeted interventions through awareness and digital literacy initiatives.

Our findings implore policymakers and educational institutions to channel their efforts into fortifying ICT infrastructure and promoting its effective integration into agricultural education. This, in turn, can lead to improved academic performance, heightened employment prospects, and a more competitive agricultural workforce. As we forge ahead, striking a harmonious balance between harnessing the benefits of ICT and addressing its potential drawbacks remains essential for a holistic and effective educational landscape.

Additionally, this study offers several notable contributions to the field. Firstly, it introduces a robust methodology for calculating indices such as ICT Awareness Index, ICT Use Index, and ICT Availability Index. These indices serve as valuable tools for researchers seeking to investigate changes in ICT infrastructure within higher education.

Secondly, by utilizing these newly developed indices, the study illustrates a practical approach to categorizing students based on their levels of ICT use,

awareness, and availability. This categorization can be instrumental in identifying target groups for various developmental initiatives, particularly those with budget constraints.

Lastly, this paper establishes an empirical framework for documenting the level of digitalization in agricultural education institutions. This framework can be adopted to assess the availability, awareness, and utilization of ICT resources in the post-NAHEP (National Agricultural Higher Education Programme during 2018-2023) era, which primarily concentrated on enhancing digital infrastructure in National Agricultural Research Systems (NARS).

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