RESEARCH PAPER / ОРИГИНАЛЬНАЯ СТАТЬЯ
МРНТИ 06.81.23
JEL: M15, O33, Q55
https://doi.org/10.58732/2958-7212-2026-3-151-167

Artificial Intelligence, Green Innovation and Organizational Learning in Pakistan

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ABSTRACT

The development of artificial intelligence and environmental innovations is changing the processes of knowledge management, decision-making, and organizational learning in companies in the digital sector. The aim of the study is to assess the impact of implementing artificial intelligence and green innovations on organizational learning, taking into account the mediating role of decision-making quality and knowledge management potential, as well as the moderating role of digital infrastructure in the information and communication technology sector in Pakistan. The study uses a quantitative approach and a cross-sectional survey method. The initial data were obtained based on a questionnaire survey of 300 employees of companies in the information and communication sector in Lahore, Pakistan. The results demonstrated a positive impact of artificial intelligence implementation on organizational learning (β=0.650; t=5.520; p<0.001) and green innovations on organizational learning (β=0.400; t=3.921; p=0.002). The quality of decision-making (β = 0.504; t = 4.134; p = 0.008) and knowledge management potential (β = 0.555; t = 5.428; p < 0.001) are also positively associated with organizational learning. Digital infrastructure strengthens the link between the implementation of artificial intelligence and organizational learning (β=0.220; t=2.45; p=0.031), as well as between green innovations and organizational learning (β=0.318; t=3.29; p=0.001). The results obtained are of social significance, as the development of artificial intelligence, green innovations, and digital infrastructure contributes to improving knowledge exchange, collaborative learning and the adaptability of employees in organizations.

ARTICLE HISTORY
Received:21 April 2026
Revised: 30 May 2026
Accepted: 18 August 2026
Published: 30 September 2026

KEYWORDS
Artificial Intelligence; Innovation; Green Innovation; Knowledge Management; Digital Infrastructure; Social Development; Pakistan

FINANCIAL SUPPORT
the study was not sponsored (own resources)

Check for updates

Conflict of interest: author(s) declare that there is no conflict of interest

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For citation: Nabia, Ahmed Dar, A. H., Awan, N. P., Iqbal, A., & Awan, M. P. (2026). Artificial Intelligence, Green Innovation and Organizational Learning in Pakistan. Qainar Journal of Social Science, 5(3), 151-167. https://doi.org/10.58732/2958-7212-2026-3-151-167

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Пәкістандағы жасанды интеллект, жасыл инновациялар және ұйымдық оқыту

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ТҮЙІН

Жасанды интеллект пен экологиялық инновациялардың дамуы цифрлық сектор компанияларындағы білімді басқару, шешім қабылдау және ұйымдық оқыту үдерістерін өзгертеді. Зерттеудің мақсаты – Пәкістанның ақпараттық-коммуникациялық технологиялар секторында шешім қабылдау сапасы мен білімді басқару әлеуетінің делдалдық рөлін, сондай-ақ цифрлық инфрақұрылымның модераторлық рөлін ескере отырып, жасанды интеллектті енгізу мен жасыл инновациялардың ұйымдық оқытуға ықпалын бағалау. Зерттеуде сандық тәсіл және көлденең қималы сауалнама әдісі қолданылды. Бастапқы деректер Пәкістанның Лахор қаласындағы ақпараттық-коммуникациялық сектор компанияларының 300 қызметкеріне жүргізілген сауалнама негізінде алынды. Нәтижелер жасанды интеллектті енгізудің ұйымдық оқытуға оң әсерін ($\beta=0.650$; $t=5.520$; $p<0.001$) және жасыл инновациялардың ұйымдық оқытуға оң әсерін ($\beta=0.400$; $t=3.921$; $p=0.002$) көрсетті. Шешім қабылдау сапасы ($\beta=0.504$; $t=4.134$; $p=0.008$) және білімді басқару әлеуеті ($\beta=0.555$; $t=5.428$; $p<0.001$) де ұйымдық оқытумен оң байланысты. Цифрлық инфрақұрылым жасанды интеллектті енгізу мен ұйымдық оқыту арасындағы байланысты ($\beta=0.220$; $t=2.45$; $p=0.031$), сондай-ақ жасыл инновациялар мен ұйымдық оқыту арасындағы байланысты ($\beta=0.318$; $t=3.29$; $p=0.001$) күшейтеді. Алынған нәтижелер әлеуметтік маңызға ие, өйткені жасанды интеллекттің, жасыл инновациялардың және цифрлық инфрақұрылымның дамуы білім алмасуды, бірлескен оқытуды және ұйымдардағы қызметкерлердің бейімделгіштігін жақсартуға ықпал етеді.

МАҚАЛАНЫҢ ТАРИХЫ
Қабылданды: 21 сәуір 2026
Қайта қаралды: 30 мамыр 2026
Жариялауға қабылданды: 18 тамыз 2026
Жарияланды: 30 қыркүйек 2026

ТҮЙІН СӨЗДЕР
жасанды интеллект; инновация; жасыл инновация; білімді басқару; цифрлық инфрақұрылым; әлеуметтік даму; Пәкістан

ҚАРЖЫЛАНДЫРУ
зерттеу демеушілік қолдау көрсеткен жоқ (меншікті ресурстар)

Мүдделер қақтығысы: автор(лар) мүдделер қақтығысының жоқтығын мәлімдейді

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Дәйексөз үшін: Набия, Ахмед Дар А.Х., Аван Н.П., Икбал А., Аван М.П. (2026). Пәкістандағы жасанды интеллект, жасыл инновациялар және ұйымдық оқыту. Қайнар әлеуметтік ғылымдар журналы, 5(3),151-167. https://doi.org/10.58732/2958-7212-2026-3-151-167

Искусственный интеллект, зеленые инновации и организационное обучение в Пакистане

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АННОТАЦИЯ

Развитие искусственного интеллекта и экологических инноваций меняет процессы управления знаниями, принятия решений и организационного обучения в компаниях цифрового сектора. Цель исследования провести оценку влияния внедрения искусственного интеллекта и зеленых инноваций на организационное обучение с учетом посреднической роли качества принятия решений и потенциала управления знаниями, а также модерирующей роли цифровой инфраструктуры в секторе информационно-коммуникационных технологий Пакистана. В исследовании использован количественный подход и метод поперечного опроса. Исходные данные получены на основе анкетирования 300 сотрудников компаний информационно-коммуникационного сектора г. Лахор, Пакистан. Результаты показали положительное влияние внедрения искусственного интеллекта на организационное обучение ($\beta=0.650$; $t=5.520$; $p<0.001$) и зеленых инноваций на организационное обучение ($\beta=0.400$; $t=3.921$; $p=0.002$). Качество принятия решений ($\beta=0.504$; $t=4.134$; $p=0.008$) и потенциал управления знаниями ($\beta=0.555$; $t=5.428$; $p<0.001$) также положительно связаны с организационным обучением. Цифровая инфраструктура усиливает связь между внедрением искусственного интеллекта и организационным обучением ($\beta=0.220$; $t=2.45$; $p=0.031$), а также между зелеными инновациями и организационным обучением ($\beta=0.318$; $t=3.29$; $p=0.001$). Полученные результаты имеют социальную значимость, поскольку развитие искусственного интеллекта, зеленых инноваций и цифровой инфраструктуры способствует улучшению обмена знаниями, совместного обучения и адаптивности работников в организациях.

ИСТОРИЯ СТАТЬИ
Получено: 21 апреля 2026
Доработано: 30 мая 2026
Принято: 18 августа 2026
Опубликовано: 30 сентября 2026

КЛЮЧЕВЫЕ СЛОВА
искусственный интеллект; инновация; зеленая инновация; управление знаниями; цифровая инфраструктура; социальное развитие; Пакистан

ФИНАНСИРОВАНИЕ
исследование не имело спонсорской поддержки (собственные ресурсы)

Конфликт интересов: авторы заявляют об отсутствии конфликта интересов

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Для цитирования: Набия, Ахмед Дар А.Х., Аван Н.П., Икбал А., Аван М.П. (2026). Искусственный интеллект, зеленые инновации и организационное обучение в Пакистане. Кайнар журнал социальных наук, 5(3),151-167. https://doi.org/10.58732/2958-7212-2026-3-151-167

1. Introduction

Digital technologies have substantially reshaped the way businesses operate, innovate, and develop new organizational capabilities (Ye et al., 2023). Artificial Intelligence (AI) technologies and Green Innovation (GI) practices are becoming more common in today's business landscape and are increasingly being used to enhance organizational efficiency, sustainability, and long-term competitiveness. At the same time, sustainability has become increasingly important for business development, particularly in emerging economies (Akande et al., 2026). These transformations also have a social dimension, as they influence employee engagement, knowledge sharing, learning, and adaptability within organizations (Agarwal et al., 2022; Argote & Fahrenkopf, 2016; Salisu & Abu Bakar, 2020).

AI technologies are increasingly incorporated into organizational processes and can influence productivity, employee engagement, and workplace behavior (Agarwal et al., 2022). Their application can support information processing, automation, and organizational decision-making. From a social perspective, the adoption of AI can also affect how employees interact with technology, participate in organizational processes, acquire knowledge, and adapt to changes in the workplace.

Organizations are also facing new regulatory requirements, climate change risks, and growing stakeholder expectations regarding environmentally responsible business practices. GI involves the development and application of environmentally oriented products, processes, and technologies aimed at improving sustainability and environmental performance (Akhtar et al., 2024). Green innovation can also contribute to the creation and use of organizational knowledge and support continuous improvement. Organizational learning (OL) is therefore an important capability in contemporary organizations, enabling firms to acquire, disseminate, and apply knowledge and adapt to changing environments. Firms with stronger learning capabilities are generally better positioned to develop new competencies and respond to technological and market changes (Salisu & Abu Bakar, 2020).

The use of AI and green technologies offers organizations opportunities to improve learning processes, information exchange, experimentation, and knowledge development. In the digital business environment, decision-making quality (DMQ) has become an important organizational capability. AI can support information processing and data-informed decision-making, while GI introduces environmental and sustainability considerations into organizational decisions. Effective decision-making can, in turn, support knowledge sharing, problem-solving, and adaptive learning. Thus, decision-making quality may represent an important mechanism connecting AI adoption and GI with OL.

Although AI, sustainable innovation, and organizational learning have been widely examined as separate research areas, their combined relationships remain insufficiently explored, particularly in the information and communication technology sector of Pakistan. Existing research on learning organizations in emerging economies demonstrates the importance of knowledge management for learning and innovative organizational culture (Acevedo & Diaz-Molina, 2023). However, less attention has been given to how AI adoption and GI jointly contribute to OL through Knowledge Management Capability (KMC) and Decision-Making Quality (DMQ), and how these relationships depend on Digital Infrastructure (DI). Knowledge management is important for acquiring, transferring, sharing, and applying organizational knowledge (Argote & Fahrenkopf, 2016), while effective knowledge management practices can contribute to firms' innovation

performance (Bawa et al., 2023). Digital infrastructure also represents an important organizational resource supporting digital operations and the integration of technological capabilities (Mironova & Rubtsov, 2025).

Hence, the aim of the study is to assess the impact of implementing artificial intelligence and green innovations on organizational learning, taking into account the mediating role of decision-making quality and knowledge management capability, as well as the moderating role of digital infrastructure in the information and communication technology sector in Pakistan. This study brings together technological innovation, sustainability practices, and organizational learning within a conceptual framework based on the Knowledge-Based View and Organizational Learning Theory. The study also highlights the social relevance of digital and green transformation through their potential contribution to employee learning, knowledge exchange, workplace interaction, and organizational adaptability. The findings may therefore provide useful implications for managers, policymakers, and researchers interested in the strategic and social dimensions of AI adoption, green innovation, and organizational learning.

2. Literature review

The adoption of Artificial Intelligence has emerged as an important strategy for organizations seeking to enhance efficiency, innovation, and competitiveness. AI technologies can support information processing, knowledge creation, and organizational learning by enabling organizations to analyze large volumes of data and generate insights for organizational decision-making (Olusegun et al., 2025; Sposato, 2025). Organizational learning refers to the processes through which organizations acquire, share, interpret, and apply knowledge to improve their capabilities and adapt to changing environments (Alhusban et al., 2025).

Previous research suggests that AI can support organizational learning by facilitating access to information, knowledge exchange, and data-driven learning processes. Sposato (2025) emphasizes the role of AI and data analytics in organizational learning and development, while Han et al. (2025) demonstrated that AI technology is closely connected with organizational learning capability and innovation performance. AI can therefore contribute to continuous learning and improve organizations' ability to respond to technological and market changes. At the organizational level, these processes also have a social dimension because they influence employee learning, knowledge exchange, collaboration, and adaptation to technological change.

Green Innovation refers to the development and implementation of environmentally oriented products, processes, and technologies aimed at reducing environmental impacts while improving organizational outcomes (Chen et al., 2006; Akhtar et al., 2024). Green innovation requires organizations to acquire new environmental knowledge, experiment with alternative technologies, and integrate sustainability principles into organizational processes. These activities can stimulate knowledge creation, knowledge sharing, and continuous learning.

Research has also demonstrated a close relationship between green innovation and organizational learning. Tu and Wu (2021) show that organizational learning plays an important role in translating green innovation into competitive advantage, indicating that green innovation and learning processes are closely interconnected. Green innovation therefore creates learning opportunities by requiring organizations to acquire, integrate, and apply new environmental and technological knowledge. Such learning can also improve organizational adaptability and support long-term sustainability.

Decision-Making Quality refers to the extent to which decisions are based on relevant information, systematic analysis, and appropriate evaluation of available alternatives (Donelan et al., 2016). High-quality decision-making enables organizations to use available knowledge more effectively and respond to changing organizational conditions. Effective decisions can also facilitate problem-solving, knowledge exchange, and organizational learning.

AI can improve the information available for managerial decision-making by supporting data processing, analytics, and knowledge generation (Sposato, 2025). Organizations that effectively transform AI-generated information into managerial actions may be better able to learn from experience and adapt their practices. Therefore, decision-making quality may represent an important mechanism through which AI adoption contributes to organizational learning.

Green Innovation also requires organizations to consider environmental risks, resource efficiency, sustainability objectives, and alternative technological solutions in their strategic decisions. Research on green innovation demonstrates that environmental knowledge and sustainability practices are increasingly integrated into organizational strategies and performance processes (Akhtar et al., 2024; Tripopsakul, 2025). Consequently, organizations capable of making well-informed sustainability-related decisions may be better positioned to translate green innovation activities into organizational learning.

Knowledge Management Capability refers to an organization's ability to acquire, organize, share, and apply knowledge effectively. Knowledge management is closely related to organizational learning because knowledge acquisition, dissemination, and utilization enable organizations to transform individual knowledge into organizational capabilities (Acevedo & Diaz-Molina, 2023). Empirical research also shows that knowledge management capability contributes to organizational innovation and helps organizations respond to technological change (Riaz et al., 2023).

Effective knowledge management facilitates communication, collaboration, knowledge sharing, and organizational adaptation. In learning organizations, systematic knowledge acquisition and dissemination can strengthen innovative culture and support continuous organizational learning (Acevedo & Diaz-Molina, 2023). Therefore, organizations with stronger knowledge management capabilities are expected to demonstrate higher levels of organizational learning.

AI technologies can support knowledge management by improving information processing, access to organizational data, and knowledge-sharing mechanisms. Research indicates that information technology competency contributes to knowledge management processes, while AI and data analytics can extend the capacity of organizations to generate and use knowledge (Pérez-López & Alegre, 2012; Sposato, 2025). When organizations possess effective knowledge management capabilities, technological information generated through AI can be more effectively transformed into shared knowledge and organizational learning (Acevedo & Diaz-Molina, 2023).

Green Innovation also involves the acquisition, integration, and application of environmental and technological knowledge. Research on green innovation highlights the importance of absorptive and knowledge-related capabilities for converting environmental knowledge into innovation outcomes (Akhtar et al., 2024). At the same time, effective knowledge management enables organizations to acquire, disseminate, and respond to new knowledge, thereby strengthening organizational learning (Acevedo & Diaz-Molina, 2023). Based on this reasoning,

Knowledge Management Capability may serve as a mechanism through which Green Innovation contributes to organizational learning.

Digital Infrastructure includes technological resources such as information systems, software, hardware, communication networks, databases, cloud technologies, and digital platforms that support organizational activities and information exchange (Gavrilova et al., 2026; Mironova & Rubtsov, 2025). Digital infrastructure has increasingly become an important organizational resource because it facilitates access to data, technological integration, communication, and digital transformation.

Research also indicates that information technology capabilities can strengthen knowledge management processes and organizational performance (Pérez-López & Alegre, 2012). Consequently, organizations with stronger digital infrastructure may be better able to obtain value from AI technologies and Green Innovation because the necessary technological resources allow information, knowledge, and digital applications to be integrated more effectively into organizational learning processes. Digital Infrastructure may therefore strengthen the effects of technological and green innovation on organizational learning.

Based on the reviewed literature, this study proposes a conceptual framework linking Artificial Intelligence adoption and Green Innovation with Organizational Learning through the mediating roles of Decision-Making Quality and Knowledge Management Capability, while Digital Infrastructure is considered as a moderating factor. The proposed conceptual framework and the relationships among the study constructs are presented in Figure 1.

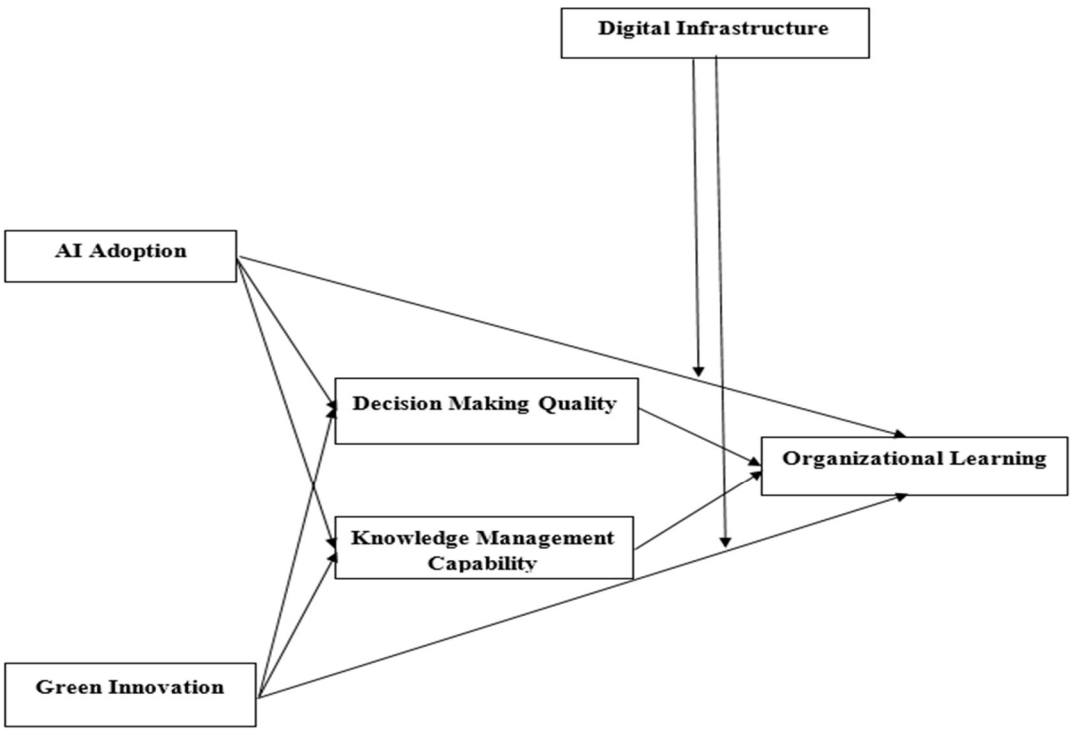


Figure 1. Conceptual model.

Accordingly, the following hypotheses are proposed:

H1: Artificial Intelligence adoption has a positive effect on organizational learning.

H2: Green Innovation has a positive effect on organizational learning.

H3: Decision-Making Quality has a positive effect on organizational learning.

H4: Decision-Making Quality mediates the relationship between Artificial Intelligence adoption and organizational learning.

H5: Decision-Making Quality mediates the relationship between Green Innovation and organizational learning.

H6: Knowledge Management Capability has a positive effect on organizational learning.

H7: Knowledge Management Capability mediates the relationship between Artificial Intelligence adoption and organizational learning.

H8: Knowledge Management Capability mediates the relationship between Green Innovation and organizational learning.

H9: Digital Infrastructure positively moderates the relationship between Artificial Intelligence adoption and organizational learning.

H10: Digital Infrastructure positively moderates the relationship between Green Innovation and organizational learning.

3. Research methods

The study employed a quantitative, cross-sectional survey design to examine the effects of Artificial Intelligence adoption and Green Innovation on Organizational Learning. The study also examined the mediating roles of Knowledge Management Capability and Decision-Making Quality and the moderating role of Digital Infrastructure in the information and communication technology sector of Pakistan. A deductive approach was used to test the proposed hypotheses.

The target population consisted of employees of information and communication technology companies located in Lahore, Pakistan. Lahore was selected because it is one of the country's major business and technology centers and hosts a considerable number of software houses and information technology firms. The sampling frame was developed using registered information and communication technology organizations identified through relevant industry directories and official databases, including the Pakistan Software Export Board and the Punjab Information Technology Board.

A total of 300 employees working in managerial, technical, and administrative positions participated in the survey. The measurement model contained 57 items. Based on the minimum sample-size criterion of five respondents per measurement item, at least 285 respondents were required (57 × 5 = 285); therefore, the final sample of 300 respondents exceeded this minimum threshold.

Primary data were collected using a structured questionnaire consisting of closed-ended items measured on a five-point Likert scale. The measurement items were adapted from previously published studies. Organizational Learning was measured using items adapted from Sinkula et al. (1997), Artificial Intelligence adoption from Jamil et al. (2025), Green Innovation from Chen et al. (2006), Knowledge Management Capability from Pérez-López and Alegre (2012), Decision-Making Quality from Donelan et al. (2016), and Digital Infrastructure from Ghosh (2009).

Before the main survey, a pilot study involving 30 respondents was conducted to assess the clarity and reliability of the questionnaire. Based on respondents' feedback, minor revisions were made to improve the wording and clarity of selected items.

The demographic analysis showed that most of the respondents were male (68.3%) while the female respondents made up 31.7% of the sample. As far as work experience is concerned, most of the respondents had 5-10 years of professional experience within the ICT sector (see Table 1).

Table 1. Demographic profile of respondents.

Variable	Category	Frequency	Percent (%)
Gender	Female	95	31.7
	Male	205	68.3
Age	20 to 25 years	48	16.0
	26 to 35 years	140	46.7
	36 to 45 years	94	31.3
	Above 45 years	18	6.0
Qualification	Bachelor	116	38.7
	Masters	156	52.0
	MS/M.Phil./PhD	28	9.3
Tenure	Less than 5 years	84	28
	5-10 years	146	48.7
	11-15 years	48	16
	More than 15 years	22	7.3
	Total	300	100.0

Note: compiled by the authors.

4. Results

Discriminant validity was confirmed using the HTMT ratio and the Fornell–Larcker criterion, while the structural model was evaluated based on R^2, Q^2, and f^2 values. Hypotheses were tested using bootstrapping with 5,000 resamples, reporting standardized path coefficients (β), t-values, p-values, and confidence intervals for all relationships. Given that the study relies entirely on self-reported cross-sectional survey data, common method bias should also be assessed (e.g., using Harman's single-factor test). In addition, the SmartPLS version and bootstrapping procedure (e.g., 5,000 resamples with bias-corrected confidence intervals) should be specified.

To assess the quality of the measurement and structural models, reliability, convergent validity, discriminant validity, model fit, explanatory power, effect sizes, and predictive relevance were examined. As shown in Table 2, the model demonstrated an SRMR value of 0.080 and an NFI value of 0.818. These indicators provide information on the overall fit of the estimated model.

Table 2. Model fit summary.

No.	Indicator	Value
1	SRMR	0.080
2	NFI	0.818

Note: compiled by the authors.

The SRMR value was 0.080, which corresponds to the commonly used threshold level and indicates an acceptable fit of the model to the empirical data. The NFI value was 0.818, which indicates a moderate level of model fit. Since this indicator is below the commonly used benchmark value of 0.90, the results of the model fit assessment should be interpreted with some caution.

The explanatory power of the structural model was evaluated using the coefficient of determination (R^2). As presented in Table 3, the model explained 40.8% of the variance in Decision-Making Quality (R^2=0.408), 41.6% of the variance in Knowledge Management Capability (R^2=0.416), and 61.9% of the variance in Organizational Learning (R^2=0.619).

Table 3. Coefficient of determination (R^2) and adjusted R^2 values.

Variable	R^2	R^2 adjusted
DMQ	0.408	0.404
KMC	0.416	0.412
OL	0.619	0.609

Note: compiled by the authors.

The R^2 value for decision-making quality was 0.408, which means that the factors included in the model explain 40.8% of the variation in this indicator. For knowledge management capacity, the R^2 value was 0.416, meaning the model explains 41.6% of its variation. The highest coefficient of determination was obtained for organizational learning — R^2=0.619, indicating that 61.9% of the variation in this indicator is explained. The adjusted R^2 values were 0.404, 0.412, and 0.609, respectively, which indicates the stability of the model's explanatory power after accounting for the number of predictors.

Effect sizes were examined using the f^2 statistic. As shown in Table 4, the effects varied across the structural relationships.

Table 4. Effect size (f2).

Variable	f^2
Ai Adoption -> DMQ	0.184
Ai Adoption -> KMC	0.119
Ai Adoption -> OL	0.693
DMQ -> OL	0.214
DI -> OL	0.065
DI x Ai Adoption -> OL	0.201
DI x GI -> OL	0.236
GI-> DMQ	0.192
GI-> KMC	0.261
GI-> OL	0.312
KMC -> OL	0.304

Note: compiled by the authors.

Predictive relevance was assessed using Q^2predict. As reported in Table 5, the Q^2predict values were positive for Decision-Making Quality (0.392), Knowledge Management Capability (0.453), and Organizational Learning (0.578), indicating predictive relevance for all endogenous constructs.

Table 5. Predictive performance.

Q^2 Value	Q^2predict	RMSE	MAE
Decision Making Quality	0.392	0.794	0.533
Knowledge Management Capability	0.453	0.753	0.508
Organizational Learning	0.578	0.658	0.465

Note: compiled by the authors.

The Q^2predict values for decision-making quality, knowledge management potential, and organizational learning were 0.392, 0.453, and 0.578, respectively. Positive Q^2predict values indicate the presence of predictive relevance of the model for all endogenous variables. The highest value was obtained for organizational learning (Q^2predict = 0.578), which indicates a higher predictive ability of the model for this indicator. The RMSE values were 0.794, 0.753 and 0.658, and the MAE values were 0.533, 0.508 and 0.465, respectively. The lower prediction error values for organizational learning further indicate a relatively higher forecasting accuracy for this variable.

As presented in Table 6, all Cronbach's alpha and Composite Reliability values exceeded 0.70, while all AVE values exceeded 0.50.

Table 6. Reliability, validity and discriminant validity (Fornell-Larcker Criterion).

Construct	CR	α	AVE	AI	DMQ	DI	GI	KMC	OL
AI Adoption	0.952	0.951	0.694	0.833					
Decision Making Quality	0.919	0.916	0.598	0.543	0.774				
Digital Infrastructure	0.859	0.857	0.638	0.349	0.539	0.798			
Green innovation	0.861	0.858	0.586	0.455	0.547	0.592	0.765		
Knowledge Management Capability	0.858	0.853	0.632	0.383	0.491	0.639	0.636	0.795	
Organizational Learning	0.934	0.931	0.593	0.739	0.447	0.488	0.502	0.456	0.770

Note: compiled by the authors.

Results indicate satisfactory internal consistency and convergent validity. The diagonal values in the Fornell–Larcker matrix represent the square roots of AVE and are higher than the corresponding inter-construct correlations, supporting discriminant validity.

Discriminant validity was further examined using the Heterotrait–Monotrait ratio (HTMT). As shown in Table 7, all reported HTMT values were below 0.85, with the highest value being 0.775 for the relationship between the two interaction constructs.

Table 7. Discriminant validity *(*Heterotrait- Monotrait Ratio).

Construct	AI	DMQ	DI	GI	KMC	OL	DIxAI	DIxGI
Ai Adoption								
Decision Making Quality	0.579							
Digital Infrastructure	0.377	0.592						
Green innovation	0.500	0.607	0.678					
Knowledge Management Capability	0.422	0.547	0.744	0.737				
Organizational Learning	0.774	0.464	0.540	0.557	0.503			
Digital Infrastructure x Ai Adoption	0.320	0.291	0.414	0.395	0.341	0.330		
Digital Infrastructure x Green Innovation	0.288	0.447	0.578	0.545	0.495	0.334	0.775	

Note: compiled by the authors.

All HTMT values are below the recommended threshold level of 0.85, which indicates sufficient discriminability of the constructs under study. The highest HTMT value was 0.775 for the interacting variables Digital Infrastructure × Artificial Intelligence Adoption and Digital Infrastructure × Green Innovation, and it also does not exceed the established threshold. The obtained results confirm the presence of discriminant validity of the measurement model.

The study aimed to examine the proposed direct, mediating, and moderating relationships between variables was conducted by utilizing the PLS-SEM method which was tested using the SmartPLS software. The results showed that the use of AI and green innovations had a significant and positive impact on organizational learning (Table 8).

Table 8. PLS-SEM result.

Hypothesis	Direct Relationship	β	T-values	P-values	Result
H1a	Ai Adoption -> OL	0.650	5.520	0.001	Supported
H1b	Ai Adoption -> DMQ	0.375	3.700	0.001	Supported
H1c	Ai Adoption -> Knowledge Management Capability	0.225	2.014	0.033	Supported
H2a	GI-> OL	0.400	3.921	0.002	Supported
H2b	GI-> DMQ	0.379	3.784	0.000	Supported
H2c	GI-> Knowledge Management Capability	0.583	5.802	0.000	Supported
H3	DMQ -> Organizational Learning	0.504	4.134	0.008	Supported
H6	Knowledge Management Capability -> Organizational learning	0.555	5.428	0.001	Supported

Note: compiled by the authors.

The direct effects presented in Table 8 confirmed the significant relationships among the main constructs. To further examine the mechanisms underlying these relationships, the mediating effects of Decision-Making Quality and Knowledge Management Capability were assessed. The results of the mediation analysis are presented in Table 9.

Table 9. PLS-SEM result.

Hypothesis	Direct Relationship	β	T-values	P-values	Result
H4	Ai Adoption -> DMQ -> OL	0.189	3.19	0.002	Partial
H7	Ai Adoption -> Knowledge Management Capability ->OL	0.124	2.65	0.008	Partial
H5	GI-> DMQ -> OL	0.191	3.52	0.001	Partial
H8	GI-> Knowledge Management Capability -> OL	0.323	4.51	0.001	Partial

Note: compiled by the authors.

As shown in Table 9, Decision-Making Quality significantly mediated the relationship between Artificial Intelligence Adoption and Organizational Learning (β=0.189; t=3.19; p=0.002), as well as the relationship between Green Innovation and Organizational Learning (β=0.191; t=3.52; p=0.001). Knowledge Management Capability also significantly mediated the effect of Artificial Intelligence Adoption on Organizational Learning (β=0.124; t=2.65; p=0.008) and the effect of Green Innovation on Organizational Learning (β=0.323; t=4.51; p<0.001). Since the corresponding direct effects remained statistically significant, the results indicate partial mediation. Thus, H4, H5, H7, and H8 were supported.

Moderating effects of digital infrastructure are presented in Table 10.

Table 10. PLS-SEM result.

Hypothesis	Direct Relationship	β	T-values	P-values	Result
H9	Moderating role of DI between Ai Adoption and OL Interaction term DI x AI	0.220	2.45	0.031	Supported
H10	Moderating role of DI between GI and OL Interaction term DI x GI	0.318	3.29	0.001	Supported

Note: compiled by the authors.

As presented in Table 10, Digital Infrastructure significantly moderated the relationship between Artificial Intelligence Adoption and Organizational Learning (β=0.220; t=2.45; p=0.031). Digital Infrastructure also significantly moderated the relationship between Green Innovation and Organizational Learning (β=0.318; t=3.29; p=0.001). Both interaction effects were positive, indicating that stronger Digital Infrastructure is associated with stronger relationships between Artificial Intelligence Adoption, Green Innovation, and Organizational Learning. Therefore, H9 and H10 were supported.

Figure 2 presents the final structural model, including the estimated path coefficients, direct effects, and interaction effects.

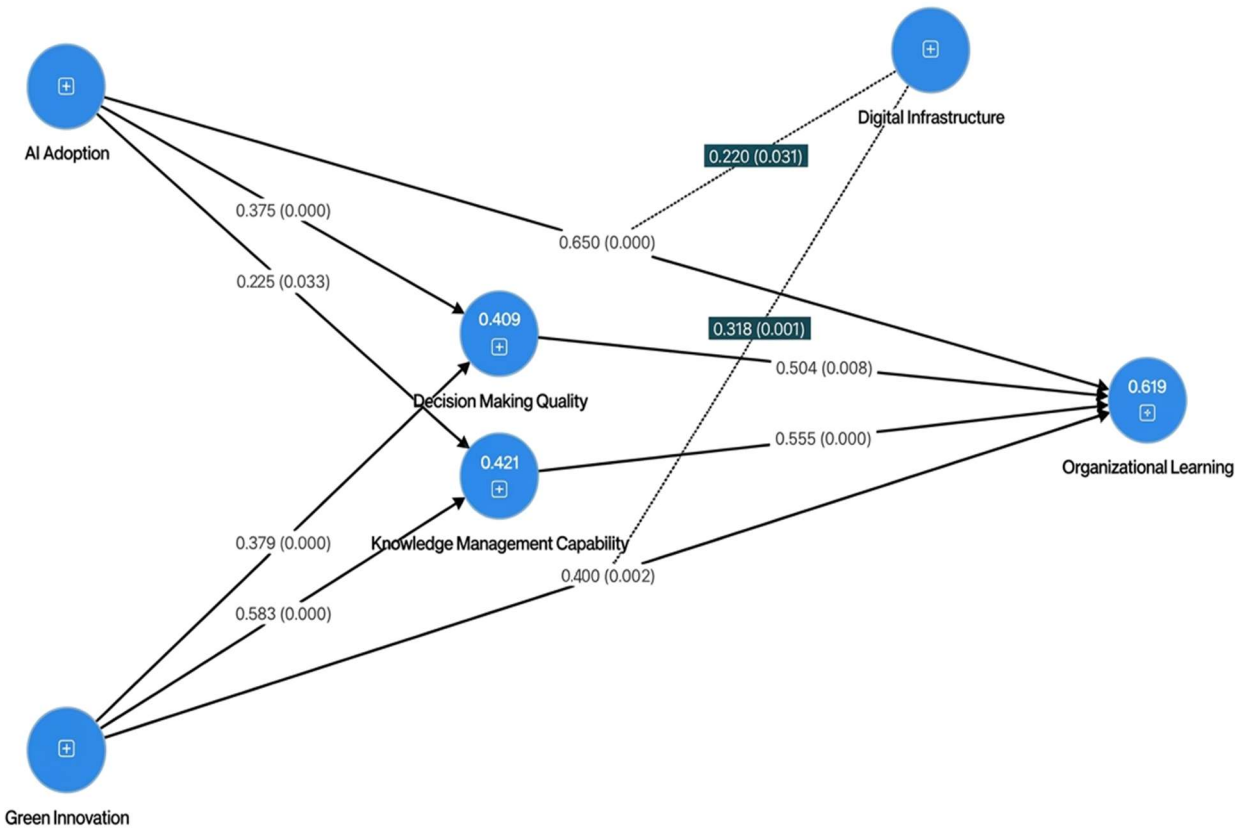


Figure 2. PLS-SEM Structural model.

5. Conclusions

This study examined the effects of Artificial Intelligence adoption and Green Innovation on Organizational Learning in the information and communication technology sector of Pakistan, while considering Decision-Making Quality and Knowledge Management Capability as mediating mechanisms and Digital Infrastructure as a moderating factor. The findings indicate that Artificial Intelligence adoption and Green Innovation are positively associated with Organizational Learning. Decision-Making Quality and Knowledge Management Capability also play important roles in explaining how technological and green innovations are translated into organizational learning, while Digital Infrastructure strengthens these relationships.

The results demonstrate that technological and environmental innovation alone may not be sufficient to improve organizational learning. Their effectiveness depends on organizations' ability to manage knowledge, make informed decisions, and provide an appropriate digital environment. Organizations with stronger knowledge management practices and digital capabilities are therefore better positioned to transform technological and environmental innovations into continuous learning and organizational adaptability.

From a social perspective, the study highlights the potential importance of Artificial Intelligence and Green Innovation for employee learning, knowledge exchange, collaboration, and adaptation to technological change. Digital transformation can reshape employees' roles, communication practices, and knowledge requirements. Therefore, organizations should complement technological investment with continuous learning opportunities, knowledge-sharing mechanisms, and support for employees adapting to new digital and sustainability-related work practices. This may help ensure that digital and green transformation contributes not only to organizational performance but also to more adaptive and learning-oriented workplaces.

Several limitations should be considered when interpreting the findings. First, the study was limited to employees of information and communication technology firms in Lahore, Pakistan; therefore, the findings should not be generalized to other industries, regions, or countries without further empirical examination. Second, the cross-sectional research design identifies statistical relationships but does not establish causality or capture changes over time. Future research could employ longitudinal designs to examine how Organizational Learning evolves during Artificial Intelligence adoption and green transformation. Third, the study focused mainly on Decision-Making Quality, Knowledge Management Capability, and Digital Infrastructure. Future studies could extend the model by examining organizational culture, leadership, technological readiness, employee engagement, digital skills, and other social and organizational factors.

Finally, future research could examine the social consequences of Artificial Intelligence and Green Innovation more directly by including employee-level indicators such as learning opportunities, digital skills, participation in decision-making, workplace collaboration, job adaptation, and employee well-being.

Author Contributions: Conceptualization and theoretical framework, N, AHAD, NPA, AI, MPA; Methodology and research design, N; Software, AHAD, NPA; Validation, AI, MPA; Formal analysis, N; Investigation, AI; Resources, MPA; Data curation, AI; Draft writing, N, AHAD, NPA, AI, MPA; Writing-review and editing, N, AHAD, NPA, AI, MPA; Visualization, N; Supervision, AHAD; Project Administration, NPA, AI, MPA; Funding acquisition, N, AHAD, NPA, AI, MPA. All authors have read and agreed to the published version of the manuscript.

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