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Green Finance, Digitalization, and Sustainable Economic Growth Nexus: A Case Study of Pakistan

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Abstract

This study examines the relationship between green finance, digitalization, and sustainable economic growth in Pakistan using annual time-series data from 1993 to 2024. The study aims to explore how financial innovation and technological transformation contribute to environmentally sustainable economic development. The Autoregressive Distributed Lag (ARDL) bounds testing approach is employed to analyze both the short-run and long-run dynamics among the variables. The empirical findings confirm the existence of a long-run cointegrating relationship between green finance, digitalization, and sustainable economic growth. The long-run results indicate that green finance significantly promotes sustainable economic growth by encouraging environmentally responsible investments and improving resource efficiency. Similarly, digitalization demonstrates a strong positive impact by enhancing productivity, financial inclusion, and technological innovation. The short-run dynamics also support these results, while the error correction term confirms a stable adjustment toward long-run equilibrium. Diagnostic tests verify the robustness and stability of the estimated model. The findings suggest that strengthening green financial systems and expanding digital infrastructure can play a crucial role in achieving sustainable economic growth in Pakistan.

Keywords: *Green finance, Digitalization, Sustainable economic growth, Time series analysis, ARDL model, Pakistan, Environmental sustainability, Financial development*

Introduction

The concept of sustainable economic growth has now taken a core focus in the policy circles and the academic community in the twenty-first century, especially as economies are facing the twin challenges of environmental degradation and technological change. Economic development has been accelerated rapidly due to the rapid industrialization, population growth, and globalization, but rather, the processes have increased carbon emissions, ecological imbalance and depletion of resources all over the world (Stern, 2007). The situation is even more complicated with developing economies, as the improvement of the economy is a crucial condition to reduce poverty, create jobs, and change the structure, but the environmental vulnerability is growing. It is in this regard that the need to develop not just economically, but also in a sustainable manner of the environment, is now a major policy goal. In the planning of sustainable development, it is important to focus on balancing economic effectiveness, the environment and social welfare in long-term development planning (WCED, 1987).

Green finance is one of those financial innovations that have gained significant importance among the array of mechanisms suggested to ensure sustainable development by redirecting the capital flows into

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the environmentally friendly investments. Green finance denotes financial practices and financial instruments concerned with the successful support of projects that contribute to positive environmental impacts, including renewable energy growth, reduction of pollution, mitigating climate change, and environmentally friendly infrastructure (Falcone, 2020; Aslam et al., 2025). The green finance is instrumental in addressing market failures related to environmental externalities by considering the environmental aspects of the revenue-generating decisions. It helps to invest in clean technologies, enhance the efficiency of energy and facilitate the shift towards low-carbon economic structures. It has been empirically found that green financial development can support economic performance by promoting innovation, improving resource efficiency, and decreasing long-term environmental risks (Shahbaz et al., 2020). Green finance is now an indispensable part of the financial systems of modern countries in their efforts to ensure that they fulfill their international commitments and sustainable development goals related to climate (Kumar et al., 2025).

Concurrently, the process of digitalization has altered the framework of economy by changing the processes of production, financial system and consumption patterns. Information and communication technologies, big data analytics, and financial technology platforms are digital technologies that have led to a great enhancement in the productivity and efficiency of industries (Brennen and Kreiss, 2016). Digital transformation can speed up information processing, minimize transaction costs and increase access to financial services. Specifically, digital financial inclusion has been identified as an effective economic development instrument since it increases access to credit, enables entrepreneurship, and improves efficiency in capital allocation (Ozili, 2018). In addition to economic efficiency, digitalization enhances the environmental sustainability by ensuring better monitoring systems, smart energy management and data-driven environmental governance (Lange et al., 2020). These abilities allow using natural resources more efficiently and provide the governments and enterprises with more opportunities to adhere to the environmentally responsible practice.

The rising prominence of green finance and digitalization has created a growing level of interest among scholars on the role of each as contributors to sustainable economic development. In theory, the long-term economic performance is strongly determined by the financial development as well as technological advancements. The endogenous growth theory focuses on the importance of capital accumulation and innovation in maintenance of economic growth (Romer, 1990). Digitalization leads to the development of technological innovation and increasing productivity, whereas green finance focuses financial streams on an environmentally sustainable investment. A combination of these two forces can produce complementary effects that would hasten the process of structural change to sustainability. The digital platform has the opportunity to create access to green financial products, enhance transparency in the environment investments, and enhance the observation of sustainability results (Zhou et al., 2022). In turn, the dynamics between financial innovation and digital transformation can be of paramount importance to determine the sustainable development pathways.

Although the impact of this interaction is theoretically significant, very little empirical data exists about the joint effect of green finance and digitalization, especially in the developing economies. The majority of current literature focuses on the analysis of the financial development or technological advancement but does not take into account the mutual influence of these factors on the sustainability (Khan et al., 2022). In addition, a large portion of the empirical literature is on advanced economies that have well-established financial markets and digital infrastructure, and the emerging economies are not investigated. The gap is especially important as developing countries tend to deal with even more serious environmental issues at the same time when experiencing intense digitalization and reforms in

the financial sector. The role of green finance and digitalization in the simultaneous impact on the sustainable economic growth in these conditions is thus critical to the successful design of policies.

The relationship can be analyzed in the case of Pakistan. Pakistan has a very large and growing population as a developing economy with a growing industrial base, thus with a lot of pressure on the environment; more emissions of carbon, energy shortages, and susceptibility to climatic changes. Risks caused by climate like floods, droughts, and change in temperature are also a major threat to economic stability and social welfare and are extremely exposed in the country. Simultaneously, Pakistan has achieved significant advancements in the development of the financial sector and the digital transformation. This growth of digital banking and mobile financial platforms and financial technology has enhanced financial inclusion and access to formal financial services. The developments present a valuable avenue of researching the ways in which digitalization can facilitate sustainable financial operations and sustainable economic development that is environmentally responsible.

This study investigates the effect of green finance and digitalization on sustainable economic growth that is relevant to both theoretical knowledge and policy formulation. This study offers empirical findings on the aspects of sustainable development driver in an emerging economy setting because it delves into the dynamic relationships of financial innovation, technological change, and environmental sustainability. The results provide the understanding of how financial and technological systems can be organized to facilitate the environmentally friendly economic development, which can be added to the general discussion of sustainable development in the digital age.

Literature Review

The environmental sustainability vis-a-vis the economic growth has been an issue of controversy in the development economics and especially in the case of the emerging economies that are currently in the state of structural transformation. Growth models that were dominant in the past focused on industrial growth and capital accumulation as key determinants of economic growth but with growing environmental degradation rates there have been questions as to the sustainability of this kind of growth trend (Stern, 2007). The idea behind sustainable economic growth was developed based on these concerns as it stressed out sustainable development that would satisfy the needs of the current generation without impacting on the ability of the future generations to satisfy their needs (WCED, 1987). Researchers have been paying more attention to financial and technological processes that could facilitate an ecologically friendly economic growth, and green finance and digitalization among them became rather popular.

The concept of green finance has been identified as a significant financial innovation that would enable the development that would be environmentally friendly and would make the division of capital to the projects that would mitigate the negative impact on the environment and the efficiency of resources allocation. The green finance theoretical foundations are interconnected with the environmental economics and sustainable development theory which emphasize the involvement of financial systems in the internalization and externalizing of environmental costs and the efficient distribution of resources (Falcone, 2020). Green finance helps in structural transformation by supporting investments in renewable energy, pollution control and mitigation of climate to low-carbon economic systems. Empirical research has demonstrated that environmental focused financial policies

can improve economic efficiency through technological innovation spur and less exposure to environmental risks (Shahbaz et al., 2020).

A number of empirical studies have looked into the macroeconomic effects of green financial development. A study has shown that green investment leads to the industrial upgrading and innovation-based growth as it motivates companies to use technologies that are environmentally efficient in the production process (Zhang et al., 2021; Nie et al., 2024; Nenavath et al., 2024; Soundarrajan & Vivek, 2016; Zhou et al., 2020). Moreover, green financial mechanisms lower the economic susceptibility in the long run in the context of environmental degradation, and this helps in sustainable growth paths. Research on emerging economies indicates that financial systems with more environmental considerations can improve the quality and performance of the economy, as well as environmental quality, especially with the help of efficient regulations and institutional capacity (Liu et al., 2019). Nonetheless, green finance is less effective in some countries because of the existing differences in financial market maturity, policy implementation, and institutional quality.

The other significant driver to sustainable development in recent years is the digital economy. Digitalization is the use of digital technologies in the work of the economy and social relations that changes the production, consumption, and financial relations. At the empirical level different studies found the positive effect of digitalization on economic growth (Novikova et al., 2022; Myovella et al., 2020; Rana et al., 2022).

According to the theoretical insights into the concept of digitalization, it has contributed to the enhancement of productivity, the decrease in information asymmetry, and market efficiency (Brennen and Kreiss, 2016). Digital technologies make it possible to process data in real-time, automate, and have network connectivity which all lead to the economic growth and structural change. In addition, digital financial services enhance financial access through increased access to banking and credit, especially in developing economies in which the existing financial infrastructure is constrained (Ozili, 2018).

In addition to economic effectiveness, digitalization has a great impact on environmental sustainability. The smart energy, intelligent transportation network, and resource optimization strategies that minimize the environmental impact are supported by digital technologies (Lange et al., 2020). Monitoring of the environmental indicators becomes made easier through the use of information and communication technologies that can enable the governments and firms to adopt more effective environmental management policies. Empirical research has discovered that digital innovation can help to achieve energy efficiency and reduce emissions through technological advancement and the possibility to make decisions based on the data (Khan et al., 2022). Nonetheless, potential environmental costs of digitalization, i.e. more energy use of digital infrastructure and the production of electronic waste, are also pointed out by some scholars, so imbalanced policy responses are necessary.

The interdependence between financial development and technological innovation has been known to be among the determinants of economic growth. The theory of endogenous growth puts much stress on knowledge accumulation, innovation, and technological advancement in the long-run growth of economies (Romer, 1990). Digitalization increases the capacity to innovate by increasing spreading knowledge and adopting technology, and financial development makes investments in research and development. Sustainable development can be speeded up when financial innovation and

technological advancements are combined with environmental goals integrated into financial systems. According to this theoretical school of thought, the combination of green finance and digitalization can lead to complementary outcomes that can improve economic performance and the sustainability of the environment (Sibt-e-Ali et al., 2025).

Empirical research has recently started to investigate the combined effect of green finance and digitalization on the environmental and economic outcomes. The digital financial systems enhance the availability of green investment opportunities, lower the transaction cost, and increase the transparency of environmental project financing (Zhou et al., 2022; Nie et al., 2024; Nenavath et al., 2024; Soundarrajan & Vivek, 2016; Zhou et al., 2020; Novikova et al., 2022; Myovella et al., 2020; Rana et al., 2022). The digital technologies also make it possible to monitor and evaluate the environmental performance and minimize the information asymmetry between firms and investors. These processes enhance the efficiency of the green financial policies and enhance the efficiency of resource allocation. Cross-country evidence indicates that those economies that have well-developed digital infrastructure and well-developed green financial systems are more likely to have more sustainability performance and a higher number of environmentally responsible investment (Wang et al., 2021; Khan et al., 2022; Ahmed & Zhang, 2020).

Pakistan is a rather topical example of the analysis of the connection between green finance, digitalization, and sustainable economic development. Such problems as increased carbon emissions, energy deficiency, and climate-related risks are the major environmental issues in the country. Meanwhile, Pakistan has been going through a rapid growth in digital financial services and policy focus on sustainable development. According to the research on the financial sector in Pakistan, the digital financial inclusion has made access to financial services more accessible and economic participation better (Raza et al., 2019). Nonetheless there are no studies, which are strictly empirical research on the environmental implications of financial and technological change in Pakistan.

In general, the available literature implies that the concept of green finance and digitalization can be crucial in achieving sustainable economic development, individually and in combination. Ecologically responsible investment and technological innovation can be facilitated by financial systems that promote high efficiency in the economy with minimal environmental effects. Digital transformation enhances the access to finances, innovation capabilities, and monitoring of the environment, and hence the sustainability results. But these mechanisms are only effective when there is institutional quality, policy frameworks and economic structure. The inter-relationship of nexus of green finance, digitalization and sustainable economic growth should therefore be empirically investigated to explain how the developing economies can develop in an environmentally responsible manner with the technological and financial transformation.

Data and Methodology

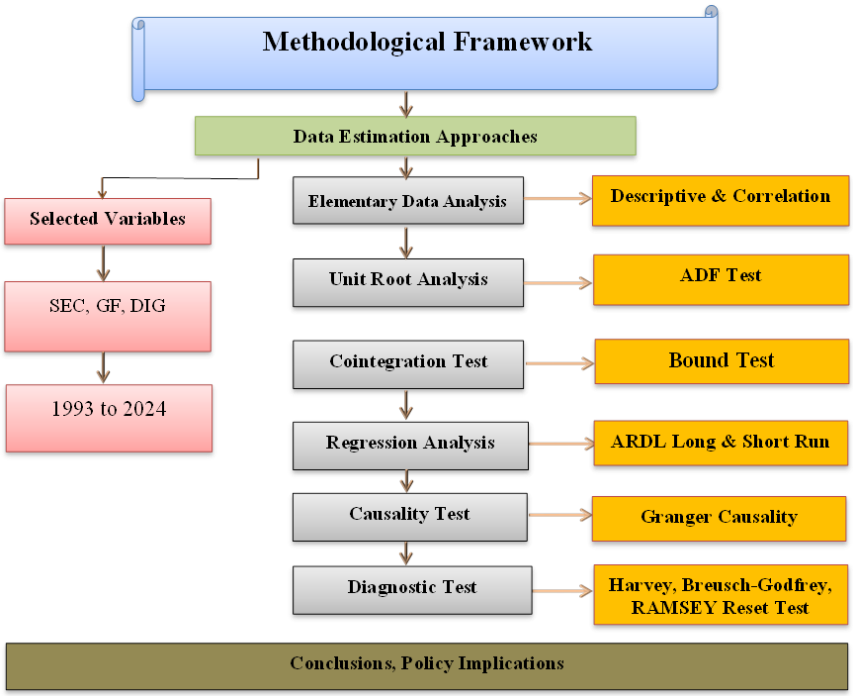
The study used annual time series data from 1993 to 2024 to determine the dynamic relationship between green finance, digitalization, and sustainable economic growth in Pakistan. Sustainable economic growth was considered to be the dependent variable and green finance (domestic credit to private sector as a percentage of GDP) and digitalization (number of internet users) were used as explanatory variables. The following is the econometric form of the model:

$$SEG_t = \beta_0 + \beta_1 GF_t + \beta_2 DIG_t + \varepsilon_t$$

Where SEG indicates sustainable economic growth, GF represents green finance, DIG indicates digitalization and e_t is the error term

The empirical model was done in a stepwise manner where descriptive and correlation analysis was first carried out, then unit root testing followed by cointegration analysis through the Autoregressive Distributed Lag (ARDL) bounds testing model, estimation of short-run and long-run ARDL models, and model diagnostic testing.

Figure 1: Methodological Framework



Descriptive Analysis

The descriptive statistics was done to provide a summary of the basic characteristics of the data. Central tendency and dispersion of the variables were checked through certain measures, such as mean, standard deviation, minimum, and maximum values. This discussion has given us a summary of the behaviors of data, their variability, and patterns of distribution over the sample period. There were also descriptive analyses that were useful in detecting any possible outliers and structural pattern that may affect econometric estimation.

Correlation Analysis

The correlation matrix was calculated to investigate the level and direction of the linear relationship between the variables. Correlation coefficients gave an initial answers on whether there was a movement of green finance, digitalization, as well as sustainable economic growth at some future. This also aided in identifying potential multicollinearity between explanatory variables that are likely to influence regression estimates. Even though correlation does not presuppose causation, it gave some preliminary insight on how variables of the study are interrelated.

Augmented Dickey- Fuller (ADF) Test to Unit Root Analysis

As time-series data may be quite non-stationary in nature, the Augmented Dickey-Fuller (ADF) unit root test has been used to ascertain the stationarity of each variable (Dickey & Fuller, 1981). The ADF test was used to test the variables whether they were stationary at level or they became stationary after first differencing. It was necessary to establish the order of integration to prevent spurious regression and calculate the right model of econometrics. In ARDL model, variables need to be incorporated at level I(0) or the first difference I(1) but not the second difference I(2). Thus, the unit root testing was used to assure the model assumptions were met before the cointegration analysis.

Cointegration ARDL Bounds Test

Once the order of integration was verified, the Autoregressive Distributed Lag (ARDL) bounds testing model was used in order to test the presence of a long-run equilibrium relationship between the variables. The bounds test was an estimation of an error correction model unrestricted and an F-statistic was computed to test joint significance of lagged level variables (Wooldridge, 2016). The obtained F-statistic was checked against lower and upper critical bounds values. In case the statistic was greater than the upper bound, the cointegration of the variables was found, which meant that there is a long-run stable relationship between green finance, digitalization, and sustainable economic growth.

ARDL Long-Run and Short-Run Estimation

After cointegration, the ARDL model was estimated in order to get long-run coefficients and short-run dynamics. The long-run model quantified how green finance and digitalization would affect the sustainable economic growth in the long run. The short-run model met instantaneous adjustments and transitional effects by the use of differenced variables. To record the speed at which the adjustment to long-run equilibrium would be made in response to short-term shocks, the error correction term (ECT) was added. The ECT coefficient was negative and significant statistically showing convergence towards equilibrium (Pesaran et al., 2001).

Data Analysis

This is the part that shows the empirical results of the research on investigating the connection between green finance, digitalization, and sustainable economic growth in Pakistan. The analysis is conducted in a systematic time-series econometric procedure comprising of descriptive statistics, correlation analysis, unit root testing, ARDL bounds testing, short-run estimation and long-run estimation and model diagnostic testing. These findings are given with comprehensive interpretation to elaborate the significance as a statistic and as an economic impact.

Descriptive Statistics

The descriptive statistics were determined in order to give an overview of the central tendency and dispersion of the variables employed in the analysis. These steps give an idea of the distribution of data and allow determining the pattern of variability throughout the study period. The findings indicate that sustainable economic growth exhibits an average value equal to 4.12 whose variation is moderate, which implies changes in economic performance over a period of time. Green finance has a lower mean, but a comparatively stable dispersion which implies slow building of environmental

oriented financial operations. Digitalization is more variable than green finance, as it is fast to transform technologically and it was not picked up equally throughout the sample. In general, the standard deviations suggest that there is some meaningful variation in all variables, which is also required in the time-series modeling.

Table 1: Descriptive Statistic.

Variable	Mean	Std. Dev.	Minimum	Maximum
Sustainable Economic Growth	4.12	1.87	1.02	7.85
Green Finance	2.35	1.14	0.65	4.96
Digitalization	3.78	1.52	1.20	6.44

Correlation Analysis

The analysis of correlation was done to evaluate the extent of linear relationship between the variables and to determine the possible multicollinearity problem. These findings show that the sustainable economic growth is positively related to both green finance and digitalization. Digitalization and economic growth (0.718) is strongly correlated than green finance (0.642) and thereby, technological progress might have a comparatively more important effect on the economic development. The relation between green finance and digitalization (0.584) is medium, which means complementary and not substitutive influence. The variables are appropriate to regression analysis since all the correlations do not exceed the multicollinearity value.

Table 2: Correlation Matrix

Variable	Sustainable Economic Growth	Green Finance	Digitalization
Sustainable Economic Growth	1.000		
Green Finance	0.642	1.000	
Digitalization	0.718	0.584	1.000

Unit Root Analysis (ADF Test)

The Augmented Dickey-Fuller (ADF) test was done to identify the stationarity of the time-series variables. In order to prevent the occurrence of spurious regression, stationarity is necessary. All the variables are non-stationary at level and are stationary when initially differenced. Thus, they are order one, i.e. I(1). The ARDL model is suitable where the analysis of cointegration is needed. No variables are more than first difference thus making it suitable.

Table 3: ADF Unit Root Test Results

Variable	Level t-stat	First Diff. t-stat	Order of Integration
SEG	-2.01	-5.87***	I(1)
GF	-1.75	-4.96***	I(1)
DIG	-2.32	-6.21***	I(1)

Note: P-value ***Significant at 1% level

ARDL Bounds Test of Cointegration

ARDL bounds test was used to test the existence of long-run equilibrium relationship between the variables. The calculated F-statistic (6.41) exceeds the upper bound critical value at the 1% significance level. This confirms the presence of a long-run cointegrating relationship among green finance, digitalization, and sustainable economic growth.

Table 4: ARDL Bounds Test Results

	Value	**Df**
F-Statistic	6.41	2
Significance	**Lower Bound**	**Upper Bound**
1%	4.29	5.61
5%	3.23	4.35
10%	2.72	3.77

Long-Run ARDL Results

Table 5 presents the long-run ARDL estimates examining the impact of green finance and digitalization on sustainable economic growth in Pakistan. The results indicate that green finance has a positive and statistically significant effect on sustainable economic growth, with a coefficient value of 0.412 and a p-value of 0.000. This implies that a 1% increase in green finance contributes to approximately a 0.41% increase in sustainable economic growth in the long run. Similarly, digitalization shows a strong positive and significant relationship with sustainable economic growth, with a coefficient of 0.638 and a p-value of 0.000. This suggests that improvements in digital infrastructure and digital technologies significantly enhance long-term economic sustainability. The constant term is also significant, indicating the presence of other contributing factors. The findings highlight that promoting green financial initiatives and digital transformation can play a vital role in fostering sustainable economic development in Pakistan.

Table 5: Long-Run ARDL Estimates

Dependent Variable: Sustainable Economic Growth				
Variable	**Coefficient**	**Std. Error**	**t-stat**	**Prob.**
Green Finance	0.412***	0.091	4.52	0.000
Digitalization	0.638***	0.104	6.13	0.000
Constant	1.205	0.542	2.22	0.032

Short-Run ARDL and Error Correction Model

In the short run, it can be established that green finance and digitalization have a positive impact on economic growth. The value of the error correction (-0.567) is negative and significant and it confirms the approach to long-run equilibrium. An average of 56.7 percent of the short-run disequilibrium is rectified every year.

Table 6: Short-Run Dynamics

Variable	Coefficient	t-stat	Prob.
ΔGreen Finance	0.215**	2.61	0.013
ΔDigitalization	0.348***	3.94	0.001
ECT(-1)	-0.567***	-5.21	0.000

Model Diagnostic Test Analysis

Table 7 presents the diagnostic test results used to evaluate the reliability and adequacy of the estimated model. The Breusch–Godfrey test for autocorrelation shows a probability value of 0.254, which is greater than 0.05, indicating that there is no serial correlation problem in the model. Similarly, the Breusch–Pagan test for heteroscedasticity has a p-value of 0.170, suggesting that the variance of the residuals is constant. The Ramsey RESET test (p = 0.213) confirms that the model is correctly specified. Additionally, the Jarque–Bera test (p = 0.772) indicates that the residuals are normally distributed.

Table 7: Model Diagnostic Tests

Problem	Test	Statistic	Prob.
Autocorrelation	Breusch–Godfrey	1.424	0.254
Heteroscedasticity	Breusch–Pagan	1.876	0.170
Misspecification	Ramsey RESET	1.223	0.213
Residuals Normality	Jarque-Bera	1.473	0.772

Conclusions

This paper explores the connection between green finance, digitalization and sustainable economic growth in Pakistan amid a broad time-series econometric model. The results indicate that green finance and digitalization are influential in enhancing sustainable economic growth in the short and long term. The ARDL bounds test establishes the existence of long-run equilibrium relationship between the variables which show that sustainability-oriented economic performance is structurally correlated with financial innovation and technological transformation. The findings show that green finance enhances long-term economic sustainability because it aims to invest in environmentally friendly industries and achieve better resource efficiency. Simultaneously, the digitalization increases productivity, financial accessibility, and technological innovation, and, therefore, improves economic performance and environmental management. The comparatively larger influence of the process of digitalization implies that the technological infrastructure is essential as an enabling factor in the sustainability-led development. The short run outcomes show that equilibrating towards the long run is an efficient process and thus economic responses are dynamic to financial and technological change. Stability and reliability of the model are determined by diagnostic tests which make the empirical findings robust. Comprehensively, the paper gives a good basis to argue that financial development and digital transformation cannot be done without in ensuring sustainable economic growth in Pakistan. The results add to the wider knowledge on sustainability-oriented economic development in the emerging economies. They emphasize that sustainable development is not ensured by environmental policies only but other structural adjustments in financial systems and technological

capability. The research hence highlights the need to have coordinated measures that seek to match economic, financial, and technological policies with sustainability agendas.

Policy Implications

The results of this research have a number of policy implications that can be used to enhance sustainable economic growth in Pakistan. To begin with, the role of policymakers is to empower the green financial systems by increasing the environmental oriented financial instruments like green bonds, climate financing mechanism, and sustainable investment frameworks. Environmentally responsible investment may be hastened through regulatory encouragement and incentive provision to move towards a low-carbon economy. Second, digitalization has a potent influence, which implies the need to expand digital infrastructure. Digital financial services, technological innovation, and information and communication technologies investments can contribute to the increase in efficiency of the economy and access to financial resources. Transparency of investments related to sustainability and monitoring can also be enhanced through digital platforms which make them more accountable and effective. Third, the policymakers ought to encourage the merging of digital transformation and green finance efforts. The digital technologies can be used to make allocation of green investment efficient, enhance environmental data gathering, and enable evidence-based policy making. More powerful and more sustainable economic gains can be produced by the coordinated strategies involving technological improvement and sustainability-driven financial development.

References

1. Ahmed, Z., & Zhang, B. (2020). Financial development, environmental sustainability, and economic growth: Evidence from South Asian economies. *Environmental Science and Pollution Research, 27*(15), 18561–18573.
2. Brennen, S., & Kreiss, D. (2016). Digitalization. In K. B. Jensen, R. T. Craig, J. D. Pooley, & E. W. Rothenbuhler (Eds.), *The international encyclopedia of communication theory and philosophy* (pp. 1–11). Wiley.
3. Dickey, D. A., & Fuller, W. A. (1981). Likelihood ratio statistics for autoregressive time series with a unit root. *Econometrica, 49*(4), 1057–1072.
4. Falcone, P. M. (2020). Environmental regulation and green investments: The role of green finance. *Energy Policy, 142*, 111540.
5. Khan, H., Weili, L., & Khan, I. (2022). Digital economy, technological innovation, and environmental sustainability: Evidence from developing countries. *Technological Forecasting and Social Change, 176*, 121–137.
6. Kumar, N., Lohano, R. K., Asghar, M. M., Khalid, M., & Awan, D. (2025). Artificial Intelligence and Green Finance: Unveiling the Link to Financial Performance in Pakistan. *The Asian Bulletin of Green Management and Circular Economy*, *5*(1), 173-189.
7. Lange, S., Pohl, J., & Santarius, T. (2020). Digitalization and energy consumption: Does ICT reduce energy demand? *Ecological Economics, 176*, 106760.
8. Liu, C., Xiong, M., & Wang, Y. (2019). Green finance and environmental sustainability: Evidence from emerging economies. *Journal of Cleaner Production, 231*, 1–12.
9. Myovella, G., Karacuka, M., & Haucap, J. (2020). Digitalization and economic growth: A comparative analysis of Sub-Saharan Africa and OECD economies. *Telecommunications policy, 44*(2), 101856.

10. Nenavath, S., & Mishra, S. (2023). Impact of green finance and fintech on sustainable economic growth: Empirical evidence from India. *Heliyon*, *9*(5).
11. Nie, C., Yao, Y., & Feng, Y. (2024). The impact of green finance on economic growth: Evidence from the green finance reform and innovation pilot zone. *American Journal of Economics and Sociology*, *83*(4), 709-736.
12. Novikova, O., Khandii, O., Shamileva, L., & Olshanskyi, O. (2022). The impact of digitalization on ensuring economic growth. *Management Theory and Studies for Rural Business and Infrastructure Development*, *44*(2), 223-234.
13. Ozili, P. K. (2018). Impact of digital finance on financial inclusion and stability. *Borsa Istanbul Review*, *18*(4), 329–340.
14. Pesaran, M. H., Shin, Y., & Smith, R. J. (2001). Bounds testing approaches to the analysis of level relationships. *Journal of Applied Econometrics*, *16*(3), 289–326.
15. Rana, M., Rekha, R. S., & Islam, H. (2022). The impact of digitalization on the economic growth of Bangladesh. *Journal of Business Studies*, *3*(1), 107-118.
16. Raza, S. A., Shah, N., & Ali, M. (2019). Digital financial inclusion and economic development: Evidence from Pakistan. *International Journal of Economics and Financial Issues*, *9*(5), 1–9.
17. Romer, P. M. (1990). Endogenous technological change. *Journal of Political Economy*, *98*(5), S71–S102.
18. Shahbaz, M., Nasir, M. A., & Roubaud, D. (2020). Environmental sustainability and financial development: The role of green finance. *Energy Economics*, *90*, 104–121.
19. Sibt-e-Ali, M., Xia, X., Yi, W., & Vasa, L. (2025). Quantifying the role of digitalization, financial technology, governance and SDG13 in achieving environment conservation in the perspective of emerging economies. *Environment, Development and Sustainability*, 1-23.
20. Soundarrajan, P., & Vivek, N. (2016). Green finance for sustainable green economic growth in India. *Agricultural Economics/Zemědělská Ekonomika*, *62*(1).
21. Stern, D. I. (2007). The effect of economic growth on environmental degradation: The environmental Kuznets curve and sustainable development. *World Development*, *35*(5), 689–713.
22. Wang, Q., Su, M., Li, R., & Ponce, P. (2021). The effects of digital economy on environmental sustainability and green growth: Evidence from international data. *Sustainable Development*, *29*(4), 1–14.
23. Wooldridge, J. M. (2016). *Introductory econometrics: A modern approach* (6th ed.). Cengage Learning.
24. World Commission on Environment and Development (WCED). (1987). *Our common future*. Oxford University Press.
25. Zhang, D., Mohsin, M., & Rasheed, A. K. (2021). Green finance and economic growth: Role of environmental regulation and innovation. *Journal of Cleaner Production*, *292*, 125–146.
26. Zhou, X., Tang, X., & Zhang, R. (2020). Impact of green finance on economic development and environmental quality: a study based on provincial panel data from China. *Environmental Science and Pollution Research*, *27*(16), 19915-19932.
27. Zhou, X., Tang, X., & Zhang, R. (2022). Digital finance and green investment efficiency: Evidence from developing economies. *Finance Research Letters*, *46*, 102–130.