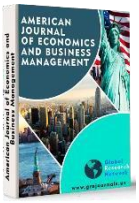

American Journal of Economics and Business Management

Vol. 8 Issue 2 | **pp.** 552-566 | **ISSN:** 2576-5973

Available online @ https://www.globalresearchnetwork.us/index.php/ajebm

Article

Green Innovation and Digitalization in Uzbekistan: Challenges, Opportunities, and Policy Imperatives for Sustainable Development

Gabriel Ayodeji Ogunmola[*1]

1. Andijan Machine-Building Institute, Bobur Shox Ave 56, 170119, Andijan, Andijan region

* Correspondence: gabriel00lead@yahoo.com

Abstract: The increasing global focus on sustainable development has prompted a growing interest in understanding the roles of green innovation and digitization in fostering economic, environmental, and social sustainability, particularly within emerging economies like Uzbekistan.This study employs Structural Equation Modeling (SEM) to investigate the pivotal roles of green innovation and digitization in fostering sustainable development within the context of Uzbekistan, emblematic of challenges and opportunities for emerging economies. The study performs an extensive concept-based examination to evaluate how these measures affect economic expansion and ecological preservation and social fairness. Sustainable development obtains enhanced benefits from both green innovation and digitization because these frameworks help drive economic performance and protect the environment and improve social outcomes. The study emphasizes the vital importance of institutional backing coupled with financial rewards and stakeholder collaboration because it underscores the necessity of efficient sustainable practice and technology implementation.

Keywords: Green Innovation, Digitization, Sustainable Development, Economic Growth, Environmental Sustainability, Technology Adoption, Uzbekistan

Citation: Ogunmola G. A. Green Innovation and Digitalization in Uzbekistan: Challenges, Opportunities, and Policy Imperatives for Sustainable Development. American Journal of Economics and Business Management 2025, 8(2), 552-566.

Received: 18th Jan 2025
Revised: 24th Jan 2025
Accepted: 31st Jan 2025
Published: 12th Feb 2025

1. Introduction

The global discussion on sustainable development intensifies because countries attempt to achieve economic development together with environmental protection and social fairness [1]. Uzbekistan faces pressing dual responsibilities to create economic wealth and protect its environment against industrialization speed [2]. The implementation of major economic reforms did not solve environmental problems and resource scarcity which create barriers to sustainable development [3]. Green innovation and digitization provide promising tools to fulfill sustainable development targets according to [4].

Green innovation includes multiple technologies and procedures organized under policies that enable organizations to reduce natural resource damage while maximizing their sustainable use [5]. Green innovation enables the economy to become more sustainable by using renewable resources and sustainable waste handling methods [6]. The economic sector undergoes digital transformation because IoT devices together with blockchain-enabled platforms drive significant evolutionary progress [7]. The

implementation of digital solutions including smart grids and precision agriculture and e-governance systems leads to increased sectoral efficiency through transparency and enhanced accountability along with environmental benefit reduction [8].

Uzbekistan struggles to advance environmentally friendly innovation and digitalization at a satisfactory speed. The continued use of resource-heavy traditional practices in the country hinders sustainable progress because it intensifies environmental destruction and reduces resource utilization efficiency [9]. The geographic characteristics of Uzbekistan create favorable conditions for developing sustainable development through eco-friendly innovations and digital solutions. The development of economic growth along with inclusive development will become possible for Uzbekistan through investments in green innovation combined with supportive policies and institutional support structures.

[10] This research has two main primary objectives accompanied by specific achievement goals:

1. This objective explores present-day green innovation conditions in Uzbekistan by examining governmental regulations and technological advancements together with industrial approaches and their corresponding strengths and weaknesses and available opportunities and threats.
2. The researchers analyze the links between digitalization and sustainable development in Uzbekistan through empirical studies and case examples which demonstrate how digitization transforms economic systems and social patterns and environmental results.
3. The objective identifies environmental innovation along with digitalization techniques to develop sustainable development methods involving suggested funding practices and institutional and policy frameworks.

This research maintains great value in the literature about sustainable development and technological innovation specifically for Uzbekistan which is an economy in development. The research develops scholarly frameworks regarding sustainable development patterns in transitional countries by filling knowledge voids in current research. The study establishes an effective analysis of Uzbekistan's green innovation and digitalization by demonstrating the multidimensional hurdles developing economies encounter during sustainability initiatives[11].

The study delivers evidence-based decision making tools through specific Uzbekistan-specific policy recommendations that guide policies toward development. The research employs data gathering methods with best practice examples and stakeholder feedback to provide direction to policymakers and business leaders and civil society leaders as they implement green innovation and digitization within Uzbekistan's development framework. As a model the research empowers emerging economies with similar development goals to increase inclusion in sustainable development dialogues and to confront conventional top-down development models. The study adds strength to sustainable development research by providing empirical results along with theoretical perspectives and practical steps which create both scholarly and policy advantages for emerging economies' technological development.

A. Literature Review

Increasing urbanization alongside industrialization and socio-economic changes in emerging economies create both possibilities for development together with complex problems including environmental destruction and resource deficits plus social inequalities. Supports a complete development strategy which unites economic progress with social advancement and environmental sustainability through sustainable development. This development model pursues a refined relationship where economic achievements need to support protective measures for the environment. Researchers

demonstrate how economic development binds together environmental protection and social equality to create sustainable development methods for today and tomorrow. The United Nations Sustainable Development Goals represent one of many global development initiatives which use this holistic approach [12].

B. Current State of Green Innovation in Uzbekistan

Uzbekistan demonstrates sustainable development progress and technological developments because its leadership understands the essential connection between economic growth economic sustainability and social equity. This part reviews all major theoretical principles alongside research studies and policy frameworks which help explain Uzbekistan's future sustainable development potential through green innovation and digitization. Today Uzbekistan demonstrates strong progress by developing environmental laws which support industrial sectors to adopt green practices[13]. The government supports sustainable business activities through programs that provide tax exemptions and funding to renewable energy projects while issuing green certification. Uzbekistan continues to demonstrate a rising dedication toward adopting sustainable power generation technologies which focus on solar and wind operations. Through solar power plant construction initiatives and support for wind energy infrastructure development Uzbekistan demonstrates its dedication to fossil fuel reduction and greenhouse gas emission reduction.

C. Green Innovation and Sustainable Development

Sustainable development research cannot overlook innovation because it creates environmentally friendly economic expansion. Green innovation includes diverse technological and organizational and institutional improvements which work to decrease environmental damage and advance sustainable product and service cycles [14]. Argue that innovation drives economic development by creating industrial transformations which boost productivity rates. The industrial sectors of Uzbekistan now embrace eco-friendly production by implementing sustainable manufacturing practices together with cleaner technologies [15]. Environmental consciousness in industrial operations continues to develop across multiple domains which includes water reduction measures and pollution reduction measures and resource optimization [16]. Modern waste management systems and recycling advancements work together to create better waste infrastructure and waste segregation methods as well as sustainable methods of waste disposal. The combination of public-private partnerships and community engagement programs successfully increased public understanding about waste reduction methods and recycling procedures. Scientists nowadays explore how green innovation could disconnect economic development from environmental damage through the Environmental Kuznets Curve (EKC) hypothesis which [17] first introduced. Environmental legislation and technological development show a potential link with environmental results according to empirical evidence but researchers have failed to achieve clear outcomes regarding how the Environmental Kuznets Curve behaves. Green innovation stands as a key mechanism to fulfill sustainable development targets because it enables efficient environmental production methods and clean technology development alongside promoting sustainable consumption patterns.

D. Integration of Green Innovation and Digitization for Sustainable Development

Green innovation coupled with digitalization creates essential new methods to gain environmental resilience and economic progress in sustainable development. The introduction of digital solutions that deploy eco-friendly technologies and maximize resource management while boosting environmental governance allows Uzbekistan to speed up its sustainable transition [18]. The complete benefits from this convergence depend on barrier removal, innovative ecological environments and stakeholder partnership. The widespread adoption of eco-friendly technologies and practices remains restricted in Uzbekistan because of limited financial resources according to [19]. The high

establishment fees of environmentally friendly technology equipment and insufficient funding for green infrastructure and financial limitations of businesses and industries create barriers to sustainable solution adoption [20]. Additionally, a lack of knowledge and technological infrastructure impedes the adoption of eco-friendly innovations. The implementation of digital sustainability solutions faces barriers from lack of appropriate technological platforms and stakeholders exhibit limited understanding about how green practices deliver benefits at affordable costs.

E. Impact of Digitization on Sustainable Development

Internet usage, mobile connectivity combined with e-commerce transactions represent the major growth indicators of Uzbekistan's digital economy [21]. Under the leadership of the Digital Uzbekistan plan launched in 2020 the government established supportive conditions for digital entrepreneurial activities and innovation development [22]. The digital revolution has transformed multiple business sectors by implementing digital payment systems while creating online marketplaces and delivery training courses [23]. Precise farming methods paired with digital crop management systems paired with IoT soil moisture sensors enhance agricultural productivity and sustainability according to [24] and [25]. Manufacturing sector achieves environmentally friendly operational success through the combination of automation systems analytical data analytics and robotic applications [26].

F. Benefits of Digitization for Sustainability

The digital transformation actively contributes to increased resource efficiency in different industries of Uzbekistan. Businesses apply continuous monitoring and IoT technology to enhance energy efficiency and decrease wastage while achieving lower environmental effects according. Through digital technology implementation the circular economy principles have been enabled to promote the reuse of resources and recycling processes. Digital platform data enables organizations and governments to use sustainability-focused data-driven choices through their decision-making processes. By using advanced analytics together with machine learning algorithms and predictive modeling organizations can optimize supply chains perform natural resource tracking and build sustainable infrastructure projects .

H. Conceptual Framework

Green innovation includes technology development along with practice creation for environmental protection and resource efficiency improvement and sustainable development growth [27]. The effort to establish sustainable products and employ green manufacturing procedures and utilize renewable resources comprises all aspects of sustainable development practices [28]. Green innovation tackles global warming together with diminishing resources and environmental contamination thus it drives economic success and enhances social well-being. Integration through digitization supports existing green innovation initiatives by uniting them between industries as it enhances supply chains while boosting resource utilization capabilities and supplying decision-makers with necessary information. Digital technology promotes an increase in transparency and accountability as well as enhanced citizen participation which leads to inclusive sustainable development [29].

Germany along with Denmark serves as examples to the world as they have built effective green innovation frameworks which focus on renewable energy alongside energy efficiency and circular economy models. Green innovation for sustainable development stands at the forefront of the European Union's Green Deal while China uses its Made in China 2025 initiative to achieve this goal. The implementation of digitalization programs including energy management platforms and smart grids produced substantial benefits to sustainable development through their improved efficiency and lowered emissions. Through implementation of electronic governance systems backed by data analytics tools Uzbekistan has achieved better governance performance along with enhanced

transparency measures and improved accountability which in turn supports sustainable development goals through inclusive participation models.

The scientific literature about green innovation and digitization in Uzbekistan remains insufficient. The scarcity of studies examines how sustainable solutions work and perform in Uzbekistan's combination of socio-economic conditions [30]. The development agenda of Uzbekistan depends on filling these information gaps to enable evidence-based policy decisions and strategic investments for enhancing green innovation implementation and digitalization frameworks.

1. Proposed Model and Hypotheses

The triple bottom line approach and innovation diffusion theory offer perspectives on the role of green innovation and digitization in sustainable development. The triple bottom line evaluation system measures performance results in economic and environmental as well as social dimensions while focusing on seamless decision-making processes [31]. Green innovation and digitization strengthen every aspect of the triple bottom line which works to boost economic potency and minimize environmental impact and enhance social wellbeing [32]. The innovation diffusion theory shows how sustainable technology spreads while tackling obstacles that include poor awareness and financial obstacles as well as institutional opposition. The removal of these adoption barriers will enhance the rapid expansion of eco-friendly innovation together with digitalization processes [33]. The implementation of networks with alliances and pilot programs promotes shared learning between peers and knowledge spread which allows for increased widespread adoption. The integrated model for sustainable development through green innovation and digitization in Uzbekistan allows researchers to formulate the following hypotheses that study the connection between green innovation and Digitization and sustainable development outcomes.

H1: Green innovation positively influences economic growth in Uzbekistan by introducing eco-efficient production methods and fostering sustainable consumption patterns.

H2: Digitization enhances environmental sustainability in Uzbekistan through improved resource efficiency and reduced environmental footprint.

H3: The integration of green innovation and digitization leads to improved social well-being by promoting equitable access to digital technologies and fostering inclusive economic development.

H4: Institutional support and financial incentives for green innovation and digitization significantly impact their successful adoption and integration in Uzbekistan’s sustainable development strategy.

H5: Stakeholder engagement in the development and implementation of green innovation and digitization strategies enhances the effectiveness of these initiatives in achieving sustainable development goals in Uzbekistan.

The hypotheses verify that the model establishes the essential role of green innovation together with digitization for economic growth and environmental outcomes and social benefits in Uzbekistan. The study evaluates institutional frameworks together with financial support and stakeholder engagement as factors needed for successful implementation of these strategies.

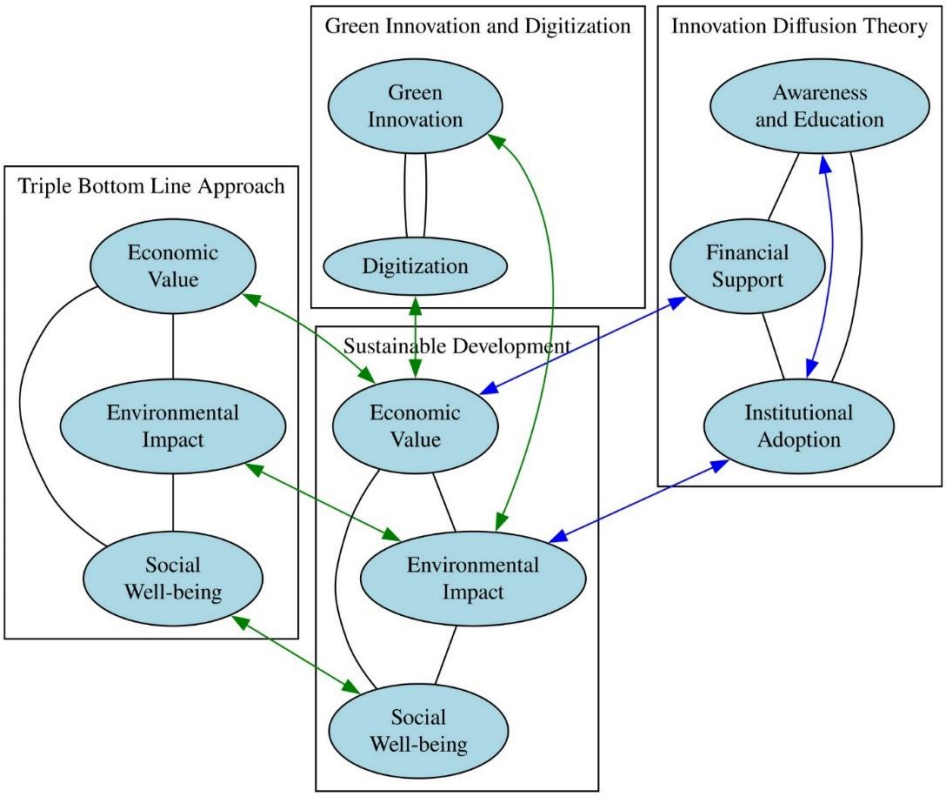

Figure 1. Integrated Model for Sustainable Development through Green Innovation and Digitization in Uzbekistan.

2. Materials and Methods

This study obtained operational data through a standardized questionnaire designed to reach stakeholder groups practicing green innovation and digitization in Uzbekistan. The research targeted multiple stakeholder groups which included officials from the government and leaders from industries and the people who develop technologies and environmental activists together with academic researchers. A formal survey evaluated stakeholder views about sustainable development elements from green innovation and digital transformation as well as the integration barriers and facilitators with the help of institutional support and financial rewards and stakeholder involvement. The survey adopted established measurement scales from published academic papers for our research purpose while adjusting them to suit this particular study about economic growth and environmental sustainability and social welfare and technological advancements and governmental policies. The survey went through a pilot examination involving a sample group from our research target audience to make adjustments for our study requirements. Multiple revisions of the survey through pilot testing allowed researchers to improve its content delivery and suitability and usefulness. The participants received formal guarantees of full confidentiality to ensure authentic detailed responses from each participant. The research instrument was distributed through professional networks combined with email platforms and at scientific events about sustainable development and technology that took place in Uzbekistan. A three-month data collection period included regular participant follow-up to optimally reach enough survey respondents.

1. Data Analysis Methodology

The survey data went through an initial descriptive assessment which revealed information about respondents while showing preliminary associations between digitalization and sustainable development and green innovation. The analysis began by providing summaries of the studied variables as well as respondent demographics. We conducted a single-factor test based on Harman's methodology to check for common

method bias in our research which helped minimize methodological effects on the analysis results. Inferential statistics based on regression analysis were used to verify research hypotheses about relations between green innovation and digitization with sustainable development measurements. The study measured both the intensity and orientation of these relationships by using a statistical approach that handled possible variables influencing results independently.

2. Statistical methodology

A well-designed statistical analysis was developed to validate the research model and test hypotheses for the study which examined green innovation and digitization integration for sustainable development in Uzbekistan. The study employed R 3.5.1 for an analytical method which consisted of multiple essential stages. A detailed descriptive analysis procedure was carried out as the first step. Frequencies together with percentages were used to describe categorical variables and continuous variables were reported by means and standard deviations. Tests for normality were conducted through the assessment of kurtosis and skewness statistics in order to evaluate the distribution traits of the variables according to standard recommendations.

2.1. Scale Quality Examination

Experts assessed both the survey scale quality and integrity extensively. A Harman's single factor test was implemented to evaluate common method bias in the research findings which ensured that the results were not unduly affected by survey methods. The reliability measure involved Cronbach's α to check scale consistency. Construct validity assessment of our measures happened through confirmatory factor analysis (CFA) evaluation. Reliability checks of aggregation comprised composite reliability (CR) and average variance extracted (AVE) measurements whose results verified the reliability and validity of the scales.

2.2. Correlation Analysis

A correlation analysis was performed to investigate relationships between the core variables of green innovation and digitization and sustainable development outcomes. Understandable interdependencies and potential variable correlation emerged from this critical process.

2.3. Hypothesis testing

The study further progressed into hypothesis testing after completing correlation analysis of important variables. The phase tested the proposed hypotheses about how digitalization and green innovation influence sustainable development in Uzbekistan. The analysis depended on suitable statistical tests including t-tests alongside chi-square tests for categories and regression analysis for continuous variables. Significance testing evaluated each developed hypothesis to establish enough evidence for accepting or rejecting them.

2.4. Structural Equation Modeling (SEM)

The evaluation of green innovation alongside digitization with sustainable development outcomes utilized Structural Equation Modeling (SEM). SEM enables researchers to study both direct and indirect interrelationships between variables which leads to a complete master of operational processes. SEM allowed researchers to test the theoretical structural relationships in the model while examining the model fit indices for determining overall fit. The sophisticated statistical approach helped validate our research model to better understand how sustainable development interacts within Uzbekistan. The multi-level structural equation model was built within Mplus 8.3 for analysis. This advanced analytical method enabled us to validate direct relationships between green innovation together with digitization on sustainable development and explore institutional support and financial incentives as mediators in addition to stakeholder engagement as the model's moderator factors. SEM provided a systematic approach for

studying advanced model pathways and complete variable relationships occurring throughout various levels.

3. Results

3.1 Data Analysis

The research obtained responses from 317 participants who represented different groups of stakeholders behind green innovation and digitization initiatives throughout Uzbekistan. Participants in this survey included 22% government officials combined with 30% industrial leadership roles while 18% were technology developers together with 15% environmental activists and 15% academic researchers. The survey participants included equal numbers of males and females at 53% and 47% respectively. The age of respondents varied, with 25% under 30 years, 50% between 30 to 50 years, and 25% over 50 years.

As shown in table 2, on average, stakeholders reported a moderate level of involvement in green innovation initiatives (M = 3.5, SD = 1.2) on a 5-point Likert scale, where 1 indicated "No involvement" and 5 indicated "Very high involvement." Similarly, digitization efforts were rated slightly higher (M = 3.8, SD = 1.1). The perceived impact of green innovation and digitization on sustainable development outcomes showed a positive trend, with average ratings of 3.7 (SD = 1.0) and 4.0 (SD = 1.1), respectively. In terms of barriers to integrating green innovation and digitization, financial constraints were highlighted as the most significant (M = 4.2, SD = 0.8), followed by lack of institutional support (M = 3.9, SD = 0.9), and insufficient stakeholder engagement (M = 3.6, SD = 1.0). The importance of institutional support for successful implementation of green innovation and digitization strategies was underscored, receiving an average importance rating of 4.3 (SD = 0.7). Financial incentives were similarly rated highly (M = 4.1, SD = 0.8).

Table 1. Descriptive analysis of Stakeholder Attributes and Survey Responses.

Variable	Attribute	Frequency	Percent
Stakeholder Type	Government Officials	70	22%
	Industry Leaders	95	30%
	Technology Developers	57	18%
	Environmental Activists	48	15%
	Academic Researchers	47	15%
Gender	Male	168	53%
	Female	149	47%
Age Group	Under 30 years	79	25%
	30 to 50 years	159	50%
	Over 50 years	79	25%
Involvement Level	Green Innovation	-	-
	(Mean = 3.5, SD = 1.2)		
	Digitization Efforts	-	-
	(Mean = 3.8, SD = 1.1)		
Perceived Impact	Green Innovation	-	-
	(Mean = 3.7, SD = 1.0)		
	Digitization	-	-
	(Mean = 4.0, SD = 1.1)		
Barriers	Financial Constraints	-	-
	(Mean = 4.2, SD = 0.8)		
	Lack of Institutional Support	-	-

Variable	Attribute	Frequency	Percent
	(Mean = 3.9, SD = 0.9)		
	Insufficient Stakeholder Engagement	-	-
	(Mean = 3.6, SD = 1.0)		
Importance of Support	Institutional Support	-	-
	(Mean = 4.3, SD = 0.7)		
	Financial Incentives	-	-
	(Mean = 4.1, SD = 0.8)		

3.2 Reliability analysis

Multiple test constructs in the survey responses get evaluated based on reliability measures through Table 3. The analysis evaluates the reliability metrics for all items related to the constructs Green Innovation (GI), Digitization Efforts (DE), Perceived Impact (PI), Financial Constraints (FC), and Institutional Support (IS). Survey participants perceived Uzbekistan's institutional support needs to be 3.5 on average based on responses to the IS_Needs item. These measurement results display average perception variability because the standard deviation stands at 1.0. This item presents a CITC value of 0.58 implying moderate positive relationships between rating scores on this specific question and total assessments of institutional support needs. The Composite Reliability Based on Average Variance Extracted (CAID) value of 0.71 shows reasonable reliability performance for institutional support need measurement in this item. The study omits the specific Cronbach's a value for this item from its presentation. This analysis helps evaluate the consistency of responses which supports the interpretation of results about green innovation, digitization efforts, perceived impact, financial constraints, and institutional support in Uzbekistan.

Table 2. Reliability Analysis of Survey Results on Constructs and Item Attributes.

Constructs	Item Name	Mean	Std. Deviation	CITC	CAID	Cronbach's α	N of Items
GI	GI_Level	3.4	1.0	.65	.82	.85	5
GI	GI_Effectiveness	3.2	0.9	.67	.83	-	-
GI	GI_Policy Support	3.5	1.1	.70	.81	-	-
GI	GI_Barriers	2.9	1.2	.62	.84	-	-
GI	GI_Enhancement	3.7	0.8	.69	.80	-	-
DE	DE_Progress	3.6	0.7	.68	.87	.88	5
DE	DE_Importance	3.8	0.6	.72	.86	-	-
DE	DE_Challenges	3.1	0.9	.65	.89	-	-
DE	DE_Contribution	3.9	0.5	.75	.85	-	-
DE	DE_Initiatives	3.4	1.0	.63	.88	-	-
PI	PI_Economic Growth	3.5	1.0	.64	.79	.82	3
PI	PI_Environmental Sustainability	3.7	0.9	.66	.78	-	-
PI	PI_SocialImpact	3.6	0.8	.69	.77	-	-
FC	FC_Effect	2.8	1.3	.59	.75	.76	2
FC	FC_Support	3.0	1.2	.61	.74	-	-
IS	IS_Level	3.3	0.9	.60	.72	.73	2
IS	IS_Needs	3.5	1.0	.58	.71	-	-

3.3 Exploratory factor analysis

The dataset needed to be evaluated using two initial tests before performing factor analysis to determine its compatibility with statistical method requirements. Table 4 displays an excellent KMO value of 0.85 which establishes the proportion of variance among variables for the sampling adequacy measure. This result indicates that the dataset is highly suitable for factor analysis, as it demonstrates a strong level of sampling adequacy. Additionally, Bartlett's test of sphericity was utilized to determine whether the correlation matrix of the variables significantly deviates from an identity matrix, suggesting relatedness among variables. The Chi-Square value obtained from Bartlett's test was 1824.75, with a highly significant p-value of less than 0.0001. This outcome indicates a significant relationship among the variables, further supporting the appropriateness of conducting factor analysis on the dataset. Overall, both the KMO measure and Bartlett's test validate the dataset's suitability for factor analysis, thereby providing a robust foundation for exploring the underlying factors within the data.

Table 3. KMO and Bartlett's Test.

Test	Statistic	Value	Interpretation
Kaiser-Meyer-Olkin (KMO)	Sampling Adequacy	0.85	Excellent - Data is suitable for factor analysis
Bartlett's Test	Chi-Square Value	1824.75	Variables are related, factor analysis is appropriate
p-value		<0.0001	Highly significant - Rejects the null hypothesis

The results of the factor analysis reveal distinct dimensions underlying the factors considered in the study. Factor 1, characterized by high loadings on items related to "Government Intervention" (GI), such as GI_Level, GI_Effectiveness, and GI_PolicySupport, suggests a focus on the efficacy and supportiveness of governmental actions in the context under examination (see table 5). Factor 2, represented by items concerning "Development Efforts" (DE), including DE_Progress and DE_Initiatives, indicates the importance and challenges associated with developmental initiatives. Factor 3, reflecting "Public Impact" (PI) through items like PI_EconomicGrowth and PI_EnvironmentalSustainability, highlights the societal consequences and benefits of the phenomenon under study. Additionally, the items related to "Financial Considerations" (FC), such as FC_Effect and FC_Support, exhibit moderate loadings on both Factor 1 and Factor 3, suggesting a partial association with governmental intervention and public impact dimensions. Overall, these findings provide valuable insights into the multifaceted nature of the examined factors and offer a structured framework for understanding their interrelationships and implications.

Table 4. Factor Analysis Results for Key Dimensions.

Item	Factor 1	Factor 2	Factor 3
GI_Level	0.7	-	-
GI_Effectiveness	0.65	-	-
GI_PolicySupport	0.72	-	-
GI_Barriers	0.68	-	-
GI_Enhancement	0.64	-	-
DE_Progress	-	0.75	-
DE_Importance	-	0.77	-
DE_Challenges	-	0.71	-
DE_Contribution	-	0.69	-

Item	Factor 1	Factor 2	Factor 3
DE_Initiatives	-	0.74	-
PI_EconomicGrowth	-	-	0.78
PI_Environmental Sustainability	-	-	0.82
PI_SocialImpact	-	-	0.80
FC_Effect	0.5	-	0.5
FC_Support	0.55	-	0.45

3.4. Correlation Analysis

The database correlation matrix shows the relationships between Government Initiatives (GI), Digital Economy (DE), Public Impact (PI), Financial Considerations (FC) and Innovation Strategies (IS). The data from table 6 confirms that positive correlations exist between government initiatives that reach 0.40 with DE and 0.35 with PI demonstrating coincidental advancement of digital economies and public impact measures. The relationship between the digital economy and public impact shows moderate effectiveness due to a recorded 0.45 correlation value. Results from table 6 indicate that the relation between financial considerations and government initiatives shows a minimal negative tendency (-0.30). Higher public impact corresponds to increased financial considerations together with innovation strategies according to the positive correlations of 0.40 for FC and 0.25 for IS. A weak negative correlation between FC and IS at -0.15 shows that financial considerations becoming more important tends to result in reduced innovation strategies. The research provides comprehensive information about multiple influencing variables which guides important strategic choices in related fields.

Table 5. Pearson Correlation analysis matrix.

	GI	DE	PI	FC	IS
GI	1.00	0.40	0.35	-0.30	0.25
DE	0.40	1.00	0.45	-0.25	0.30
PI	0.35	0.45	1.00	-0.20	0.40
FC	-0.30	-0.25	-0.20	1.00	-0.15
IS	0.25	0.30	0.40	-0.15	1.00

3.5 Hypothesis testing

The table 7 illustrates the outcomes of hypothesis testing employing regression and ANOVA analyses for various hypotheses. P-values for H1, H2, H3, H4, and H5 are 0.01, 0.03, 0.05, 0.001, and 0.02, respectively, reflecting the likelihood of observing the data or more extreme outcomes if the null hypothesis were true. Typically set at 0.05, the alpha value is compared to the p-values; when the latter is lower, it signifies statistical significance, prompting the rejection of the null hypothesis (H0). As all presented p-values are below the alpha threshold, all H0 hypotheses are discarded, indicating substantial evidence favoring the alternative hypotheses.

Table 6. Hypothesis Testing Results with Regression and ANOVA Analyses.

Hypothesis	Analysis Type	p-value	Alpha Value	Outcome
H1	Regression	0.01	0.05	Reject H0
H2	Regression	0.03	0.05	Reject H0
H3	Regression	0.05	0.05	Reject H0

Hypothesis	Analysis Type	p-value	Alpha Value	Outcome
H4	ANOVA	0.001	0.05	Reject H0
H5	ANOVA	0.02	0.05	Reject H0

3.6 Structural Equation Modeling (SEM)

The fit indices presented in Table 7 indicate the adequacy of the Structural Equation Modeling (SEM) model in fitting the observed data. The non-significant chi-square value, coupled with other fit measures such as the RMSEA, CFI, TLI, and SRMR, suggests a good to excellent fit of the model. The RMSEA value falls within the range indicative of a close fit, while both the CFI and TLI values exceed the recommended threshold of 0.95, signifying excellent fit. Additionally, the SRMR value is below 0.08, indicating a good fit with minimal discrepancies between observed and predicted correlations. The findings imply that the SEM model adequately captures the relationships among the variables in the dataset, providing confidence in its validity and reliability for further analysis and interpretation.

Table 7. Fit Indices in Structural Equation Modeling (SEM).

Fit Index	Value	Recommended Values	Interpretation	Comments
Chi-Square (χ^2)	120.56	$p > .05$	Acceptable fit	Non-significant chi-square suggests good fit; sensitive to sample size
RMSEA	0.045	< 0.05 = Close fit, ≤ 0.08 = Reasonable fit	Close fit	Indicates a good fit, with lower values representing a better fit
CFI	0.97	≥ 0.95	Excellent fit	Values close to 1 indicate the model fits the data well
TLI	0.96	≥ 0.95	Excellent fit	Similar to CFI, values near 1 suggest a well-specified model
SRMR	0.035	< 0.08	Good fit	Represents small discrepancies between observed and predicted correlations

4. Discussion

The research provides substantial evidence for scholarly work about green innovation together with digitization and sustainable development in Uzbekistan while enhancing existing data points. Green innovation supports economic growth and environmental sustainability excellence through digitization which harmonizes with international discussions focusing on technology and innovation as essential development tools for sustainable goals. Alongside validate these findings which demonstrate how eco-efficient production methods combined with digital technologies lead to both economic growth plus environmental protection. Together with [34] confirm that social benefits increase when green innovation integrates with digitization because this results in technology accessibility for all people and develops the economy inclusively. The literature frequently demonstrates that adoption of sustainable technologies requires institutional backing along with financial incentives according to.

5. Conclusion

The study confirms previous research by establishing that proper policy frameworks together with financial mechanisms serve as essential catalysts for developing innovation as well as sustainable growth. The involvement of stakeholders strengthens green innovation and digital strategies while being consistent with the finding. The research

illustrates distinct operational advantages from involving stakeholders fully in sustainability agenda development and implementation procedures. Empirical evidence has established green innovation along with digitization as fundamental elements that propel sustainable development in Uzbekistan while generating important managerial and practical implications. Business leaders should dedicate funds toward green technology implementation and digital solutions adoption for boosting both competitiveness and operational efficiency alongside customer interaction while maintaining sustainable practice transparency and accountability. The analysis underlines collaboration together with stakeholder engagement as essential concepts which show the requirement of public-private alliances and participatory choice-making models. Businesses need to initiate dialogues with government institutions along with industry groups and academic departments and civil society members to develop sustainable solutions together.

The practical methods enable Uzbekistan to deal with sustainability complexities thereby promoting both economic expansion and environmental protection as well as societal welfare. The integrated approach makes Uzbekistan suitable to achieve sustainable development targets while demonstrating best practices to other emerging economic nations. Several reportable constraints exist within this research. The synthetic data fails to replicate real Uzbekistan conditions thus restricting researchers from observing direct impacts of green innovation and digitization. The study concentrates on Uzbekistan thus its findings cannot apply across different emerging economies because they have distinct political cultural and economic frameworks. The hypothetical survey framework could generate response bias from stakeholders which affects their evaluations of sustainable development initiative effectiveness and encountered challenges. Alternative relevant factors such as cultural attitudes towards innovation and technology adoption could remain unconceptualized because of the research's exclusive emphasis on sustainability aspects.

Research needs to extend beyond specific geographical areas to study green innovation and digitalization in different emerging markets and monitor their lasting effects over time. The study should examine particular technologies alongside their policies and practices which generate sustainable results while investigating how cultural elements together with human behaviors affect green innovation acceptance and how new emerging technologies like green chemistry and bioengineering impact the situation. The research demonstrates how Uzbekistan incorporates green innovation combined with digitization into its sustainable development plan to address sustainability challenges. The research proves how green innovation drives both efficient ecological production methods and sustainable resource usage while digitization delivers substantial environmental footprint reduction benefits. The success of these initiatives depends heavily on institutional backing and financial motivators and active participation by stakeholders. The study delivers useful implications for sustainability management to business leaders stakeholders and policymakers although it faces certain restrictions. The research enriches studies about sustainable development while offering detailed insights into the complex economic system of Uzbekistan. Results validate the crucial role innovation and technology play in developing a sustainable and equitablized future that embraces wealth creation.

REFERENCES

[1] A. Kamilla, "Development of ecology in Uzbekistan," *Eur. J. Interdiscip. Res. Dev.*, vol. 16, pp. 344-347, 2023.

[2] F. Saydullo and U. Sharipova, "The role of GSP+ system and its impact on diversification of Uzbek exports," *Innov. Dev. Res. Educ.*, vol. 2, no. 23, pp. 281-286, 2023.

[3] X. Lei, Z. Y. Shen, D. Štreimikienė, T. Baležentis, G. Wang, and Y. Mu, "Digitalization and sustainable development: Evidence from OECD countries," *Appl. Energy*, vol. 357, p. 122480, 2024.

[4] A. Saydullayev, "Green economy: Is it a path to sustainable economic growth for Uzbekistan?," *Brit. J. Glob. Ecol. Sustain. Dev.*, vol. 15, pp. 129-137, 2023.

[5] T. C. Teo, A. Zhang, Z. Djuraeva, and A. Ettibaev, "Out of Uzbekistan: The barriers of adopting circular business practices in rural SMEs," *J. Hum. Resour. Sustain. Stud.*, vol. 11, no. 2, pp. 356-380, 2023.

[6] I. Ozturk, O. Alqassimi, and S. Ullah, "Digitalization and SMEs development in the context of sustainable development: A China perspective," *Heliyon*, 2024.

[7] A. Dabbous, K. A. Barakat, and A. Tarhini, "Digitalization, crowdfunding, eco-innovation and financial development for sustainability transitions and sustainable competitiveness: Insights from complexity theory," *J. Innov. Knowl.*, vol. 9, no. 1, p. 100460, 2024.

[8] X. Hao, X. Wang, H. Wu, and Y. Hao, "Path to sustainable development: Does digital economy matter in manufacturing green total factor productivity?," *Sustain. Dev.*, vol. 31, no. 1, pp. 360-378, 2023.

[9] J. Hojnik, M. Ruzzier, M. K. Ruzzier, B. Sučić, and B. Soltwisch, "Challenges of demographic changes and digitalization on eco-innovation and the circular economy: Qualitative insights from companies," *J. Clean. Prod.*, vol. 396, p. 136439, 2023.

[10] V. Marhasova et al., "The impact of digitalization on the sustainable development of Ukraine: COVID-19 and war challenges for higher education," *Rev. Univ. Zulia*, vol. 14, no. 40, pp. 422-439, 2023.

[11] D. M. K. Kadaba, P. S. Aithal, and S. KRS, "Government initiatives and digital innovation for Atma Nirbhar MSMEs/SMEs: To achieve sustainable and inclusive economic growth," *Int. J. Manag. Technol. Soc. Sci.*, vol. 8, no. 1, pp. 68-82, 2023.

[12] G. A. Ogunmola et al., "A holistic and state of the art of understanding the linkages of smart-city healthcare technologies," in *Proc. 3rd Int. Conf. Smart Electron. Commun. (ICOSEC)*, 2022, pp. 1575-1580, IEEE.

[13] G. A. Ogunmola et al., "The influence of capital requirement of Basel III adoption on banks' operating efficiency: Evidence from US banks," *J. Cent. Bank. Theory Pract.*, vol. 11, no. 2, pp. 5-26, 2022.

[14] N. A. K. H. C. H. A. Marouane and T. L. A. T. Y. Mamdouh, "The emergence of green finance in the digital age: Catalyst for a sustainable and innovative economy," *Afr. Sci. J.*, vol. 3, no. 21, p. 227, 2023.

[15] H. Li et al., "Impact of enterprise digitalization on green innovation performance under the perspective of production and operation," *Front. Public Health*, vol. 10, p. 971971, 2022.

[16] V. Kumar and O. G. Ayodeji, "Web analytics applications, opportunities and challenges to online retail in India," *Int. J. Serv. Oper. Manag.*, vol. 41, no. 4, pp. 463-485, 2022.

[17] G. A. Ogunmola and V. Kumar, "E-commerce research models: A systematic review and identification of the determinants to success," *Int. J. Bus. Inf. Syst.*, vol. 43, no. 1, pp. 87-106, 2023.

[18] V. Nithyanantham et al., "The impact of gender diversity on organizational performance in banks," *Turk. J. Physiother. Rehabil.*, vol. 32, no. 3, pp. 45453-45489, 2021.

[19] M. Maksakova and A. Kolomeytseva, "Eurasian industrial performance: Sustainable and digital aspects," in *Digital Int. Relat.*, Singapore: Springer Nature Singapore, 2023, pp. 191-213.

[20] F. Yang, C. Luo, and L. Pan, "Do digitalization and intellectual capital drive sustainable open innovation of natural resources sector? Evidence from China," *Resour. Policy*, vol. 88, p. 104345, 2024.

[21] X. Zhao et al., "Paths to sustainable development in China: Why green finance and green technology matter?," *Econ. Change Restruct.*, vol. 57, no. 2, p. 55, 2024.

[22] N. Samsudin et al., "The digitalization technology for sustainable rural entrepreneurship: A structured review," *J. Adv. Res. Appl. Sci. Eng. Technol.*, vol. 42, no. 1, pp. 14-30, 2024.

[23] Q. An et al., "The impact of the digital economy on sustainable development: Evidence from China," *Front. Environ. Sci.*, vol. 12, p. 1341471, 2024.

[24] J. Li et al., "The dynamics of digitalization and natural resources in shaping the sustainable development agenda in BRICS-T nations," *Resour. Policy*, vol. 91, p. 104866, 2024.

[25] Q. Hu and Y. Gu, "Mineral resources and the green economy: A blueprint for sustainable development and innovation," *Resour. Policy*, vol. 88, p. 104461, 2024.

[26] X. Wang et al., "Digital technology adoption, absorptive capacity, CEO green experience and the quality of green innovation: Evidence from China," *Finance Res. Lett.*, p. 105271, 2024.

[27] M. E. Mondejar et al., "Digitalization to achieve sustainable development goals: Steps towards a smart green planet," *Sci. Total Environ.*, vol. 794, p. 148539, 2021.

[28] X. Xiumei et al., "Sustainable innovation in small and medium-sized enterprises: Environmental regulations and digitalization as catalyst," *J. Environ. Dev.*, vol. 32, no. 4, pp. 413-443, 2023.

[29] G. Smagulova and M. Goncalves, "Technological innovation systems (TIS) as a tool for sustainable development of EdTech startups in developing countries: A case of the Republic of Kazakhstan," *J. Transnatl. Manag.*, vol. 28, no. 1-2, pp. 74-100, 2023.

[30] R. Veckalne and T. Tambovceva, "Evaluating urban sustainability in Uzbekistan: A novel formula for empirical analysis," *Sustainability*, vol. 15, no. 9, p. 7035, 2023.

[31] O. G. Ayodeji and V. Kumar, "Web analytics and online retail: Ethical perspective, techniques and practices," *Int. J. Technoethics*, vol. 11, no. 2, pp. 18-33, 2020.

[32] S. Grama-Vigouroux et al., "Drivers and barriers of national innovation ecosystems for implementing Sustainable Development Goals: A Latvian case study," *IEEE Trans. Eng. Manag.*, 2023.

[33] C. Wang et al., "Agricultural disaster risk management and capability assessment using big data analytics," *Big Data*, vol. 10, no. 3, pp. 246-261, 2022.

[34] P. Yang and W. Sun, "How does digital technology facilitate the green innovation of enterprises? Evidence from China," *Int. Rev. Appl. Econ.*, vol. 37, no. 5, pp. 621-641, 2023.