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GREEN STRUCTURAL TRANSFORMATION IN UZBEKISTAN: GREEN FINANCE AND ECO-INNOVATION FOR SUSTAINABLE INDUSTRIAL AND AGRICULTURAL DEVELOPMENT

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Abstract: The article examines sustainable development and green structural transformation in Uzbekistan with a focus on two core pillars: the rapid emergence of green finance and the diffusion of eco-innovation across industrial and agricultural value chains. Drawing on official statistics, international reports (World Bank, UNDP, OECD) and the latest sectoral data, the study analyzes the development of thematic bonds, institutional reforms in public finance, and the modernization of agro-food systems. Since 2021, Uzbekistan has issued more than USD 1.2 billion in sovereign thematic bonds, including its first sovereign green Eurobonds in 2023, accompanied by the placement of 4.25 trillion UZS in local-currency green bonds. In the agro-food sector, annual fruit and vegetable production exceeds 22–23 million tonnes, but only 10–15% is processed and 20–30% is lost post-harvest due to insufficient storage and logistics infrastructure. The study uses institutional analysis, sectoral statistics and a SWOT-type interpretative approach. The findings show that Uzbekistan has established a relatively advanced green-growth policy architecture and an emerging green-finance ecosystem; however, structural challenges persist in industrial modernization, circular-economy development and post-harvest value retention. The article concludes that long-term competitiveness will depend on scaling up green finance, accelerating eco-innovation in industry and agriculture, and strengthening institutional coordination within a coherent green-growth framework.

Key words: green economy; green structural transformation; sustainable development; green finance mechanisms; sovereign green bonds; SDG bonds; climate-aligned investment; sustainable public finance; eco-innovation; industrial modernization; Uzbekistan.

Annotatsiya: Maqolada O'zbekistonda barqaror rivojlanish va yashil tarkibiy transformatsiya ikki asosiy yo'nalishda — yashil moliyalashtirish hamda sanoat va qishloq xo'jaligida eko-innovatsiyalarni joriy etish kesimida tahlil qilinadi. Rasmiy statistika, Jahon banki, UNDP va OECD hisobotlari asosida tematik obligatsiyalar bozori, davlat moliyasi institutsional islohotlari, shuningdek agro-ozuq-ovqat tizimlarining modernizatsiyasi o'rganiladi. 2021–2024-yillarda O'zbekiston 1,2 mlrd AQSh dollaridan ortiq SDG va "yashil" toifadagi suveren obligatsiyalarni, 2023-yilda esa ilk "yashil" xalqaro evrobondlarni va 4,25 trln so'mlik milliy valyutadagi yashil obligatsiyalarni joylashtirdi. Yiliga 22–23 mln tonna mevasabzavot yetishtirilayotgan bo'lsa-da, sanoat qayta ishlash ulushi atigi 10–15 foizni tashkil etadi, 20–30 foiz hosil esa saqlash va logistika yetishmovchiligi sababli yo'qotilmoqda. Tadqiqot SWOT yondashuvi asosida amalga oshirilib, O'zbekistonda yashil o'sish uchun ilg'or normativ-huquqiy baza shakllangan bo'lsa-da, sanoat va qishloq xo'jaligida tarkibiy modernizatsiya hamda aylanish iqtisodiyoti bo'yicha muammolar mavjudligi aniqlanadi. Xulosa qilinishicha, uzoq muddatli raqobatbardoshlik yashil moliyalashtirishni kengaytirish, eko-innovatsiyalarni jadallashtirish va institutsional muvofiqlikni kuchaytirishga bog'liq bo'ladi.

Kalit so'zlar: yashil iqtisodiyot; yashil tarkibiy transformatsiya; barqaror rivojlanish; yashil moliyalashtirish mexanizmlari; suveren yashil obligatsiyalar; SDG obligatsiyalari; iqlimga mos investitsiyalar; barqaror davlat moliyasi; eko-innovatsiyalar; sanoatni modernizatsiya qilish; O'zbekiston.

Аннотация: В статье исследуются устойчивое развитие и зелёная структурная трансформация Узбекистана через два ключевых направления: становление зелёного финансирования и распространение эко-инноваций в промышленности и сельском хозяйстве. Используя официальную статистику, отчёты международных организаций и отраслевые данные, автор анализирует выпуск суверенных зелёных облигаций, реформы бюджетного планирования и модернизацию агропродовольственных цепочек. В 2021–2024 годах Узбекистан разместил более 1,2 млрд долларов в суверенных облигациях категорий SDG и Green, включая первый выпуск суверенных зелёных евробондов в 2023 году и 4,25 трлн сумов внутренних зелёных облигаций. При этом в аграрном секторе ежегодно производится 22–23 млн тонн плодоовощной продукции, но перерабатывается лишь 10–15%, а 20–30% теряется на этапах хранения и транспортировки. Результаты подчёркивают, что, несмотря на развитую стратегическую базу зелёного роста, сохраняются структурные барьеры — низкая глубина переработки, недостаточное применение циркулярных решений и технологическая отсталость части предприятий. В заключение показано, что долгосрочная конкурентоспособность Узбекистана будет зависеть от расширения зелёного финансирования, внедрения эко-инноваций и усиления институциональной согласованности.

Ключевые слова: зелёная экономика; зелёная структурная трансформация; устойчивое развитие; механизмы зелёного финансирования; суверенные зелёные облигации; облигации SDG; климатически ориентированные инвестиции; устойчивые государственные финансы; эко-инновации; модернизация промышленности; Узбекистан.

INTRODUCTION

Green structural transformation has become one of the central conceptual frameworks for rethinking development models in emerging economies. According to analytical reports of the OECD and UNEP, the notion of green structural transformation describes a systemic shift from resource-intensive and environmentally unsustainable production patterns toward innovation-driven, low-waste and institutionally coordinated models of economic growth [1]. This paradigm integrates sustainability principles into the core of economic modernization and requires reforms in public finance, industrial upgrading, and technological diffusion, as emphasized in global sustainable-development frameworks [2].

In Uzbekistan, the institutional foundations for such a transformation were formally established through the Strategy for the Transition to a Green Economy for 2019–2030, which defines the restructuring of production systems, the development of sustainable finance mechanisms, and the modernization of industrial and agricultural sectors as national development priorities [3]. This strategic orientation is aligned with the United Nations 2030 Agenda for Sustainable Development and reflects the international consensus that long-term economic competitiveness depends on the capacity of states to integrate innovation, environmental management, and financial sustainability into their policy architecture [4].

One of the most significant domains of Uzbekistan's green transformation is the rapid development of green finance. Since 2021, the country has entered the international thematic bond market, issuing sovereign Sustainable Development Goals (SDG) bonds and, subsequently, its first sovereign green bonds, thereby demonstrating institutional readiness to channel public finance toward sustainability-related investment priorities [5]. International assessments by the World Bank and UNDP underscore that the expansion of green finance is a prerequisite for structural modernization, as it provides long-term capital for environmentally responsible projects and strengthens the alignment of fiscal policy with sustainable development goals [6].

An equally important dimension of green structural transformation in Uzbekistan is the diffusion of eco-innovation in industry and agriculture. Empirical data from FAO and the Ministry of Agriculture indicate that Uzbekistan produces more than 22–23 million tonnes of fruits and vegetables annually, yet the depth of industrial processing remains limited – approximately 10–15% – while post-harvest losses reach 20–30% due to outdated logistics, insufficient storage capacity, and technological gaps in supply-chain management [7]. These inefficiencies highlight the need for modernization of agro-industrial value chains through resource-efficient technologies, circular-economy practices, digital traceability systems, and innovation-based production models. Such approaches are consistent with the recommendations of UNIDO, which emphasizes eco-innovation as a critical driver of competitiveness, productivity, and sustainability in developing economies [8].

The scientific relevance of this study arises from the need to analyze how Uzbekistan is operationalizing the principles of green structural transformation through two interdependent mechanisms: green finance and eco-innovation in industry and agriculture. A comprehensive assessment of institutional reforms, financial instruments, and technological modernization processes provides a deeper understanding of the structural shifts currently underway in the national economy. Furthermore, this research contributes to the broader academic discourse on sustainable economic development by identifying the opportunities and constraints associated with Uzbekistan's transition toward a green and innovation-oriented growth model.

REVIEW OF LITERATURE ON THE SUBJECT

The concept of green structural transformation has evolved into a central analytical framework for understanding how emerging economies can shift toward sustainable, innovation-driven development. The intellectual foundations of this paradigm were shaped by scholars such as Dani Rodrik, who demonstrated that structural transformation requires reallocating resources toward higher-productivity sectors while simultaneously embedding environmental considerations into industrial policy. OECD and UNEP studies reinforce this view by emphasizing that environmentally oriented industrial restructuring must integrate technological upgrading, efficient resource use and long-term institutional reforms to achieve sustainable competitiveness.

Within this broader discourse, green finance has emerged as a critical driver for structural modernization. Research by Nicholas Stern, the World Bank and the IMF shows that transitioning to low-carbon and resource-efficient economies depends heavily on mobilizing targeted financial flows through instruments such as green bonds, sustainability-linked loans and blended-finance facilities. Empirical studies by scholars including Wang, Zeng and Broadstock find that green bonds contribute to lower capital costs for environmentally oriented firms, support the expansion of renewable-energy projects and improve long-term environmental performance. Furthermore, reports by the Climate Bonds Initiative and the European Investment Bank highlight that the effectiveness of green-finance mechanisms depends on transparent taxonomies, credible verification systems and institutional coordination between financial regulators and market participants.

Eco-innovation forms the second critical dimension of green structural transformation. Theoretical contributions by Horbach, Rennings and Del Rio conceptualize eco-innovation as a multifaceted process that reduces environmental impact through technological, organizational and systemic changes. These scholars argue that eco-innovation diffusion is influenced by regulatory incentives, market demand, technological capabilities and the absorptive capacity of firms. Empirical evidence from studies conducted by the European Environment Agency and UNIDO shows that eco-innovation exerts a significant positive effect on energy efficiency, industrial productivity and supply-chain resilience. In the agricultural sector, research by Fuglie, Pingali and the FAO demonstrates that eco-innovative technologies—such as precision agriculture, post-harvest loss reduction systems and climate-smart farming—substantially enhance resource efficiency and reduce ecological pressure in developing economies.

Several scholars have explored the interplay between green finance and eco-innovation. Studies by OECD, Aghion, Dechezleprêtre and Johnstone conclude that access to sustainable finance accelerates technological innovation by reducing risk for green R&D, enabling firms to invest in clean technologies and strengthening national innovation systems. The European Bank for Reconstruction and Development provides complementary evidence that targeted green-finance programs stimulate eco-innovation particularly in countries with developing financial markets and early-stage industrial modernization.

In the context of Uzbekistan, research by the World Bank, UNDP, ADB and national think tanks indicates that the country's transition to a green economy requires coordinated reforms in finance, industrial upgrading and agricultural modernization. Analysis of Uzbekistan's sovereign green bonds and thematic debt instruments shows that the financial sector is becoming an increasingly important platform for funding low-carbon infrastructure and sustainable agri-food systems. UNDP and FAO assessments also highlight that eco-innovation adoption remains uneven across industrial and agricultural enterprises, largely due to structural constraints such as limited access to credit, skill shortages and gaps in technological diffusion. These studies converge on the conclusion that Uzbekistan's green structural transformation will depend on strengthening financial mechanisms for sustainability, accelerating innovation diffusion and ensuring integration across value chains.

Overall, the global scientific literature demonstrates that green finance and eco-innovation are mutually reinforcing pillars of sustainable development. For Uzbekistan, aligning financial reforms with targeted industrial and agricultural innovation policies offers a coherent pathway for achieving long-term green structural transformation and improving national environmental and economic resilience.

RESEARCH METHODOLOGY

The methodological architecture of this study is grounded in the theoretical and empirical principles of sustainable-development economics, green-growth diagnostics, and structural-transformation analysis. The research adopts a multilevel analytical model, integrating institutional, financial, sectoral and technological dimensions of Uzbekistan's green transformation. This framework corresponds to the methodological guidelines of the OECD Green Growth Strategy [1], UNDP Green Finance Platform [2] and FAO–UNIDO approaches to agro-industrial system modernization [3].

The empirical foundation of the study is constructed exclusively from authoritative and verifiable sources. National-level data were obtained from the Strategy for Transition to a Green Economy (2019–2030), official reporting of the Ministry of Economy and Finance, and statistical compendiums of the Ministry of Agriculture. International sources include OECD green-growth diagnostics, UNDP assessments of green-finance readiness, FAO datasets on agro-food systems, and World Bank analytical reports on structural reforms [4].

To ensure methodological reliability, all data were systematically cross-validated. The research uses a 2015–2024 temporal frame, reflecting the decade in which Uzbekistan institutionalized and operationalized its green-development agenda (Table 1).

Table 1. Data Sources Used in the Research (OECD (2020), UNDP (2021), FAO (2023), World Bank (2022))

<i>Source Category</i>	<i>Institution</i>	<i>Type of Data</i>	<i>Relevance to Research</i>
National strategies & regulatory frameworks	Government of Uzbekistan	Green economy strategy, institutional reforms	Analysis of policy architecture and institutional transformation
Sectoral statistics	Ministry of Agriculture	Production volumes, losses, processing ratios	Eco-innovation, value-chain performance
Financial data	Ministry of Economy and Finance	Green bonds, SDG bonds, public finance	Green-finance mechanisms, investment flows
International reports	OECD, UNDP, FAO, World Bank	Green growth, sustainable finance, agro-systems	Comparative analysis, methodological benchmarks

Institutional and policy analysis forms the first methodological pillar of the research and provides the conceptual foundation for understanding the systemic dynamics of Uzbekistan's green structural transformation. Within this analytical block, the study investigates how governance architectures, regulatory instruments and public-finance mechanisms interact to shape the national transition toward sustainable development. Particular attention is given to the degree of coherence between overarching national strategies – such as the Strategy for Transition to a Green Economy – and sector-specific programs in agriculture, industry and public finance. This allows the identification of institutional complementarities and potential inconsistencies that may hinder or accelerate the implementation of green-growth objectives.

A core component of this institutional assessment is the evaluation of the country's readiness for green budgeting, which involves examining the extent to which sustainability principles are embedded in budget-planning cycles, expenditure tagging systems and fiscal-allocation procedures. Equally important is the analysis of allocation mechanisms governing green-labelled expenditures, as their effectiveness determines whether financial resources are directed toward genuinely transformative, environmentally responsible activities. The study further explores how sustainability criteria are integrated into decision-making processes within public-finance management, including investment prioritization, monitoring frameworks and accountability mechanisms. Methodologically, this institutional inquiry follows international diagnostic standards developed by the OECD Institutional Mapping Framework and the UNDP Green Finance Readiness Assessment [5], ensuring the analytical rigor and comparability of findings.

The second methodological pillar is constituted by structural and sectoral analysis, an essential tool for examining transformation processes in industrial and agro-industrial systems. This analytical approach enables the study to uncover the underlying structural characteristics of Uzbekistan's production sectors, including the configuration of agro-industrial value chains, the depth and quality of technological modernization, and the systemic efficiency of post-harvest processes. By focusing on these structural attributes, the research evaluates how existing production systems either contribute to or constrain the diffusion of eco-innovations across the economy.

Following the methodological guidelines of FAO and UNIDO, the analysis investigates the degree of integration within agro-industrial chains, identifying points of fragmentation that lead to inefficiencies, elevated post-harvest losses and reduced value-added generation. The technological dimension is examined through the assessment of equipment modernization, production-process upgrading and the adoption of environmentally responsible technologies across enterprises. Furthermore, the study evaluates resource productivity through indicators such as waste intensity, loss ratios and material efficiency, which provide an empirical basis for identifying sustainability gaps. Particular emphasis is placed on understanding innovation-diffusion patterns within enterprises and clusters, as the uneven adoption of eco-innovations reflects deeper structural constraints related to access to finance, human capital and institutional support.

Taken together, this structural and sectoral analysis provides a comprehensive view of modernization needs and eco-innovation priorities across key segments of Uzbekistan's industrial and agricultural systems, laying the groundwork for informed policy recommendations and strategic planning (Table 2).

Table 2. Analytical Dimensions of Sectoral and Structural Analysis (FAO (2022), UNIDO (2022), OECD Green Growth Analytical Framework (2011), World Bank (2022))

Dimension	Indicator Group	Analytical Purpose
Value-chain structure	Processing ratio, logistical capacity	Identify structural bottlenecks
Technological modernization	Equipment age, innovation adoption	Assess eco-innovation diffusion
Resource efficiency	Waste levels, post-harvest losses	Evaluate sustainability performance
Institutional–market integration	Access to finance, cluster linkages	Assess structural competitiveness

Statistical and comparative analysis constitutes the third methodological foundation of the study, enabling the systematic examination of quantitative trends and structural patterns within Uzbekistan's green transformation. This analytical component is grounded in internationally recognized quantitative methodologies adopted by the World Bank, OECD and FAO, which emphasize the use of coherent, cross-validated, and multi-source datasets as the basis for empirical evaluation [6]. The statistical dimension of the analysis employs descriptive indicators to trace the dynamics of production volumes, industrial processing depth, post-harvest loss rates, and the scale and structure of green finance instruments. These indicators allow for the identification of temporal trends, structural shifts, and anomalies that reflect underlying changes in sectoral performance and institutional behavior.

In addition to descriptive statistics, a comparative analytical framework is applied to position Uzbekistan's progress within a broader international context. This involves benchmarking key national indicators against those of comparable developing economies undergoing similar agricultural and industrial modernization processes. Such comparison provides insight into relative performance, enabling the detection of structural asymmetries, competitiveness gaps, and best-practice trajectories that may inform policy refinement. By juxtaposing domestic and international datasets, the analysis reveals the extent to which Uzbekistan's green transformation aligns with global patterns of sustainable economic development.

Furthermore, the comparative component is used to assess the efficiency and effectiveness of green finance mechanisms in mobilizing investment toward environmentally significant sectors. Through the examination of international cases – consistent with the methodological approach recommended in World Bank cross-country diagnostics – the study interprets Uzbekistan's progress not as an isolated phenomenon but as part of a global trend toward climate-aligned and sustainability-oriented investment ecosystems. The combination of statistical rigor and comparative evaluation ensures the analytical depth necessary for understanding both the achievements and unresolved challenges in Uzbekistan's pathway toward green structural transformation.

ANALYSIS AND RESULTS

The empirical results of the study indicate that Uzbekistan has entered a decisive phase of green structural transformation, characterized by the institutionalization of sustainable public finance instruments and the gradual integration of eco-innovation within industrial and agricultural production systems. The data demonstrate that the development of green finance mechanisms has progressed more rapidly than technological modernization in real sectors, resulting in an asymmetric but strategically significant pattern of transformation. This asymmetry aligns with broader global trends, in which financial reforms precede structural modernization, as documented in OECD and UNDP transition studies [1].

Evidence collected from national financial reports and international assessments confirms that Uzbekistan has successfully established the foundations for a thematic finance ecosystem. Since 2021, the country has issued more than USD 1.2 billion in sovereign SDG- and green-labelled bonds, marking a substantial institutional breakthrough in aligning public expenditures with sustainability criteria [4]. The issuance of the first sovereign green Eurobonds in 2023 and the placement of 4.25 trillion UZS in local-currency green bonds reflect an emerging financial architecture capable of mobilizing long-term capital for environmentally oriented reforms.

Furthermore, the entry of corporate actors – such as Agrobank with its USD 455 million green Eurobond package – demonstrates the diffusion of sustainability principles beyond public institutions into the private-sector financial landscape. Comparative analysis with thematic-bond markets in developing countries indicates that Uzbekistan's trajectory is consistent with global patterns of sustainable finance expansion, where early adoption of green bonds serves as a catalyst for further institutional and market development (Table 3) [6].

Table 3. Key Indicators of Green Finance Development in Uzbekistan (World Bank (2022), UNDP (2023), OECD (2020))

Indicator	Value / Evidence	Source
Sovereign SDG & Green bonds issued (2021–2024)	USD 1.2 billion	[4]
First sovereign green Eurobonds (2023)	Yes	[4]
Domestic green bonds issued (national currency)	4.25 trillion UZS	[4]
Corporate green Eurobonds (Agrobank)	USD 455 million	[4]
Institutional frameworks	Green Budget Guidance; SDG Financing Framework	[5]

The empirical evaluation indicates that Uzbekistan's advancement in green finance demonstrates a promising structural trajectory. The rapid institutionalization of green-finance frameworks, despite their recent introduction into the national financial architecture, reflects the system's adaptability and the growing capacity of financial institutions to operationalize sustainability principles. Furthermore, the emergence of green budgeting practices shows a gradual but measurable alignment of public-expenditure processes with sustainability criteria, consistent with UNDP methodological guidelines [2]. This dynamic suggests that the integration of environmental priorities into fiscal governance is likely to strengthen in the upcoming policy cycles.

Sectoral and structural assessments demonstrate that Uzbekistan's agricultural and agro-industrial systems possess considerable potential for technological upgrading and efficiency enhancement. With annual fruit and vegetable production exceeding 22–23 million tonnes, the current level of industrial processing and storage capacity offers substantial room for expansion. According to FAO and Ministry of Agriculture data, increasing the share of processed output and modernizing storage and logistics systems will enable the sector to unlock significant value-added potential and support the transition toward sustainable, innovation-oriented production models [7]. These trends indicate favorable conditions for future productivity gains and stronger integration into global agri-food value chains.

The diffusion of eco-innovations across industries demonstrates differentiated but steadily improving patterns. Large enterprises are already adopting advanced resource-efficient technologies, waste-valorization solutions and digital traceability systems, which can serve as reference points for broader technological modernization. For small and medium enterprises, the existing transformation trajectory highlights the opportunity to accelerate modernization through targeted financial instruments, expanded capacity-building programs and improved access to knowledge-intensive technologies. These directions are consistent with UNIDO's analytical perspectives and suggest that Uzbekistan's innovation landscape is positioned for more balanced and inclusive technological growth over the medium term (Table 4) [8].

Table 4. Structural Performance Indicators of Agro-Industrial Systems (UNIDO 2022)

Indicator	Observed Trend	Source
Annual horticultural production	22–23 million tonnes	[7]
Industrial processing depth	10–15%	[7]
Post-harvest losses	20–30%	[7]
Adoption of eco-innovation technologies	High in large enterprises; low in SMEs	[8]
Value-chain integration	Fragmented, low processing density	[7]

These results indicate that the existing agro-industrial structure in Uzbekistan is functionally productive but structurally sub-optimal. The majority of value-added potential remains unrealized, primarily due to limited modernization of post-harvest systems, fragmented logistics and insufficient diffusion of eco-innovations. Comparative analysis demonstrates that Uzbekistan's performance is consistent with the developmental trajectories of middle-income economies transitioning toward innovation-driven agro-industrial systems [6].

Taken together, the results across institutional, financial and sectoral dimensions demonstrate that Uzbekistan's green structural transformation is unfolding along two interdependent but uneven trajectories:

1. The financial architecture is transforming rapidly – green bonds, SDG bonds and sustainability-aligned budgeting are expanding at a pace comparable to advanced emerging economies.
2. Real-sector modernization is progressing gradually, constrained by technological gaps, fragmented value chains and limited eco-innovation diffusion.

This dual trajectory reflects a broader structural pattern identified in sustainable-development literature: financial mechanisms often mature earlier than industrial and agricultural modernization due to lower capital requirements, faster institutional adoption rates and stronger support from international partners [1].

Nevertheless, the results clearly show that Uzbekistan has already established the core pillars necessary for long-term sustainable transformation. The challenge now lies in strengthening the interface between green finance and eco-innovation, ensuring that financial instruments effectively catalyze modernization processes across production systems.

The results of the study demonstrate that Uzbekistan's green structural transformation is advancing along an uneven but strategically coherent trajectory, in which financial modernization significantly outpaces technological and industrial upgrading. This asymmetry is not unique to Uzbekistan; it reflects a general pattern observed in transition economies, where institutional and fiscal reforms require fewer physical resources and therefore progress more rapidly than real-sector modernization. In this sense, the development of green finance mechanisms serves as a precursor rather than a culmination of structural transformation. The rapid institutionalization of sustainable-finance instruments indicates that the country has reached an important threshold of financial readiness, laying the groundwork for long-term investment flows into environmentally significant sectors.

The discussion of results indicates that Uzbekistan's agro-industrial sector, a core component of national economic development, is entering a phase with considerable opportunities for deepening modernization. Expanding processing capacity, improving post-harvest management and strengthening the integration of innovative practices into production processes represent areas with strong potential for value-added growth. Enhancing technological capacity across storage, logistics and distribution systems will support the transition toward more sustainable agricultural practices and help the sector realize a greater share of its inherent economic value. Current differences in innovation adoption between large enterprises and SMEs highlight a valuable opportunity for targeted modernization programs aimed at broadening technological upgrading across the entire sector.

Within this context, the diffusion of eco-innovation emerges as a central factor shaping the long-term progress of green structural transformation. Although the institutional and financial foundations for eco-innovation are steadily expanding, further strengthening mechanisms that widen access to finance for smaller enterprises, enhance skills development and foster dynamic innovation ecosystems will accelerate progress. As value-chain integration improves, coordinated modernization efforts are expected to reduce accumulated inefficiencies and enhance the overall performance of production and distribution networks.

The analysis also underscores that aligning green finance with real-sector modernization offers a promising pathway for amplifying the transformative impact of ongoing reforms. Uzbekistan's launch of sovereign green bonds, SDG bonds and domestic green financial instruments demonstrates strong institutional commitment. The next stage involves expanding the pipeline of bankable green projects, refining eligibility taxonomies, reinforcing monitoring frameworks and enhancing enterprise capacity to effectively utilize sustainability-oriented investments. Strengthening these institutional and technological linkages will allow green finance to evolve into a fully integrated driver of industrial transformation.

A broader conceptual insight arising from the discussion is that Uzbekistan's green structural transformation represents the early formation of a comprehensive development paradigm. The emergence of green budgeting practices, the growing integration of sustainability criteria into public-finance management and the progressive modernization of agro-industrial systems illustrate a systemic shift toward innovation-driven and environmentally responsible economic governance aligned with global models of sustainable restructuring.

The long-term sustainability of this trajectory will benefit from accelerating eco-innovation diffusion, expanding cross-sector modernization and strengthening institutional mechanisms that connect financial resources with technological upgrading. By deepening these intersections, Uzbekistan can build a cohesive green-growth model that enhances productivity, reduces resource losses, supports climate resilience and elevates the competitiveness of national industries.

Overall, the discussion suggests that Uzbekistan is moving confidently toward a modern, sustainability-oriented development framework. The continued harmonization of green finance, technological modernization and institutional reforms will enable the country to consolidate initial achievements into a stable, innovation-based and internationally competitive green transformation model.

CONCLUSIONS AND SUGGESTIONS

The findings of this study demonstrate that Uzbekistan's green structural transformation is unfolding as a multidimensional and institutionally driven process in which financial innovation is advancing more rapidly than technological modernization in the real sectors of the economy. The emergence of a national ecosystem of

green finance – supported by sovereign SDG and green bonds, the introduction of green-budgeting elements, and the growing participation of corporate actors – indicates that the financial architecture of the country is increasingly aligned with global standards of sustainability-oriented economic governance. This establishes a stable foundation for mobilizing long-term capital toward structural modernization and environmentally responsible development.

At the same time, the empirical evidence reveals that eco-innovation diffusion within industrial and agricultural systems remains uneven and constrained by structural bottlenecks. Limited processing depth, elevated post-harvest losses, fragmented value chains, and pronounced technological disparities between large enterprises and small and medium-sized firms hinder the transition toward resource-efficient and innovation-driven production models. These findings underscore that financial modernization alone is insufficient to ensure transformative change; rather, it must be complemented by systematic technological upgrading, improved logistics and storage infrastructure, and integrated innovation ecosystems capable of supporting broad-based modernization.

In conceptual terms, Uzbekistan's trajectory reflects the early stages of a transition from a resource-intensive development model toward a sustainability-oriented, innovation-based growth paradigm. The coherence of national strategies, the commitment to institutional reform, and the establishment of green-financial instruments collectively indicate that the foundations of this shift are already in place. The decisive challenge now lies in operationalizing these frameworks in ways that accelerate eco-innovation, enhance productivity, reduce losses, and foster the emergence of integrated, modernized value chains.

In conclusion, Uzbekistan has made significant progress in constructing the institutional and financial pillars of green structural transformation. To fully realize the potential of this transition, it is imperative to reinforce technological modernization, strengthen linkages between green finance and real-sector innovation, and promote systemic integration across industrial and agricultural domains. Achieving this alignment will enable the country to consolidate its early achievements and advance toward a stable, competitive and sustainable economic model aligned with international standards of green growth.

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