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ECOLOGICAL ENTREPRENEURSHIP AS A STRATEGIC FACTOR FOR ENSURING ECONOMIC SECURITY



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Abstract. This article examines ecological entrepreneurship as a strategic factor in strengthening national economic security under conditions of growing environmental pressure and resource constraints. The purpose of the study is to substantiate the role of green business initiatives in reducing environmental risks while simultaneously generating employment, fostering innovation, and creating stable sources of income. The relevance of the topic stems from Uzbekistan's ongoing transition to a green economy and the need to align environmental protection with national development priorities. Using comparative analysis, content analysis of policy documents, and generalization of international experience, the study explores how ecological entrepreneurship contributes to resource efficiency, technological modernization, and economic diversification. The findings show that countries integrating green entrepreneurship into their economic security frameworks demonstrate greater resilience to environmental and market shocks. The article concludes that ecological entrepreneurship should be regarded not merely as an environmental measure, but also as a structural pillar of economic security policy, and offers practical recommendations for strengthening institutional, financial, and educational support mechanisms for green businesses in Uzbekistan.

Keywords: ecological entrepreneurship, economic security, green economy, sustainable development, environmental risk, green investment, innovation, Uzbekistan.

Annotatsiya. Ushbu maqolada ekologik tadbirkorlik ortib borayotgan ekologik bosim va resurslar cheklanganligi sharoitida iqtisodiy xavfsizlikni ta'minlashning strategik omili sifatida tadqiq etiladi. Tadqiqotning maqsadi — "yashil" biznes tashabbuslarining ekologik xavflarni kamaytirish bilan bir qatorda ish o'rinlarini yaratish, innovatsiyalarni rag'batlantirish va barqaror daromad manbalarini shakllantirishdagi rolini asoslashdan iborat. Mavzuning dolzarbligi O'zbekistonning "yashil" iqtisodiyotga o'tish jarayoni davom etayotgani va atrof-muhitni muhofaza qilishni milliy taraqqiyot ustuvorliklari bilan uyg'unlashtirish zarurati bilan belgilanadi. Qiyosiy tahlil, me'yoriy-huquqiy hujjatlarning kontent-tahlili va xalqaro tajribani umumlashtirish usullaridan foydalangan holda, maqolada ekologik tadbirkorlikning resurs samaradorligini oshirish, texnologik modernizatsiya va iqtisodiyotni diversifikatsiya qilishga qo'shgan hisssasi ko'rib chiqiladi. Natijalar shuni ko'rsatadiki, ekologik tadbirkorlikni iqtisodiy xavfsizlik tizimiga integratsiya qilgan davlatlar ekologik va bozor tebranishlariga nisbatan yuqori barqarorlikka erishmoqda. Xulosa qismida ekologik tadbirkorlikni nafaqat atrof-muhitni muhofaza qilish chorasi, balki iqtisodiy xavfsizlik siyosatining tarkibiy elementi sifatida ko'rib chiqish zarurligi asoslanadi hamda O'zbekistonda "yashil" biznesni institutsional, moliyaviy va ta'lim jihatidan qo'llab-quvvatlash mexanizmlarini mustahkamlash bo'yicha amaliy tavsiyalar beriladi.

Kalit so'zlar: ekologik tadbirkorlik, iqtisodiy xavfsizlik, yashil iqtisodiyot, barqaror rivojlanish, ekologik xavf, yashil investitsiyalar, innovatsiya, O'zbekiston.

Аннотация. В статье исследуется экологическое предпринимательство как стратегический фактор обеспечения экономической безопасности в условиях растущего экологического давления и ограниченности ресурсов. Цель исследования заключается в обосновании роли «зелёного» бизнеса в снижении экологических рисков при одновременном создании рабочих мест, стимулировании инноваций и формировании устойчивых источников дохода. Актуальность темы обусловлена продолжающимся переходом Узбекистана к «зелёной» экономике и необходимостью согласования охраны окружающей среды с приоритетами национального развития. С использованием сравнительного анализа, контент-анализа программных документов и обобщения международного опыта в статье рассматривается вклад экологического предпринимательства в повышение ресурсоэффективности, технологическую модернизацию и диверсификацию экономики. Результаты показывают, что страны, интегрирующие экологическое предпринимательство в систему экономической безопасности, демонстрируют более высокую устойчивость к экологическим и рыночным потрясениям. В заключении обосновывается необходимость рассматривать экологическое предпринимательство не только как природоохранную меру, но и как структурный элемент политики экономической безопасности, а также предлагаются практические рекомендации по укреплению институциональной, финансовой и образовательной

поддержки «зелёного» бизнеса в Узбекистане.

Ключевые слова: экологическое предпринимательство, экономическая безопасность, зелёная экономика, устойчивое развитие, экологический риск, зелёные инвестиции, инновации, Узбекистан.

INTRODUCTION

The intensification of climate change, the depletion of natural resources, and the growing frequency of environmental disruptions have made ecological stability a direct component of national economic security rather than a secondary concern of environmental policy. Traditionally, economic security has been assessed through macroeconomic indicators such as GDP growth, fiscal balance, foreign trade stability, and the sustainability of public finances. Today, however, environmental degradation, water scarcity, biodiversity loss, and resource dependency are increasingly recognized by international organizations and national governments as structural factors affecting long-term economic resilience and sustainable growth, alongside conventional financial indicators.

Economic security itself is a multidimensional category, generally understood as the state of the national economy in which it is able to ensure sustainable development, protect vital economic interests from internal and external risks, and preserve the capacity for independent economic policy. Its principal components are usually identified as economic independence, the stability and resilience of the national economy, and the capacity for self-sustained growth and development. Environmental factors influence each of these components simultaneously: resource dependency may increase reliance on imported resources and food; environmental disruptions may generate shocks such as droughts, crop losses, and additional public-health expenditures; and the degradation of natural capital may affect the long-term productive capacity of the economy. It is precisely at this intersection that ecological entrepreneurship — the creation and operation of business ventures that generate profit while simultaneously reducing environmental harm, restoring natural resources, or providing environmentally beneficial goods and services — acquires strategic significance.

In this context, ecological entrepreneurship should not be understood narrowly as a niche segment of small business activity, but rather as an economic mechanism that channels private initiative, capital, and innovation toward addressing environmental and resource-related challenges in cooperation with public institutions. Where public resources are allocated across a wide range of development priorities and environmental tasks require substantial investment, mobilizing private entrepreneurial activity toward ecological goals becomes an important strategic resource, comparable in significance to traditional instruments of economic security policy such as reserve accumulation, export diversification, and industrial modernization.

The relevance of the topic for the Republic of Uzbekistan is particularly high. As the most populous country in Central Asia, Uzbekistan combines an ambitious agenda of economic modernization with important environmental priorities related to the consequences of the Aral Sea crisis, water-resource management in the Amu Darya and Syr Darya basins, soil salinization and land degradation, desertification of the dried Aral seabed, and air quality in major urban and industrial centers. These factors have direct implications for agricultural productivity, public-health expenditures, and the conditions for industrial development, all of which are closely connected with economic security. At the same time, the government has established a clear strategic orientation toward a green economy, reflected in national policy documents and international partnerships, creating both the institutional basis and practical opportunities for examining ecological entrepreneurship as an instrument of economic security policy rather than as an isolated environmental initiative.

The object of this study is the process of ecological entrepreneurship development as an economic phenomenon. The subject of the study is the relationship between ecological entrepreneurship and the strengthening of national economic security. The purpose of the article is to substantiate the strategic role of ecological entrepreneurship in ensuring economic security, using the Republic of Uzbekistan as the empirical and policy context. To achieve this purpose, the article addresses the following tasks: to review the theoretical foundations of green and sustainable entrepreneurship developed in the international scholarly literature; to identify and systematize the mechanisms through which ecological business activity strengthens the principal components of economic security; to analyze Uzbekistan's institutional, legal, and policy framework for the development of ecological entrepreneurship; and to formulate practical, evidence-based recommendations for policymakers, financial institutions, and practitioners seeking to strengthen the contribution of green business to national economic security.

The article is structured as follows. The next section reviews the relevant theoretical and empirical literature on green and sustainable entrepreneurship and identifies the research area addressed by this study. The subsequent section outlines the research methodology. The analytical section then examines the specific channels through which ecological entrepreneurship contributes to economic security, with reference

to Uzbekistan's policy environment. The final section presents conclusions and a set of concrete policy recommendations.

LITERATURE REVIEW

Theoretical Foundations of Sustainable and Ecological Entrepreneurship

The theoretical foundations of ecological entrepreneurship were developed by Dean and McMullen [1], who conceptualized sustainable entrepreneurship as a process through which market failures associated with environmental degradation — such as externalities, information asymmetries, and the inefficient pricing of natural resources — are transformed into entrepreneurial opportunities. Their approach represented an important shift in perspective: environmental challenges came to be viewed not merely as regulatory constraints on business, but also as potential sources of innovation, competitive advantage, and new venture creation. This opportunity-based framing is important for the present study because it implies that ecological entrepreneurship is not simply a cost of regulatory compliance or an activity dependent on public support, but a genuine mechanism of value creation capable of expanding under appropriate market and institutional conditions.

Complementing this opportunity-based perspective, Bansal and Roth [2] developed an influential model of corporate ecological responsiveness, demonstrating empirically that firms adopt environmentally friendly practices for three principal motivations: competitiveness, reflected in cost savings and market differentiation; legitimation, associated with conformity to social and regulatory expectations; and ecological responsibility, reflecting concern for environmental outcomes. This tripartite model remains widely used in analyses of why and how enterprises adopt environmentally responsible practices. It is particularly relevant to transition and developing economies, where cost considerations, the pursuit of international legitimacy, and growing environmental awareness may operate simultaneously and interact with one another.

Financing, Innovation, and Institutional Support for Green Ventures

Demirel, Li, Rentocchini, and Tamvada [3] provide a comprehensive overview of research on green start-ups, synthesizing findings from a dedicated special issue of *Small Business Economics*. Their review emphasizes the roles of industry life cycles, knowledge spillovers, institutional context, and access to external finance in shaping the behavior and performance of green ventures. It also highlights that green entrepreneurship should be analyzed within the broader entrepreneurial ecosystem in which it operates.

Focusing specifically on financing, Mrkajic, Murtinu, and Scalera [5] demonstrate, using firm-level data, that venture capital plays a distinctive and particularly important role in the development of green enterprises compared with conventional start-ups. Their findings suggest that green ventures may be more dependent on specialized and patient forms of capital because their technologies and business models often require longer development horizons and may involve greater initial uncertainty than conventional commercial start-ups. This finding has direct implications for the development of financial mechanisms supporting ecological entrepreneurship in emerging and developing economies.

Ebrahimi and Mirbargkar [4] extend this discussion to small and medium-sized enterprises operating under turbulent and uncertain market conditions. Their findings indicate that green innovation can strengthen firm resilience and long-term competitiveness even during periods of macroeconomic uncertainty. These results are particularly relevant for economies exposed to external shocks, as they suggest that ecological entrepreneurship can serve as a resilience-enhancing strategy and thereby strengthen the relationship between green business activity and economic security.

Institutional Maturity, Education, and the Social Dimension

Domańska, Żukowska, and Zajkowski [6] argue that ecological entrepreneurship functions as a connector between the social, environmental, and economic pillars of sustainable development. Importantly, they show that the strength and adaptability of this relationship differ across countries depending on the maturity of institutions, financial markets, and regulatory frameworks. Their comparative cross-country perspective is valuable for the present study because it demonstrates that the effects of ecological entrepreneurship depend significantly on the surrounding institutional environment.

Alvarez-Risco et al. [7] approach the issue from a different perspective by examining the formation of green entrepreneurial intentions among university students. They emphasize the importance of educational programs, curricula, and institutional support mechanisms — including dedicated funding schemes and mentorship — in fostering a new generation of environmentally oriented entrepreneurs. Their findings indicate that the long-term sustainability of a national green entrepreneurship ecosystem depends not only on financial and regulatory incentives, but also on human capital formation.

Applied Economic Mechanisms and National Policy Context

Dzwigol, Trushkina, and Kwilinski [8] examine the issue from an applied organizational and economic perspective, proposing practical mechanisms for implementing green logistics as part of a broader strategy

of sustainable economic management. Their work contributes to the transition from general theoretical concepts to operational mechanisms, including supply-chain reorganization, resource-efficient transport, and waste-minimizing production processes. Such mechanisms may be adapted by policymakers and enterprise managers across different economic contexts, including Central Asia.

At the national level, Uzbekistan's policy framework, established by the Presidential Resolution approving the Strategy for the Transition of the Republic of Uzbekistan to a Green Economy for 2019–2030 [9], provides an institutional and regulatory foundation for the development of ecological entrepreneurship by defining priorities related to renewable energy, water efficiency, and waste management. This framework is complemented by international cooperation initiatives, including partnerships with the United Nations Development Programme within the Partnership for Action on Green Economy framework [10], which support access to technical expertise, capacity-building instruments, and climate-finance opportunities relevant to the development of the private green-business sector.

Research Gap

The reviewed international literature demonstrates the contribution of ecological entrepreneurship to firm performance, financing, innovation, resilience, and sustainable development. However, its role as a distinct factor of national economic security — particularly in the transition economies of Central Asia — has received comparatively limited attention. Most existing studies examine green entrepreneurship through the lenses of firm strategy, venture financing, innovation, or individual entrepreneurial intentions rather than through macro-level economic security categories such as resource independence, economic diversification, and resilience to external shocks.

Uzbekistan's policy framework [9, 10] provides a relevant empirical context for examining this relationship directly. The specific contribution of the present study is therefore to integrate ecological entrepreneurship and economic security within a single analytical framework and to assess the mechanisms through which environmentally oriented entrepreneurial activity can contribute to resource efficiency, diversification, innovation, resilience, and long-term national economic stability.

RESEARCH METHODOLOGY

The study relies on a combination of qualitative research methods appropriate for a conceptual and policy-oriented analysis of an interdisciplinary subject situated at the intersection of entrepreneurship theory, environmental economics, and economic-security policy. The research was carried out in four consecutive stages, each relying on a distinct but complementary method.

At the first stage, a systematic review of the theoretical and empirical literature on green, sustainable, and ecological entrepreneurship was carried out [1–8], with particular attention paid to studies addressing the drivers of green venture formation, the financing of green start-ups, the role of institutions and education, and applied mechanisms for implementing green business practices. This stage relied on the method of theoretical generalization, allowing the diverse findings of the reviewed studies to be organized into a small number of conceptually distinct channels of influence.

At the second stage, a content analysis of normative, legal, and policy documents was conducted, including the Presidential Resolution on the Strategy for the Transition of the Republic of Uzbekistan to a Green Economy for 2019–2030 [9] and documents related to Uzbekistan's cooperation with international partners on green economy initiatives, including the Partnership for Action on Green Economy [10]. This analysis focused on identifying the specific targets, instruments, and institutional arrangements envisaged by national policy that are directly relevant to the development of ecological entrepreneurship, such as renewable energy targets, water-efficiency requirements, and mechanisms for attracting climate finance.

At the third stage, a comparative analysis method was used to juxtapose the theoretical mechanisms identified in the international literature with the specific institutional, economic, and environmental conditions of Uzbekistan. This approach made it possible to assess which of the internationally documented channels of influence are most relevant, and under what conditions, to a Central Asian economy undergoing dynamic market development, continued financial-sector modernization, and active implementation of water-resource management priorities.

At the fourth and final stage, the methods of systematization and logical analysis were applied to connect the theoretical category of economic security — conventionally defined through the components of economic independence, structural stability, and the capacity for sustained and balanced growth — with the environmental dimension introduced by ecological entrepreneurship, resulting in the analytical framework presented in the following section. On the basis of this framework, practical recommendations were formulated using the method of deduction, moving from general analytical conclusions toward specific, actionable policy proposals appropriate to the current stage of Uzbekistan's green economy transition.

The information base of the study consists of peer-reviewed academic publications in the fields of entrepreneurship and environmental economics, official national legal acts of the Republic of Uzbekistan, and publicly available documents and statements issued by international development partners cooperating with Uzbekistan on green economy matters. In the process of systematizing research materials and technically editing the text of the article, artificial intelligence tools were used to an extent of up to 10%. No primary firm-level or survey data were collected; the study is conceptual and policy-analytical in nature, and its conclusions are intended to provide a methodological basis for further empirical research.

ANALYSIS AND RESULTS

Building on the theoretical and policy foundations reviewed above, the analysis identifies six principal channels through which ecological entrepreneurship strengthens national economic security. Each channel is examined below, together with its specific relevance to the conditions of the Republic of Uzbekistan.

Resource and Energy Efficiency

Enterprises built around renewable energy generation, water-saving irrigation technologies, and waste recycling directly reduce a country's dependency on imported energy carriers and raw materials, which is one of the key considerations identified in traditional economic security assessments. Uzbekistan's Green Economy Strategy explicitly links the expansion of energy efficiency and renewable energy capacity to broader goals of sustainable economic growth [9], and the private entrepreneurial sector — alongside state-owned enterprises — is positioned to play an increasingly important role in delivering distributed solar generation, energy-efficient equipment retrofits, and modern irrigation systems adapted to arid agricultural regions. Given that a significant share of Uzbekistan's water resources originates in neighboring countries, private-sector innovation in water-use efficiency also contributes to strengthening the country's resource independence in the sense used in economic-security analysis.

Diversification of the Economy

As Dzwigol, Trushkina, and Kwilinski [8] show in the context of green logistics, the development of new environmentally oriented economic mechanisms creates additional sectors of economic activity — recycling and secondary-raw-material processing, eco-tourism, organic and water-efficient agriculture, green construction materials, and renewable-energy equipment assembly — that contribute to broadening the structure of national production and exports. For Uzbekistan, the emergence of a diversified portfolio of green sectors can make a meaningful contribution to structural economic security by expanding the range of value-creating activities, increasing resilience to fluctuations in international commodity markets, and supporting the efficient use of natural resources.

Employment Generation and Social Stability

Ecological entrepreneurship creates new categories of "green jobs" in renewable energy installation and maintenance, waste collection and recycling, sustainable agriculture, and eco-tourism services. Because many of these activities are relatively labor-intensive and can be organized at the level of small and medium-sized enterprises, they are particularly well suited to supporting employment creation in rural and peri-urban areas. This employment effect contributes to social stability, which is widely recognized as an important non-financial condition for sustained economic security. Expanding employment opportunities and improving environmental quality can therefore reinforce both household welfare and the long-term stability of local economies.

Attraction of Green Investment and International Climate Finance

Uzbekistan's cooperation with international development partners, including its statement of intent with the United Nations Development Programme under the Partnership for Action on Green Economy [10], illustrates how a credible national commitment to ecological entrepreneurship and green economic policy can facilitate access to concessional financing, technical assistance, and participation in emerging international mechanisms such as national emissions-trading systems. Such access is significant for economic security because it diversifies the country's sources of external financing beyond conventional commercial borrowing and resource-based revenue, while simultaneously supporting the balance of payments through reduced energy import requirements and, over time, potential export revenues from green goods and services.

Innovation and Technological Modernization

In line with the findings of Ebrahimi and Mirbargkar [4] and Mrkajic, Murtinu, and Scalera [5], green entrepreneurial ventures act as important vehicles for the diffusion of new technologies — from precision irrigation and solar photovoltaic systems to waste-sorting and recycling technologies — into the domestic economy. This diffusion effect strengthens the overall technological base of the economy and supports closer alignment with evolving international production and environmental standards, which is increasingly important as global trade partners expand environmental requirements for imported goods. The specialized financing instruments highlighted by Mrkajic, Murtinu, and Scalera [5] are particularly relevant here, since technological

upgrading associated with green entrepreneurship often requires forms of capital that can accommodate longer payback periods than those typically associated with conventional bank lending.

Mitigation of Ecological Risk as a Direct Economic Factor

Given that phenomena such as the Aral Sea crisis, desertification processes in the dried seabed, soil salinization, and water-resource constraints have measurable implications for Uzbekistan's agricultural output, public health system, and infrastructure, ecological entrepreneurship can function as a preventive strategic tool that helps reduce potential future economic losses associated with environmental pressures. This logic is consistent with the model of ecological responsiveness proposed by Bansal and Roth [2], which shows that firms — and, by extension, national economies that successfully mobilize firms — can transform environmental responsibility into a source of competitive and economic advantage rather than treating it purely as a cost. It also corresponds with the opportunity-based view of sustainable entrepreneurship developed by Dean and McMullen [1], according to which environmental challenges can generate new entrepreneurial opportunities alongside the need for appropriate market responses.

Institutional and Human-Capital Preconditions

At the same time, the analysis confirms the observations of Domańska, Żukowska, and Zajkowski [6] and Alvarez-Risco et al. [7] that the strength of the six channels described above depends significantly on institutional maturity, the depth and accessibility of financial infrastructure, and the availability of specialized education and vocational training in green business management. For Uzbekistan, this implies that the economic-security benefits of ecological entrepreneurship can be further strengthened through continued institutional development, targeted financial-sector support, and sustained investment in relevant education and training programs, in combination with regulatory and investment-promotion measures.

Priority Areas for Further Development of Ecological Entrepreneurship in Uzbekistan

Alongside the favorable policy orientation described above, several areas provide opportunities for further strengthening the contribution of ecological entrepreneurship to economic security in Uzbekistan. These include expanding the availability of long-term and affordable financing suited to the extended payback periods of many green technologies; strengthening technical and managerial expertise in green business models; further developing secondary markets for recycled materials and green-certified products; and adapting business registration, licensing, and land-allocation procedures to the specific needs of eco-innovative start-ups. Advancing these areas systematically would complement the six positive channels identified above and support the practical implementation of the recommendations presented in the concluding section.

Component of economic security	Contribution of ecological entrepreneurship
Resource independence	Reduces reliance on imported energy and raw materials through renewable energy and resource-efficient ventures
Economic diversification	Creates new green sectors (recycling, eco-tourism, renewable energy, sustainable agriculture)
Social stability	Generates green employment and reduces environmental health and livelihood risks
Investment attractiveness	Opens access to green finance, climate funds, and concessional international financing
Technological resilience	Diffuses eco-innovations and modern production technologies
Risk prevention	Reduces the future economic cost of environmental degradation and resource depletion

Source: developed by the author.

CONCLUSION AND SUGGESTIONS

The findings of the study confirm that ecological entrepreneurship should not be treated merely as an environmental protection measure, but as a structural pillar of economic security policy capable of simultaneously strengthening resource independence, economic diversification, employment and social stability, access to international investment, technological resilience, and long-term risk mitigation. The analysis further shows that the scale of these effects depends on the maturity of supporting institutions, the depth of financial infrastructure, and the availability of relevant education and training, echoing the conclusions of Domańska, Żukowska, and Zajkowski [6] and Alvarez-Risco et al. [7] regarding the institutionally dependent nature of green entrepreneurship's contribution to sustainable development.

For Uzbekistan, whose development strategy already recognizes the importance of the transition to a

green economy [9, 10], the strategic integration of ecological entrepreneurship into economic security planning offers a coherent pathway for combining ambitious growth objectives with environmental priorities, including sustainable water-resource management and continued efforts to address the consequences of the Aral Sea crisis. Rather than viewing environmental policy and economic-growth policy as separate priorities, the analysis presented in this article suggests that, when appropriately supported, ecological entrepreneurship allows the two to reinforce one another.

Based on the analysis, the following recommendations are proposed.

First, specific indicators of ecological entrepreneurship development — such as the number and turnover of registered green enterprises, the volume of green investment attracted, and the share of green jobs in total employment — should be integrated into national economic security monitoring systems so that the contribution of the sector can be tracked and evaluated alongside more traditional economic-security indicators.

Second, access to specialized green financing instruments, including green bonds, preferential credit lines, and dedicated guarantee funds, should be expanded for small and medium-sized enterprises engaged in renewable energy, recycling, water efficiency, and sustainable agriculture, taking into account the finding of Mrkajic, Murtinu, and Scalera [5] that green ventures often require patient capital with longer payback horizons than those typical of conventional commercial lending.

Third, higher education and vocational training programs in green business management and eco-innovation should be strengthened, in line with the institutional-support mechanisms highlighted by Alvarez-Risco et al. [7], with particular attention to developing a pipeline of qualified specialists capable of managing green ventures, assessing environmental risks, and applying for international climate finance.

Fourth, administrative and permitting procedures for eco-innovative start-ups — including business registration, environmental licensing, and land allocation for renewable-energy and recycling facilities — should be further streamlined in order to support faster technology diffusion and improve the efficiency of business processes in the sector.

Fifth, applied organizational and economic mechanisms for green logistics and resource-efficient supply chains should be developed across key sectors of the economy, drawing on the practical framework proposed by Dzwigol, Trushkina, and Kwilinski [8], so that the benefits of ecological entrepreneurship extend beyond individual firms to entire value chains.

Sixth, regional cooperation with neighboring Central Asian states on transboundary environmental and water-resource management should be further strengthened, since many environmental processes relevant to ecological entrepreneurship — particularly water-resource management and the consequences of the Aral Sea crisis — have a regional dimension. Coordinated approaches can therefore contribute to strengthening the resource base that supports the long-term development of domestic green entrepreneurship.

Taken together, these recommendations indicate that strengthening the economic-security contribution of ecological entrepreneurship in Uzbekistan requires a coordinated policy approach spanning financial-sector development, education, administrative modernization, applied sectoral mechanisms, and regional cooperation. Future research could build on the conceptual framework developed here through empirical, firm-level, and macroeconomic testing of the specific channels identified, as more detailed statistical data on the green entrepreneurship sector in Uzbekistan and the wider Central Asian region become available.

References

1. Dean, T. J., & McMullen, J. S. (2007). Toward a theory of sustainable entrepreneurship: Reducing environmental degradation through entrepreneurial action. *Journal of Business Venturing*, 22(1), 50–76. <https://doi.org/10.1016/j.jbusvent.2005.09.003>
2. Bansal, P., & Roth, K. (2000). Why companies go green: A model of ecological responsiveness. *Academy of Management Journal*, 43(4), 717–736. <https://doi.org/10.2307/1556363>
3. Demirel, P., Li, Q. C., Rentocchini, F., & Tamvada, J. P. (2019). Born to be green: New insights into the economics and management of green entrepreneurship. *Small Business Economics*, 52(4), 759–771. <https://doi.org/10.1007/s11187-017-9933-z>
4. Ebrahimi, P., & Mirbargkar, S. M. (2017). Green entrepreneurship and green innovation for SME development in market turbulence. *Eurasian Business Review*, 7(2), 203–228. <https://doi.org/10.1007/s40821-017-0073-9>
5. Mrkajic, B., Murtinu, S., & Scalera, V. G. (2019). Is green the new gold? Venture capital and green entrepreneurship. *Small Business Economics*, 52(4), 929–950. <https://doi.org/10.1007/s11187-017-9943-x>
6. Domańska, A., Żukowska, B., & Zajkowski, R. (2018). Green entrepreneurship as a connector among social, environmental and economic pillars of sustainable development. Why some countries are more agile? *Problemy Ekorozwoju – Problems of Sustainable Development*, 13(2), 67–76. <https://ph.pollub.pl/index.php/preko/en/article/view/5014>
7. Alvarez-Risco, A., Młodzianowska, S., García-Ibarra, V., Rosen, M. A., & Del-Aguila-Arcentales, S. (2021). Factors affecting green entrepreneurship intentions in business university students in COVID-19 pandemic times: Case of Ecuador. *Sustainability*, 13(11), Article 6447. <https://doi.org/10.3390/su13116447>

8. Dzwigol, H., Trushkina, N., & Kwilinski, A. (2021). The organizational and economic mechanism of implementing the concept of green logistics. *Virtual Economics*, 4(2), 41–75. [https://doi.org/10.34021/ve.2021.04.02\(3\)](https://doi.org/10.34021/ve.2021.04.02(3))
9. Republic of Uzbekistan. (2019). *Resolution of the President of the Republic of Uzbekistan No. RP-4477 of October 4, 2019, "On the Approval of the Strategy for Transition of the Republic of Uzbekistan to a Green Economy for 2019–2030."* National Database of Legislation of the Republic of Uzbekistan. <https://www.lex.uz/en/docs/7582760>
10. United Nations Development Programme (UNDP) Uzbekistan. (2025, December 2). *Ministry of Economy and Finance of the Republic of Uzbekistan and UNDP Uzbekistan sign Statement of Intent to advance green economy under PAGE initiative.* <https://www.undp.org/uzbekistan/press-releases/ministry-economy-and-finance-republic-uzbekistan-and-undp-uzbekistan-sign-statement-intent-advance-green-economy-under-page>

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