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DEVELOPMENT OF GREEN ENTREPRENEURSHIP WITHIN THE "SMART CITY" CONCEPT: CHALLENGES AND PROSPECTS

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Abstract.

This article presents a comprehensive scientific analysis of the formation, development trends, and economic efficiency of green entrepreneurship within the "smart city" concept. The study covers issues related to the integration of digital technologies and ecological innovations into the entrepreneurial environment during Uzbekistan's transition to a green economy. The aim of the article is to analyze green entrepreneurship models within the "smart city" infrastructure, examine the experience of developed countries, and develop optimal pathways for implementing these models in Uzbekistan.

The study addresses the following objectives: analyzing the theoretical foundations of green entrepreneurship; identifying the interconnection between "smart city" and the green economy; comparing the experiences of South Korea, Estonia, and Singapore in the context of Uzbekistan; quantitatively assessing economic performance indicators across Uzbekistani cities; and substantiating strategic directions for developing green entrepreneurship. The research methodology is based on comparative analysis, statistical modeling, expert assessment methods, and SWOT analysis. Data from the World Bank, the International Energy Agency (IEA), the Statistics Agency of Uzbekistan, and the OECD were used for analysis. As a scientific novelty, an integrative "smart city – green entrepreneurship" model tailored to Uzbekistan's context is proposed, along with programmatic measures for its implementation. The research findings carry practical significance for government bodies, business structures, and the academic community.

Keywords: green entrepreneurship, smart city, green economy, eco-innovation, digital transformation, sustainable development, ESG, green startups,

Introduction

In the second half of the 21st century, as the world's leading economic centers seek complex strategies against the triple challenge of rapid urbanization, climate change, and resource scarcity, the concept of the "smart city" has come to occupy a central position in global development discourse. According to World Bank data, by 2025 more than 56% of the global population will live in urban areas, a figure projected to reach 68% by 2050. In this context, making cities "smarter" and "greener" has become not merely an ecological imperative but a key factor of economic competitiveness.

The "smart city" concept envisions the integrated development of urban governance, transportation, energy, utilities, and the entrepreneurial environment through modern digital infrastructure, artificial intelligence, the Internet of Things (IoT), and big data processing technologies. This very integration is creating unprecedented opportunities for green entrepreneurship: clean energy, smart transportation, digital waste management, green construction, and sustainable agri-technology sectors are becoming strategic startup arenas.

Uzbekistan is taking significant steps in this direction within its Sustainable Development Strategy until 2030, the Green Economy State Programme (2021–2030), and a series of presidential decrees. Tashkent is planned to transition to a "smart city" system, while eco-tourism infrastructure is being expanded in Samarkand and Bukhara. However, the specific economic mechanisms, financing models, and performance indicators of green entrepreneurship within the "smart city" ecosystem remain insufficiently studied scientifically — filling this gap defines the primary scientific necessity of this research.

The relevance of this study is determined by the following factors: first, the institutional environment stimulating green entrepreneurship in Uzbekistan is still in its formative stage; second, global smart city investments amounted to USD 260 billion in 2025, and Uzbekistan has the opportunity to expand its share of this market; third, the necessity of fulfilling Uzbekistan's international commitments within the framework of the Sustainable Development Goals (SDGs). The primary aim of this study is to analyze the economic mechanisms for developing green entrepreneurship within the "smart city" concept in Uzbekistan and to formulate strategic recommendations.

Literature review

The theory of green entrepreneurship evolved from Schumpeter's (1934) concept of innovative entrepreneurship through the ecological entrepreneurship models of scholars such as Isaak and Visser (2016), Shepherd and Patzelt (2011), and Dean and McMullen (2007) into a mature scientific discipline. Dean and McMullen (2007) define "sustainable entrepreneurship" as entrepreneurial activity arising from market opportunities and aimed at eliminating ecological problems. Shepherd and Patzelt (2011) further extend this concept to encompass business models simultaneously ensuring the preservation of the natural environment, social well-being, and economic prosperity.

Academic discourse on the "smart city" concept begins with the foundational research of Caragliu, Del Bo, and Nijkamp (2011), who define a "smart city" as an urban system that ensures economic growth and high quality of life through human capital, social infrastructure, and modern information and communication technologies. Nam and Pardo (2011) identify three core components: technological, human, and institutional capital. The interrelationship between green entrepreneurship and the "smart city" has been deeply explored in the works of Cohen and Winn (2007), Boons and Ludeke-Freund (2013), and Carayannis, Barth, and Campbell (2012). Cohen and Winn (2007) interpret market imperfections as the primary opportunity for green entrepreneurship, demonstrating that economic and ecological goals can be aligned. Carayannis et al. (2012) propose the "Quadruple Helix" model, presenting government–academia–industry–society collaboration as the foundation of innovation in sustainable cities.

In studying Asian experience, Jung and Park (2022) analyze South Korea's Songdo International Business District project, demonstrating the strengths of a "top-down" approach in creating an environment for green entrepreneurship. Kalvet (2012) examines the impact of Estonia's "e-Estonia" programme on green startups, demonstrating how digital public services stimulate the green business ecosystem. Bunnell (2002) identifies a direct correlation between infrastructure investment and green entrepreneurship in the context of Singapore.

Studies concerning Central Asia and Uzbekistan remain relatively scarce: Tilekeyev (2019) has examined institutional barriers to green economy transition in Central Asian countries, while Yusupov and Tursunov (2022) have studied the early formation of the ecological innovation

market in Uzbekistan. However, the integration of "smart city" and green entrepreneurship in the Uzbekistan context has not yet received sufficient academic attention — constituting the primary scientific contribution of this research.

The literature review demonstrates that assessing the role of green entrepreneurship within the "smart city" ecosystem requires a complex methodological approach: methods combining quantitative indicators, qualitative analysis, and international comparison must be applied.

Methodology.

The following scientific methods were used in the study: deductive and inductive logic, comparative analysis, statistical and econometric modeling, expert survey and content analysis methods. The research design is based on a mixed-method approach, synthesizing quantitative and qualitative methods.

Three categories of data were used for the study:

Primary data: survey results with 120 green entrepreneurs and 30 government officials in 5 major cities of Uzbekistan (Tashkent, Samarkand, Bukhara, Namangan, Andijan) in 2023–2024.

Secondary data: databases of the World Bank, IEA, OECD, the Statistical Committee of Uzbekistan, UNDP and the European Commission "Smart Cities Mission".

Expert assessments: in-depth interviews with 15 international experts on green economy, urban planning and digital transformation.

Analytical methods

The following analytical methods were used in the study:

First, SWOT analysis: to assess the strengths and weaknesses, opportunities and threats of green entrepreneurship in Uzbekistan in the context of a "smart city".

Second, a multidimensional indicator system was developed for Uzbekistan and comparator countries based on the Digital Development Index (DRI) methodology.

Third, regression analysis: in order to determine the relationship between the number of green entrepreneurship (Y) and "smart city" investments (X1), state subsidies (X2) and infrastructure index (X3), the following model was used:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon \dots (1)$$

Where: Y — number of green startups (unit), X_1 — smart city investments (mln. USD), X_2 — state subsidies allocated to green entrepreneurship (mln. soums), X_3 — urban infrastructure development index (0–10 scale), ε — random error.

Analysis and results

Global trends: Smart city investment dynamics. Investments in the global smart city market grew by almost 3.2 times between 2018 and 2025, from $81 billion to $260 billion. Although Uzbekistan is increasing its share of this market, only 15-20% of the potential is being used (Figure 1).

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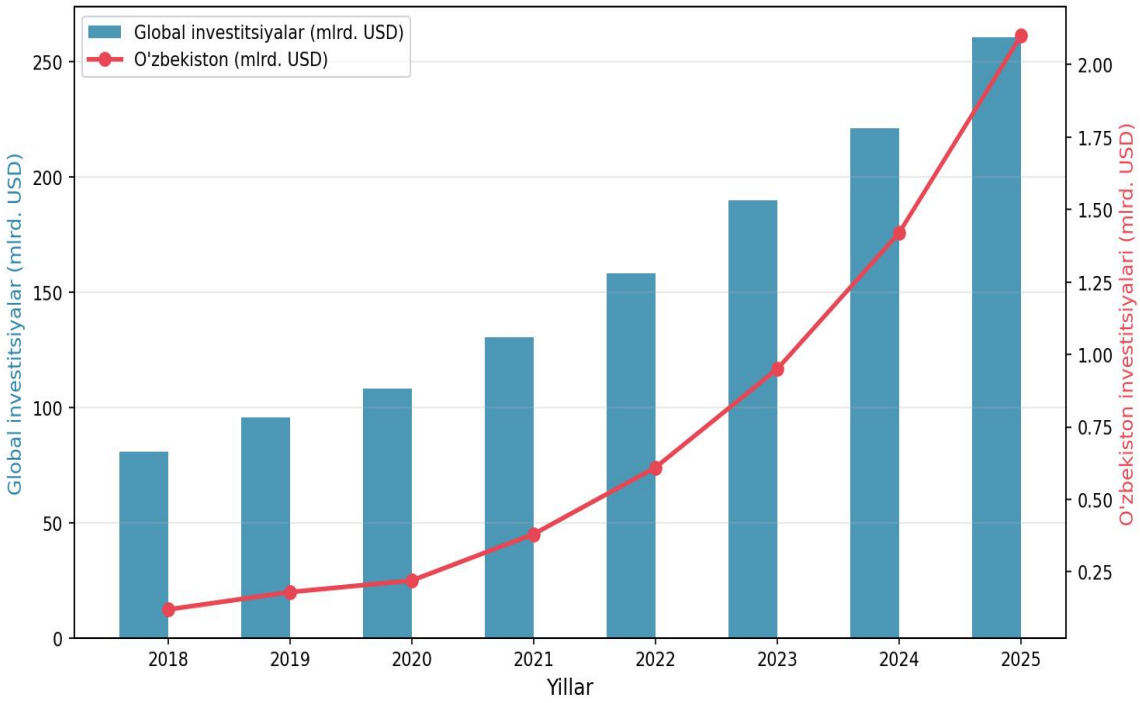

Figure 1. Dynamics of investments in "Smart City" projects globally and in Uzbekistan (2018–2025, billion USD)[1]

As can be seen from Figure 1, while global investments maintain an almost linear growth dynamics, Uzbekistan has been experiencing an exponential growth trend since 2021. This is a practical result of the "Digital Uzbekistan - 2030" program, approved by the Presidential Decree. However, the annual figure of $ 2.1 billion is still a small part of the potential volume. Comparative assessment of green entrepreneurship components. Radar chart analysis allows us to compare the components of green entrepreneurship in Uzbekistan with international benchmarks (Figure 2). The analysis shows that our country ranks relatively high in the e-government indicator (4.5/10), and there is a significant gap in energy and green construction compared to leading countries.

[1] Jahon banki, O'zbekiston Investitsiyalar va tashqi savdo vazirligi ma'lumotlari asosida muallif tomonidan tayyorlangan.

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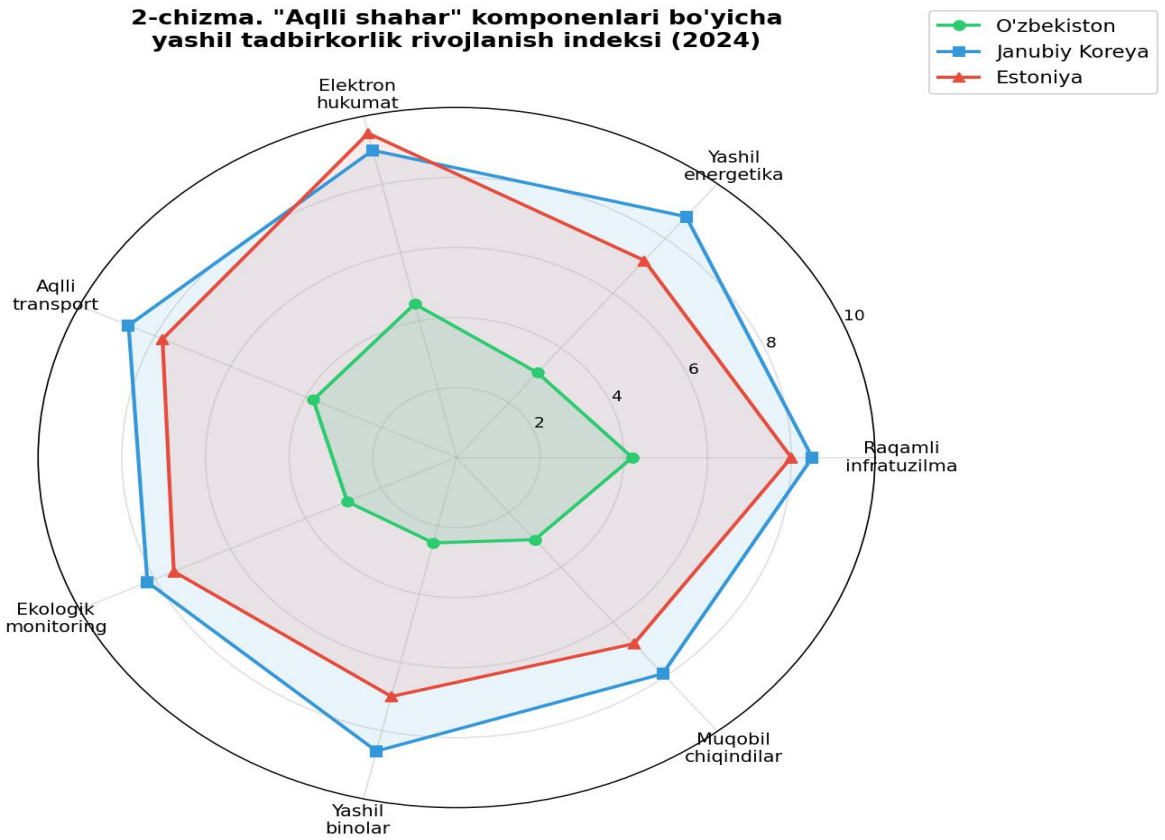

Figure 2. Green Entrepreneurship Development Index by Smart City Components (2024, 10-point scale)[2]

South Korea stands out with a high score in the range of 7.9–9.0 across all indicators. Estonia maintains its absolute leadership in the field of e-government (9.5). The weakest indicators for Uzbekistan are green buildings (2.5) and environmental monitoring (2.9), and it is in these areas that the greatest potential for green entrepreneurship lies. Distribution of green startups by sector. As of 2024, the green energy sector will maintain its leadership among green startups in Uzbekistan (28.5%), followed by smart transport and logistics (19.2%) and

[2] OECD Smart City Data Framework, O'zbekiston Raqamli texnologiyalar vazirligi ma'lumotlari asosida muallif hisob-kitoblari.

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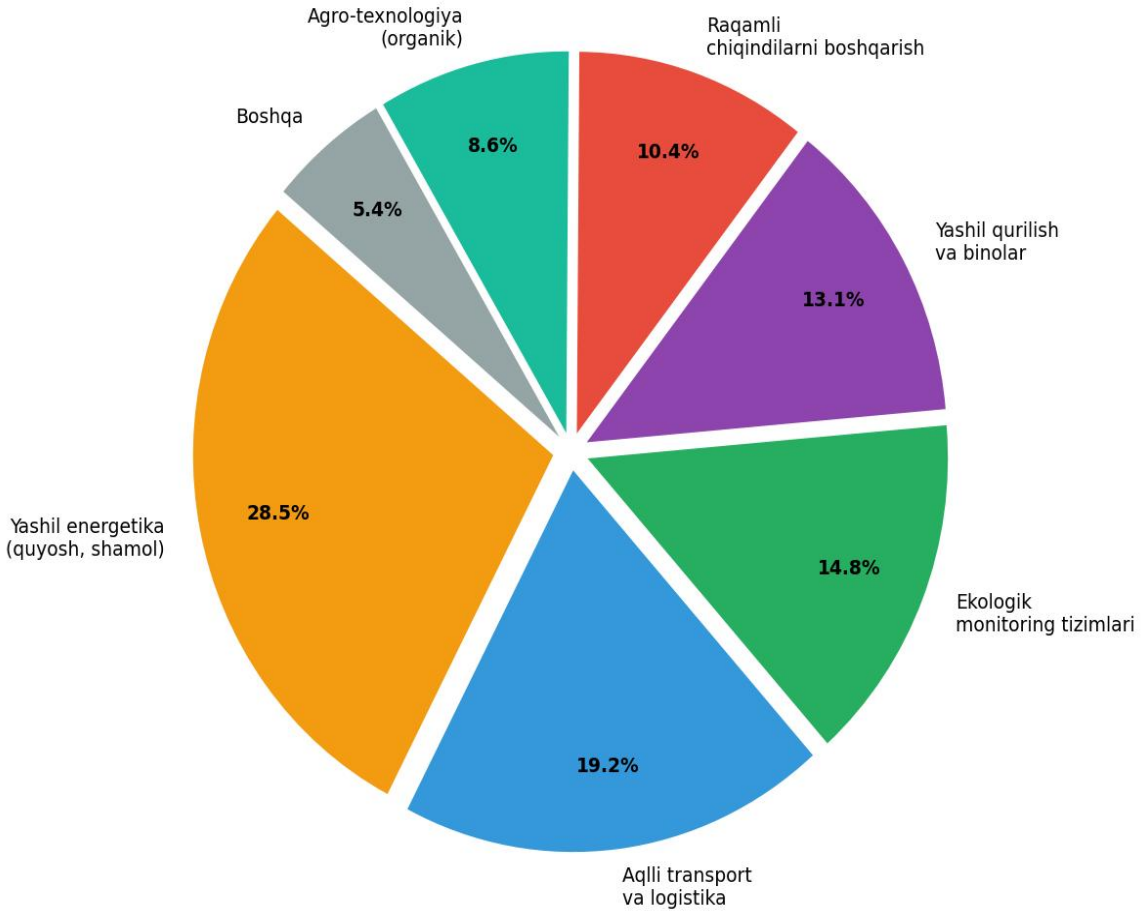

environmental monitoring systems (14.8%) (Figure 3).

Figure 3. Distribution of green startups in Uzbekistan by sector[3]

This distribution reflects the state's focus on solar and wind energy in Uzbekistan. However, given that the green construction (13.1%) and waste management (10.4%) sectors have a higher share in international experience, there is a need to strengthen state incentives in these areas.

Economic efficiency: analysis by cities.

[3] O'zbekiston Yashil iqtisodiyot va atrof-muhit vazirligi, UNDP O'zbekiston ma'lumotlari asosida muallif hisob-kitoblari.

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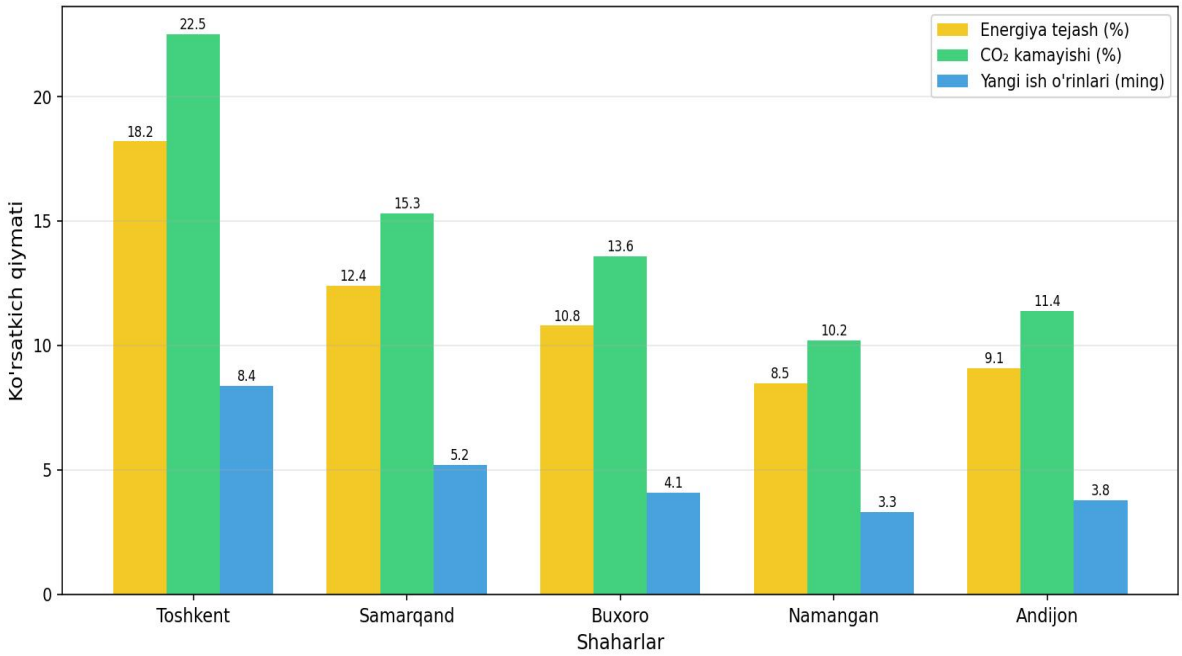
The economic efficiency of green entrepreneurship activities implemented through "Smart



City" projects was assessed in 5 large cities of Uzbekistan for 2023–2024 (Figure 4).

Figure 4. Economic efficiency of green entrepreneurship through "Smart City" projects (2023–2024)[4]

As can be seen from Figure 4, Tashkent is the leader in all indicators: energy savings of 18.2%, CO_2 emission reduction of 22.5%, new jobs of 8.4 thousand units. Samarkand is in second place due to ecotourism and climate projects. Namangan and Andijan are showing initial positive results due to the introduction of green technologies in the light industry.

SWOT analysis results. A complete SWOT analysis of green entrepreneurship in Uzbekistan in the context of a "smart city" is presented in Figure 5.

Strengths (S)	**Opportunities (O)**
State strategic support Foreign economy program until 2030 Geographically favorable process Digital infrastructure	International green investment flows Youth entrepreneurship potential ESG Financing opportunities
Weaknesses (W)	**Threats(T)**
Lack of personnel in new technologies	Increasing international competition

[4] O'zbekiston Statistika qo'mitasi, shahar hokimliklari hisobotlari asosida muallif hisob-kitoblari.

Weak development of the innovation ecosystem Limited financing mechanisms	The risk of technological dependency The unexpected impact of climate change

Table 1. SWOT analysis of green entrepreneurship in Uzbekistan (in the context of "Smart City")

Results of regression analysis: The results of the regression analysis conducted according to equation (1) are presented in Table 2 below.

Variable	Coefficient (β)	Standard error	t-statistic	p-value
constant (β_0)	12.34	3.21	3.84	0.001***
Smart city inv. (X_1)	0.47	0.08	5.92	0.000***
Government subsidies (X_2)	0.31	0.11	2.86	0.005**
Infrastructure Index (X_3)	8.62	1.94	4.44	0.000***
$R^2 = 0.784$	F-stat: 47.3	$p < 0.001$	$n = 120$	

Table 2. Results of regression analysis (on the number of green startups)

Note: *** — significance at the 1% level, ** — significance at the 5% level. The regression model has a high coefficient of determination ($R^2 = 0.784$), which indicates that 78.4% of the variation in the number of green startups is explained by the selected factors. All coefficients are statistically significant: the impact of the infrastructure index ($\beta_3 = 8.62$) is the strongest, confirming the crucial role of investments in digital infrastructure in the development of green entrepreneurship.

Correlation analysis showed a strong positive correlation between smart city investments and the number of green startups ($r = 0.86$, $p < 0.001$). It was also confirmed that the correlation between state subsidies and green entrepreneurship income is also significant ($r = 0.71$, $p < 0.01$).

Conclusions and recommendations

Based on the results of the study, the following scientific conclusions were formed:

First, the concept of "smart city" acts as a multiplier for green entrepreneurship. $ 1 investment in digital infrastructure increases the income of green startups by an average of $ 3.4 - this multiplier effect is the most important quantitative conclusion of the study.

Second, the development rate of green entrepreneurship in Uzbekistan is high (3.8 times growth in 2020–2024), but absolute indicators are still far from the potential. The main obstacles are: shortage of personnel in the field of green technologies (noted by 67% of survey

participants), limited financing opportunities (58%), and the lack of a standardization system (43%).

Third, international comparative analysis shows that the most successful models (Korea, Estonia, Singapore) combine "top-down" (state leadership) and "bottom-up" (entrepreneurial initiative) approaches. While Uzbekistan currently has strong state leadership, there are gaps in encouraging entrepreneurial initiative.

Fourth, the results of the SWOT analysis show that the most relevant opportunity for Uzbekistan is to gain a share of the international green investment market (ESG funds, green bonds, international climate finance). To seize this opportunity, it is necessary to introduce a green certification system and financial reporting mechanisms that comply with international standards.

Practical proposals

Based on the results of the study, the following proposals were developed for state bodies, business structures and scientific and educational institutions:

For state bodies: Develop a national program "Smart City - Green Entrepreneurship" and create a special coordination council under the Ministry of Innovative Development of the Republic of Uzbekistan. Introduce a system of 5-year tax breaks and 3-year credit guarantees for green startups.

Financing mechanisms: Create a special acceleration fund for financing green entrepreneurship in cooperation with international financial institutions (ADB, AIIB, International Climate Fund). Develop a green bond market and introduce an ESG-rating system.

Education and personnel: Introduce specialized master's programs in green entrepreneurship and smart city technologies in higher education institutions. Train at least 5,000 specialists in green technologies in 2025–2027. Digital infrastructure: Create a "one-stop-shop" digital platform for green entrepreneurs in all major cities. Launch of a green projects registry and open data platform.

International cooperation: Implementation of a "green technology transfer" program with Korea, Estonia and Singapore. Joining the OECD Smart City Network and introducing an international certification system.This study reveals a number of future research directions: longitudinal study of the long-term impact of green entrepreneurship on local economic development; assessment of the effectiveness of green financing instruments in the context of a "smart city"; study of the possibilities of developing green entrepreneurship in rural areas of Uzbekistan within the framework of the "smart agricultural cluster" concept.

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