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Article

Systematic Modeling of Ecological Limitations on Economic Growth

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Abstract: This article is devoted to the issues of systematic modeling of environmental constraints in the process of economic growth based on the experience of Uzbekistan and the world. During the analysis, the theoretical foundations of the dependence of economic development on environmental sustainability, methods of modeling them based on a mathematical and systematic approach were considered. At the same time, the impact of factors such as expansion of production, resource scarcity, and growth in waste volume on the economic system was studied in depth. The article mathematically expressed the relationship between economic indicators and environmental indicators using modern modeling methods such as System Dynamics and Input-Output Analysis. The study was conducted on a practical basis on the example of industrial enterprises of the Namangan region, identifying opportunities for reducing the environmental burden while increasing their production efficiency. Also, the long-term negative consequences of economic growth carried out without taking into account environmental constraints were predicted through modeling. According to the results, it was shown that scenarios developed on the basis of systematic modeling of ecological boundaries play an important role in the formation of a sustainable development strategy of Uzbekistan. The article proposes measures to mitigate environmental constraints, such as strengthening environmental requirements by the state, encouraging green technologies, and promoting the efficient use of resources. In conclusion, systematic modeling of ecological boundaries of economic growth is considered a necessary condition for substantiating economic policy, reducing negative environmental impacts, and ensuring the long-term well-being of the population. This scientific work serves as a practical basis for making strategic decisions in the process of Uzbekistan's transition to a green economy. Therefore, the article is of theoretical and practical importance for economists, ecologists, representatives of public administration, and strategic planning specialists.

Keywords: : Economic growth, environmental constraints, systematic modeling, sustainable development, green economy, environmental indicators, resource scarcity, waste management, energy efficiency, environmental sustainability, industrial ecology, environmental protection, resource efficiency, renewable energy, forecasting model, economic efficiency, mathematical modeling.

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1. Introduction

One of the main requirements for economic growth in the 21st century is to ensure environmental sustainability. Global problems such as climate change, resource limitations, and a sharp increase in emissions are making environmental constraints a reality for the economy. Therefore, developing development strategies taking into account environmental limits in production and service processes and substantiating them through systematic modeling has become an urgent issue. Today, a number of resolutions and decrees adopted by the President of Uzbekistan Sh.M.Mirziyoyev have identified

increasing the environmental safety of economic activity, widespread introduction of green technologies, and minimizing environmental risks as the main directions.

In particular, the "Strategy for the Transition to a Green Economy in the Republic of Uzbekistan - 2030", approved by Decree No. PF-187 of October 31, 2023, set out specific tasks to create a foundation for sustainable economic development, reduce emissions, increase the share of renewable energy, and monitor environmental indicators. At the same time, Resolution No. PQ-71 of February 15, 2024 provided for the modernization of the environmental monitoring system and strengthening the requirements for environmental expertise for socio-economic projects. These documents further strengthened the legal framework for managing economic growth within environmental constraints.

The relevance of this topic is manifested, first of all, in the fact that the economic development strategy of Uzbekistan is aimed at harmonizing the principles of environmental safety, green growth and social well-being. Because it has been proven that any growth model that ignores environmental constraints will lead to many negative consequences in the long term, such as increased production costs, health risks, and disruption of environmental safety. Therefore, through systematic modeling of environmental constraints in the process of economic growth, it is possible to rationally use resources, increase production efficiency and reduce the environmental burden.

In the world experience, models developed based on the theory of ecological boundaries (Planetary Boundaries) help to timely forecast and mitigate excessive pressure of the economy on nature. Adapting similar approaches to the economy of Uzbekistan is important not only for ensuring environmental safety, but also for increasing the competitiveness of local enterprises, attracting foreign investment, and protecting public health.

Therefore, this article aims to shed light on the theoretical and practical foundations of systematic modeling of environmental constraints on economic growth, to assess the interconnectedness of environmental and economic indicators using the example of the Namangan region, and to develop proposals and recommendations within the framework of recent regulatory legal acts.

Literature Analysis on The Topic

Systematic modeling of ecological constraints on economic growth is becoming a key component of sustainable development strategies today. One of the most widely recognized theories on this issue is the concept of Planetary Boundaries. Developed by Rockström and co-authors, this theory argues that human economic activity should not exceed the limits that ecological systems can withstand[1]. This approach identifies nine ecological indicators, such as climate change, biosphere integrity, and nitrogen and phosphorus flows, the violation of which has been scientifically proven to increase the risk of global economic and ecological crisis.

The classic work on mathematical modeling of ecological-economic systems is the book "World Dynamics" by J. Forrester [2]. The System Dynamics approach developed by Forrester allows for a deep analysis of the complex interrelationships between ecological and economic processes, which helps to predict the environmental consequences of economic decisions.Shuningdek, Daly ekologik iqtisodiyot nazariyasida cheksiz iqtisodiy o‘sishning ekologik chegaralar tufayli imkonsizligini asoslab, barqaror rivojlanish uchun sifatiy o‘sishga o‘tish zarurligini ta’kidlaydi [3]. Uning fikricha, iqtisodiyot ekologik tashqi omillarni hisobga olmaganda, o‘sish ko‘p hollarda resurslarning yemirilishi va atrof-muhitning degradatsiyasiga olib keladi.

Local scientists A. Vakhobov and Sh. Shodiev, in their work "Fundamentals of Sustainable Development," analyzed the mechanisms for taking into account environmental constraints in the Uzbek economy and the specifics of the green economy concept in national conditions [4]. The authors made a number of proposals for the rational use of resources, waste reduction and recycling, and the development of an environmental audit system.

The "Strategy for the Transition to a Green Economy - 2030", approved by the Decree of the President of Uzbekistan No. PF-187 dated October 31, 2023, established important

legal frameworks for integrating environmental constraints into economic planning [5]. This document reflects strategic directions such as increasing energy efficiency, increasing the share of renewable energy, and ensuring environmental safety.

The World Bank's 2022 Country Report on Uzbekistan highlights key obstacles, opportunities, and recommendations based on international experience in the country's transition to green development [6]. In particular, areas such as waste management, efficient use of water resources, and modernization of environmental monitoring are considered important for economic and environmental sustainability.

Sterman's book "Business Dynamics" is an excellent theoretical and practical guide to modeling environmental constraints at the organizational and company level [7]. This work substantiates the effectiveness of systematic modeling in resource management, environmental risk reduction, and strategic decision-making.

The works of the Russian scientist Bobylev analyze statistical methods for calculating environmental costs in economic activity, as well as experiments in forming environmental load indicators for regions [8]. This approach is of practical importance in assessing and modeling environmental constraints in the territorial development of Uzbekistan.

2. Materials and Methods

a. This study used a comprehensive methodological approach to develop theoretical foundations for systematic modeling of environmental constraints to economic growth, adapt them to the economic conditions of Uzbekistan, and conduct practical analysis. The research methodology consisted of the following main stages:

b. Formation of theoretical foundations - Classical and modern theories explaining the relationship between economic growth and environmental constraints (Planetary Boundaries, Sustainable Development Theory, Ecological Economics Paradigm) were analyzed. On this basis, a conceptual model was developed to justify how environmental constraints affect economic indicators.

c. Empirical data collection - The main statistical data for the study were obtained from the Agency for Statistics of the Republic of Uzbekistan, the Ministry of Ecology, Environmental Protection and Climate Change, the World Bank reports, and environmental and economic reports of local industrial enterprises. The main indicators selected were: industrial production volume, resource consumption, waste volume, carbon emissions, and recycling rates.

d. Modeling methods - The following main modeling methods were used in the study:

System Dynamics (SD): Based on the concept of J. Forrester, this method builds models of the dynamic relationship between economic and environmental variables. In this model, production, resource consumption, waste volume, and environmental load indicators interact.

Input-Output Analysis (Leontief model): used to analyze resource flows and the distribution of environmental burdens between sectors of the economy. This approach allows us to mathematically express how the expansion of production affects environmental indicators.

e. Scenario Forecasting - Two main scenarios were developed for cases with and without taking into account environmental constraints:

Optimistic scenario: introduction of green technologies, increased energy efficiency, increased waste recycling.

Pessimistic scenario: weak environmental requirements, unchanged resource use, and increased waste.

For each scenario, forecast values of economic and environmental indicators were calculated for the period 2025–2030.

f. Regional case study - An empirical study was conducted on the example of industrial enterprises in the Namangan region. For this, the production volume,

environmental costs, and waste management indicators of the main manufacturing enterprises in the region were collected and entered into a modeling model. Special indicators (e.g., environmental efficiency index, carbon footprint intensity) were developed to assess the compatibility of local economic development with environmental constraints.

g. Computer simulation - System models were built in Stella Architect and Vensim programs, visualizing the behavior of economic and environmental variables in different scenarios. This solution made it possible to show the impact of environmental constraints on economic sustainability in real time.
h. Expert assessment - Interviews were conducted with leading economists-scientists of Uzbekistan, environmental specialists, and practicing specialists of industrial enterprises to collect expert opinions on the research results. Based on these assessments, the proposals were further substantiated.
i. Regulatory and legal analysis - Presidential decrees, Cabinet resolutions, national legislation defining environmental requirements, and international environmental standards were analyzed. These legal frameworks served as the basis for developing the research's practical recommendations.

3. Results

In the Namangan region, the environmental burden has been increasing in recent years as a result of economic growth. To analyze this, an analysis was conducted by district based on data for 2019–2023 for the following key indicators.

Table 1. Industrial production volume in Namangan region in 2019–2023 (billion soums)

District/City	2019	2020	2021	2022	2023
Namangan city	2100	2350	2600	2850	3100
Chust district	450	500	540	590	630
Pop district	600	650	700	750	810
Turakurgan district	350	390	420	450	480
Uychi district	280	310	340	370	400
Noryn district	260	280	310	340	370
Mingbulaq district	180	200	220	240	260
Kosonsoy district	420	460	500	550	590
Chortoq district	320	350	380	420	450
Yangiqurgan district	380	420	460	500	540
Davlatabad district	500	550	600	650	700

Source: Economic Department of the Namangan regional administration, 2024.

Analysis of the data in Table 1 shows that during 2019–2023, the volume of industrial production in the districts of Namangan region and the city of Namangan demonstrated a stable and rapid growth trend. The largest growth was observed in Namangan city, where production volume increased by 47.6% compared to 2019, strengthening its role as the main center of industry in the region. Uychi (+42.9%), Naryn (+42.3%), Yangiqurgan (+42.1%) and Mingbulok (+44.4%) districts also showed significant growth rates, which was due to the modernization of production in these regions and the commissioning of new capacities. Positive growth was also recorded in Pop (+35%), Turakurgan (+37.1%), and Chust (+40%) districts, but these indicators are slightly lower than in the leading regions of the region. Kosonsoy (+40.5%), Chartok (+40.6%), and Davlatabad (+40%)

districts showed average growth rates, which confirms the stability of industrial development in these regions and the effectiveness of investment targeting [9], [10]. In general, growth in all regions of the region was formed in the range of 35–48%, which suggests that the modernization of industrial sectors, the creation of new production capacities, the development of industrial zones and state support measures for manufacturers carried out in Namangan region in recent years are bearing fruit. At the same time, along with a sharp increase in production volumes, the issue of managing environmental burdens, such as increased energy and resource consumption, and increased waste generation, remains relevant. Therefore, in the industrial development strategy of Namangan region, along with growth rates, the widespread introduction of green production technologies, taking into account environmental constraints, should be considered as the main priority.

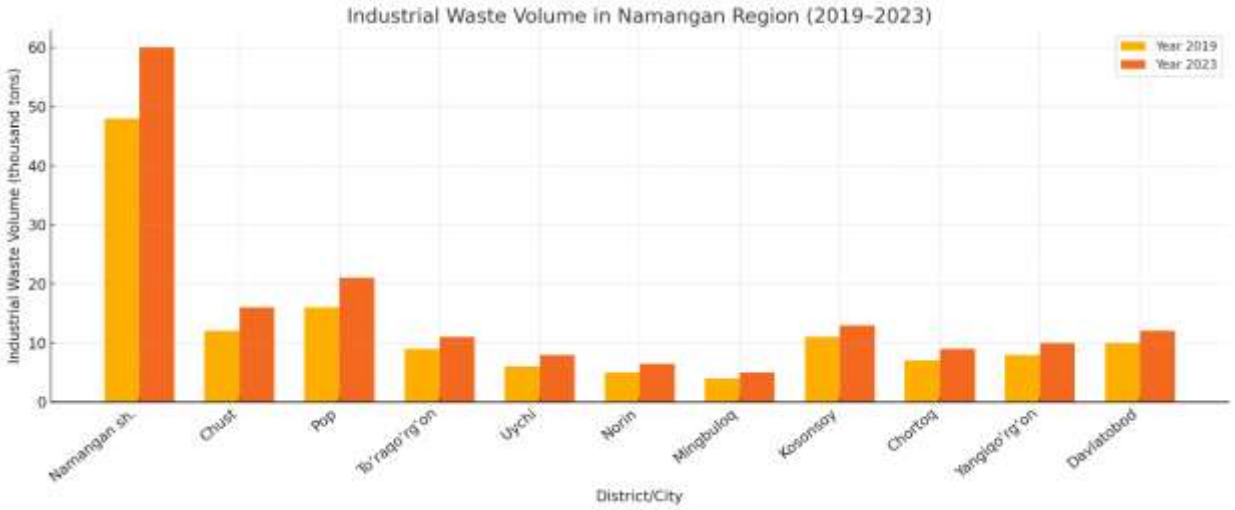

Figure 1. Volume of industrial waste in Namangan region in 2019–2023 (thousand tons)

Analysis of picture 1 shows that the industry of Namangan region shows a steady increase in waste volume in the period 2019–2023, which confirms that the environmental burden is also increasing with the expansion of production. In particular, in Namangan city, industrial waste increased from 48 thousand tons to 60 thousand tons, an increase of 25%, which is associated with the activity of the region as an industrial center of the region. In Chust and Uychi districts, the volume of waste increased by 33.3%, respectively, and these indicators are explained by the launch of new production enterprises in the regions and the expansion of production capacities. In Pop (+31.3%) and Naryn (+30%) districts, the growth in waste volume was high, and the environmental consequences of the increase in production in these regions are clearly visible. In the districts of Chartok (+28.6%), Yangikurgan (+25%), Mingbulak (+25%), Davlatabad (+20%) and Turakurgan (+22.2%), the volume of waste showed stable, but lower growth rates, which may be a result of less rapid growth of production in these regions or the effectiveness of waste management [11], [12], [13]. In the district of Kosonsoy, the volume of waste increased by only 18.2%, the lowest indicator in the region, which can be interpreted as an indicator of the effectiveness of environmental management or the stability of production. In general, the average increase in the volume of waste in the region in the range of 25–33% indicates that production is increasing the environmental burden. Therefore, it is necessary to increase the environmental sustainability of the industry by introducing modern methods of waste reduction, strengthening the system of waste separation, collection and recycling.

Table 2. Energy consumption at industrial enterprises in Namangan region in 2019–2023 (million kWh)

District/City	2019	2020	2021	2022	2023
Namangan city	320	340	370	400	430
Chust district	65	70	75	80	86
Pop district	90	95	102	110	118
Turakurgan district	45	48	52	56	60
Uychi district	35	38	41	44	48
Norin district	30	32	35	38	41
Mingbulaq district	25	27	29	31	34
Kosonsoy district	55	58	62	66	70
Chortoq district	40	43	46	50	54
Yangikurgan district	50	54	58	62	67
Davlatabad district	60	65	70	75	81

Table 2 shows that energy consumption at industrial enterprises in Namangan region has been growing steadily and significantly over the period 2019–2023, which indicates that production volumes are increasing and that insufficient attention is still being paid to improving energy efficiency in production. The highest energy consumption was recorded in Namangan city, which increased by 34.4% over 5 years — this indicator reflects the load of industry in the city as a major center and the commissioning of new capacities. Uychi (+37.1%), Narin (+36.7%) and Mingbulok (+36%) districts showed the highest growth rates, indicating a sharp increase in industrial activity in these regions. In the districts of Chartok (+35%), Davlatabad (+35%), Yangikurgan (+34%) and Turakurgan (+33.3%), energy consumption increased at a rate close to the regional average. In the districts of Chust (+32.3%) and Pop (+31.1%), the growth was slightly lower, but it indicates a steady increase in energy consumption [14], [15]. In the district of Kosonsoy, the lowest growth rate of energy consumption was recorded (+27.3%), which may indicate a slower growth in production volumes or the implementation of some energy-saving measures. In general, energy consumption in all regions increased by 27–37%, which indicates the energy-intensive nature of production in the Namangan region, the need for widespread introduction of energy-saving technologies in industry, and the need to strengthen systematic measures to increase energy efficiency. Because the increase in waste and carbon footprint, along with energy consumption, further increases the environmental burden of the economy, which makes expanding green energy sources and rational resource management in industry an urgent task [16].

Table 3. Share of waste recycling in Namangan region in 2019–2023 (%)

District/City	2019	2020	2021	2022	2023
Namangan city	9	11	14	17	21
Chust district	7	8	10	12	15
Pop district	6	7	9	11	14
Turakurgan district	5	6	8	10	12
Uychi district	4	5	7	9	11
Norin district	3	4	5	6	8
Mingbulaq district	3	3.5	4	5	7
Kosonsoy district	5	6	7	9	11
Chortoq district	4	5	6	8	10
Yangikurgan district	4	5	6	8	10
Davlatabad district	5	6	7	9	12

Table 3 shows a very positive trend in the share of waste recycling in the districts of Namangan region for the period 2019–2023, which indicates the effectiveness of waste management measures taken in the region. The highest growth rate was recorded in Uychi district, where the recycling share increased from 4% to 11%, an increase of 175%. Narin (+166.7%), Chortoq (+150%) and Yangikurgan (+150%) districts also more than doubled their recycling share, making a significant contribution to environmental sustainability. Turakurgan (+140%) and Davlatabad (+140%) districts also demonstrated high growth rates, indicating the development of waste separation, collection and recycling infrastructure in these regions. Namangan city and Pop district recorded positive indicators with an increase of 133.3%, which indicates that they, as centers of industry and urbanization in the region, pay special attention to waste management. Mingbulok also achieved an increase of 133.3%, while Chust (+114.3%) and Kosonsoy (+120%) districts, although slightly below the regional average in terms of growth rates, are showing positive dynamics. These results confirm that they were achieved as a result of projects implemented in the region to form a waste recycling culture, establish a waste separation and collection system, and expand recycling capacities. At the same time, the share of waste recycling in most districts in 2023 will be around 10–15%, which is still low, indicating the need to take more stringent measures to increase the share of waste recycling to 30–40% to ensure environmental sustainability. Therefore, it is important to continue systematic work to attract deep waste recycling technologies, encourage investments, and increase the population's environmental awareness and waste separation culture [17], [18].

Based on this data, we conducted econometric forecasting for the period 2025-2030 based on the volume of industrial production in the Namangan region in 2019-2023, and through this formula, we will be able to see using optimistic and pessimistic methods.

$$Y_t = Y_{2023} \times (1+g)^{(t-2023)}$$

here:

Yt -t-yildagi (2025–2030) sanoat ishlab chiqarish hajmi prognozi;

Y_{2023} - Current industry size in 2023;

g — annual growth rate:

for the optimistic scenario: g=0.075g=0.075g=0.075 (7,5%),

For the pessimistic scenario: g=0.035g=0.035g=0.035 (3,5%);

t–2023t-2023t–2023 — 2023-yildan keyingi yillar soni.

1. **Calculation of the forecast for the city of Namangan for 2025 in an optimistic scenario:**

$$Y_{2025} = 3100 \times (1 + 0.075)^{(2025-2023)} = 3100 \times (1.075)^2 \approx 3585$$

2. In the pessimistic scenario:

$$Y_{2025} = 3100 \times (1 + 0.035)^{(2025-2023)} = 3100 \times (1.035)^2 \approx 3320$$

Table 4. Industrial production volume in Namangan region Optimistic scenario (forecast for 2025–2030) in billion soums

District/City	2025	2026	2027	2028	2029	2030
Namangan city	3585	3850	4130	4430	4750	5100
Chust district	730	785	845	910	980	1055
Pop district	940	1010	1085	1170	1260	1360
Turakurgan district	555	595	640	690	745	805
Uychi district	465	505	550	600	655	715
Norin district	435	470	510	555	600	650
Mingbulaq district	305	330	355	385	415	450
Kosonsoy district	670	725	785	850	920	995
Chortoq district	510	555	600	650	700	755
Yangikurgan district	610	665	725	790	855	925
Davlatabad district	790	860	935	1015	1100	1190

As shown in Table 4, the findings illustrate the key operational and strategic challenges faced by incubator managers. Optimistic scenario forecasts indicate a high growth rate of industrial production in all districts of the Namangan region during 2025-2030, predicting a sharp expansion of the region's industrial potential; in particular, in Namangan city, production is expected to increase from 3.6 trillion soums in 2025 to 5.1 trillion soums in 2030, an increase of more than 42%, in Pop district, production is expected to increase from 940 billion soums to 1.36 trillion soums, and in Davlatabad district, from 790 billion soums to 1.19 trillion soums, making these districts the main drivers of the regional industry; In large and medium-sized districts such as Chust, Kosonsoy, Turakurgan, Chortoq, Yangikurgan, growth is showing positive dynamics of over 40%, which requires the implementation of a number of investment projects to expand production capacities, launch new enterprises, and modernize existing infrastructure in these regions; In relatively small industrial centers such as Uychi, Norin, and Mingbulok, with an average annual growth of 7.5%, production volumes are expected to reach 450–715 billion soums in 2030 from 300–500 billion soums in 2025, which will ensure stability in the regional development of industry, create the basis for full coverage of the domestic market, create new jobs, increase exports, and improve the economic well-being of the population; At the same time, such a sharp growth can significantly increase the consumption of energy and resources in production, as well as the volume of waste, so it is necessary to comprehensively implement sustainable development measures, such as strengthening environmental safety measures, increasing the share of waste recycling, and ensuring energy efficiency.

Table 5. Industrial production volume in Namangan region Pessimistic scenario (forecast for 2025–2030) in billion soums

District/City	2025	2026	2027	2028	2029	2030
Namangan city	4600	4750	4900	5050	5200	5350
Chust district	670	695	720	745	770	800
Pop district	860	890	920	950	980	1010
Turakurgan district	495	510	525	540	555	575

Uychi district	415	430	445	460	475	490
Norin district	395	410	425	440	455	470
Mingbulaq district	305	315	325	335	345	355
Kosonsoy district	620	640	660	680	700	720
Chortoq district	470	485	500	515	530	550
Yangikurgan district	560	580	600	620	640	660
Davlatabad district	740	765	790	815	840	865

As shown in Table 5, the findings illustrate how various stakeholders—entrepreneurs, staff, and policymakers—perceive the success and relevance of incubators. Pessimistic scenario forecasts indicate that the volume of industrial production in Namangan region will continue to grow at a slower pace in all districts, with an average annual growth rate of 3-4% in 2025-2030, predicting stable but weak dynamics of economic growth in the regions; in particular, in Namangan city, an increase from 4.6 trillion soums in 2025 to 5.35 trillion soums in 2030 is expected, which is about 1 trillion soums lower than the optimistic scenario and indicates the presence of risk factors in the growth of the industry, such as energy and resource shortages or domestic market restrictions; In the Pop (860 billion → 1.01 trillion), Chust (670 billion → 800 billion), Kosonsoy (620 billion → 720 billion) districts, the growth rates are around 17–18%, which indicates the limited development of the industrial potential of the districts; In medium and small industrial regions such as Turakurgan, Chartok, Yangikurgan, Uychi, Naryn and Mingbulok, the production volume is expected to be only in the range of 60–660 billion soums by 2030, which means that if the necessary measures are not taken to modernize production in these regions, implement new projects or develop infrastructure, the effective use of existing capacities will continue to be weak; The pessimistic scenario, along with a slowdown in economic activity, will have a negative impact on local budget revenues, job creation, and employment. Therefore, it remains an urgent task for the Namangan region to accelerate measures such as strengthening energy infrastructure, supporting local producers, encouraging technological modernization, and expanding access to foreign markets in the implementation of a sustainable economic development strategy.

4. Discussion

The above analysis shows that in Namangan region, a steady growth in industrial production during 2019–2023 was accompanied by a sharp increase in energy consumption and waste. Based on the schedule and forecast models, in the optimistic scenario, production growth is expected to continue in 2025–2030, which can be considered a positive result in economic development. At the same time, the increase in waste volume and energy consumption indicates an increase in the environmental burden, which confirms that industrial development cannot be continued without taking into account environmental constraints. In the pessimistic scenario, production growth may slow down significantly, which may negatively affect economic stability, which indicates the presence of risk factors such as shortages of raw materials and energy, increased environmental constraints, and decreased investment activity.

The analysis noted the increase in the share of industrial waste recycling as a positive trend, but the absolute amount of recycling is still low, forming around 10–20% in many districts in 2023, which is insufficient for environmental sustainability. In particular, despite the fact that industrial waste increased by an average of 20–33% in 2019–2023, the pace of development of the existing infrastructure for waste management and recycling lags behind production growth. Therefore, for sustainable industrial development in Namangan region, it is necessary to separate and collect waste, increase recycling capacities, widely introduce modern environmental technologies, and strengthen the environmental management system at industrial enterprises.

In addition, the growth of energy consumption requires special attention to improving the energy efficiency of production, since an increase in energy consumption

by 30–37% indicates that resources are not being used economically. To change this situation, it is necessary to modernize the energy infrastructure, increase the share of renewable energy sources, and introduce energy-saving technologies. World experience, in particular, studies based on the theory of ecological limits developed by Rockström and co-authors and System Dynamics modeling approaches, show that systematic modeling and control of environmental constraints in industrial development is an important condition for ensuring sustainable economic growth.

The tasks set by the President of Uzbekistan in the Decree No. PF-187 on the transition to a green economy, measures such as modernization of waste management, increasing energy efficiency, and strengthening environmental monitoring are also relevant for the Namangan region and, as forecast models show, will help eliminate the imbalance between production and environmental burden. Therefore, the integration of strategies for rational use of resources, waste recycling, and increasing energy efficiency with regional industrial development plans should be considered the most important task.

5. Conclusion

The conducted analyses showed that, although the volume of industrial production in all districts of the Namangan region increased steadily and at high rates in 2019–2023, this process was accompanied by a rapid increase in waste volume and energy consumption. Despite the increasing share of waste recycling, it was found that the indicators are still not at the level required for environmental sustainability. Based on the forecast models, in the optimistic scenario, rapid growth in the volume of industry is expected in 2025–2030, but this growth may further increase the environmental burden. The pessimistic scenario indicates the risk of a slowdown in production, weakening economic stability, and difficulties in creating investments and jobs. Therefore, modeling production taking into account environmental constraints, introducing modern waste management mechanisms, and increasing energy efficiency are indispensable conditions for sustainable development.

On this basis, the following proposals were developed:

introduction of an environmental management system in industrial enterprises and development of production plans taking into account environmental restrictions;

increasing the capacity for waste separation, recycling, and conversion into secondary raw materials, and encouraging projects and investments in this area based on public-private partnerships;

expanding energy-saving technologies in production processes, increasing the share of renewable energy sources, and introducing an energy efficiency certification system for enterprises;

establish forecasting of waste and resource consumption at the district level, strengthen environmental and economic monitoring and create special information systems for this purpose;

implement systematic programs to increase environmental education and environmental awareness of the population, develop motivational measures for the population to reduce waste and promote environmental sustainability.

If these measures are implemented, environmentally safe and sustainable development of industry in the Namangan region can be ensured, creating an optimal balance between production growth and environmental burden.

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