



# IQTISODIYOT & TARAQQIYOT

*Ijtimoiy, iqtisodiy, texnologik, ilmiy, ommabop jurnal*

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- 08.00.07 Moliya, pul muomalasi va kredit
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- 08.00.09 Jahon iqtisodiyoti
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- 08.00.11 Marketing
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- 08.00.13 Menejment
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# MUNDARIJA

O'ZBEKISTONDA RAQAMLI TO'LOV INFRATUZILMASINI SHAKILLANISHI VA RIVOJLANISH DINAMIKASI: TARIXIY, ILMIY HAMDA BOZOR TAHLILI .....	32
<b>A.A. Akbarov, X.R. Aliyev</b>	
O'ZBEKISTON RESPUBLIKASIDA BUXGALTERIYA HISOBINI TASHKIL ETISHNING ME'YORIY-HUQUQIY ASOSLARI VA ULARNING IQTISODIY AHAMIYATI.....	42
<b>Karayev Payzillaxon Yusufxonovich</b>	
TURIZM KORXONALARINING INNOVATSION FAOLIYATINI RIVOJLANTIRISHDA MOLIYAVIY AKTIVLARINING ROLI.....	47
<b>Ruzibayeva Nargiza Xakimovna</b>	
O'ZBEKISTON RESPUBLIKASIDA EKOLOGIK SOLIQLAR VA TO'LOVLAR TIZIMI TAHLILI .....	53
<b>Sadullayev Rasulbek Palvanbayevich, Abdolnizozov Murodbek Madiyarovich</b>	
O'ZBEKISTON RESPUBLIKASIDA IJTIMOYIY HIMOYA TIZIMINI MOLIYALASHTIRISHDA AMALGA OSHIRILAYOTGAN ISHLAR VA TIZIMGA KIRITILAYOTGAN O'ZGARISHLAR.....	59
<b>Kasimova Gulyar Axmatovna, Aripova Kamola Botir qizi</b>	
MINTAQAVIY RIVOJLANISHNI KOMPLEKS BAHOLASH VA PROGNOZLASHDA EKONOMETRIK VA SUN'IY INTELLEKT USULLARINING INTEGRATSIYASI .....	64
<b>Namazov Gafur Shokulovich</b>	
BALIQCILIK SUBYEKTLARINI RIVOJLANTIRISHDA DUNYO MAMLAKATLARINING O'RNI .....	69
<b>Beglayev Uchqun Xurramovich</b>	
KAMBAG'ALLIK FENOMENINING IJTIMOYIY-IQTISODIY VA NAZARIY-KONTSEPTUAL ASOSLARI .....	75
<b>Musulmonova Shahlo Nasriddinovna</b>	
RAQAMLI IQTISODIYOT SHAROITIDA HISOB VA BIZNES JARAYONLARINI TAKOMILLASHTIRISHNING ZAMONAVIY YO'NALISHLARI .....	81
<b>Artikova R.A.</b>	
AKSIYADORLIK JAMIYATLARIDA DIVIDEND TO'LASH QOBILİYATI KOEFFITSIYENTINING MAQBUL ORALIG'INI ANIQLASH VA UNING INVESTITSION SAMARADORLIKKA TA'SIRI.....	88
<b>Ibragimov G'anijon G'ayratovich</b>	
STRATEGIES TO RAISE AWARENESS OF NATURAL POLLUTION AMIDST RISING POPULATION DENSITY AND GDP PER CAPITA IN UZBEKISTAN .....	93
<b>Axliddin Aropitdinovich Valiyev, Askarov Farhod Rakhmatovich</b>	



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# STRATEGIES TO RAISE AWARENESS OF NATURAL POLLUTION AMIDST RISING POPULATION DENSITY AND GDP PER CAPITA IN UZBEKISTAN

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**Abstract.** This article analyzes the current state of environmental pollution in the Republic of Uzbekistan based on official statistics and available resources. Using methods of analysis and synthesis, scientific abstraction, induction, and deduction, the study compares Uzbekistan's data with findings from other countries. Through abstract-logical approaches, the article generalizes the results and formulates conclusions. Mathematical and statistical methods are applied for calculations, while econometric modeling is used to forecast future trends. Based on international experience, the article provides practical recommendations for reducing pollution emissions associated with factors such as GDP growth and increasing population density in Uzbekistan. The study aims to offer practical insights for raising awareness and addressing environmental challenges arising from economic and demographic growth.

**Key words:** environmental pollution, Uzbekistan, GDP growth, population density, econometric modeling, environmental emissions, sustainable development, statistical analysis, environmental policy, demographic growth.

**Annotatsiya.** Ushbu maqolada O'zbekiston Respublikasidagi ekologik ifloslanishning hozirgi holati rasmiy statistika va mavjud manbalarga tayangan holda tahlil qilinadi. Tahlil va sintez, ilmiy abstraksiya, induksiya va deduksiya usullaridan foydalanilgan holda, tadqiqot O'zbekiston ma'lumotlarini boshqa mamlakatlar tajribasi bilan taqqoslaydi. Abstrakt-mantiqiy yondashuvlar asosida maqolada natijalar umumlashtirilib, tegishli xulosalar shakllantirilgan. Hisob-kitoblar uchun matematik va statistik usullar qo'llanilgan, kelajakdagi tendensiyalarni prognozlash uchun esa ekonometrik modellardan foydalanilgan. Xalqaro tajriba asosida maqolada O'zbekistonda YaIM o'sishi va aholi zichligining ortishi bilan bog'liq ifloslanish chiqindilarini kamaytirish bo'yicha amaliy tavsiyalar ishlab chiqilgan. Tadqiqot iqtisodiy va demografik o'sish natijasida yuzaga keladigan ekologik muammolarni aniqlash hamda ularni bartaraf etish bo'yicha amaliy yondashuvlarni taklif etishga qaratilgan.

**Kalit so'zlar:** ekologik ifloslanish, O'zbekiston, YaIM o'sishi, aholi zichligi, ekonometrik modellashtirish, ifloslantiruvchi chiqindilar, barqaror rivojlanish, statistik tahlil, ekologik siyosat, demografik o'sish.

**Аннотация.** В данной статье анализируется текущее состояние экологического загрязнения в Республике Узбекистан на основе официальной статистики и доступных источников. С использованием методов анализа и синтеза, научной абстракции, индукции и дедукции исследование сопоставляет данные Узбекистана с результатами исследований других стран. Посредством применения абстрактно-логических методов в статье обобщаются результаты и формулируются выводы. Для проведения расчетов используются математические и статистические методы, а для прогнозирования будущих тенденций применяется эконометрическое моделирование. На основе международного опыта в статье предлагаются практические рекомендации по сокращению выбросов загрязняющих веществ, связанных с такими факторами, как рост ВВП и увеличение плотности населения в Узбекистане. Цель исследования заключается в выработке практических подходов к повышению осведомленности и решению экологических проблем, возникающих в результате экономического и демографического роста.

**Ключевые слова:** экологическое загрязнение, Узбекистан, рост ВВП, плотность населения, эконометрическое моделирование, выбросы загрязняющих веществ, устойчивое развитие, статистический анализ, экологическая политика, демографический рост.



## INTRODUCTION

According to the latest projections of the United Nations Department of Economic and Social Affairs, Uzbekistan's population is expected to reach 37.4 million by 2030. This growth in population density, combined with ongoing economic development, is likely to have a significant impact on environmental conditions. Economic growth, while contributing to higher living standards and greater overall prosperity, also leads to increased consumption of energy resources such as oil, gas, and petroleum products, as well as a rise in waste generation. As a result, the demand for effective environmental management and sustainable resource use continues to grow.

The importance of addressing environmental issues is reflected in the priorities of Uzbekistan's national development strategy. During the United Nations Climate Change Conference 2023 held on December 1, 2023, Shavkat Mirziyoyev emphasized environmental sustainability as one of the country's major priorities, highlighting the need to ensure that economic progress is accompanied by environmental protection. In addition, reducing air pollution and expanding green energy initiatives were identified as key priorities in Presidential Decree No. 158, issued on September 11, 2023.

This article examines the current state of environmental pollution in Uzbekistan based on official statistics and available data sources. Using methods of analysis and synthesis, scientific abstraction, induction, and deduction, the study compares Uzbekistan's situation with that of other countries. Through abstract-logical approaches, the article generalizes the findings and develops conclusions. Mathematical and statistical methods are used for calculations, while econometric modeling is applied to forecast future trends.

## LITERATURE REVIEW

Based on findings from the United Nations Environment Programme, every breath we take can introduce tiny particles into our lungs, hearts, and brains, causing numerous health issues. The most hazardous of these particles, known as PM2.5, are fine particles 2.5 microns or less in diameter, including soot, soil dust, and sulfates. In 2019, 99% of the global population lived in areas where the strictest 2021 air quality guideline levels of the World Health Organization were not met, including Uzbekistan [7,8].

In 2021, the WHO updated the PM2.5 annual mean air quality guideline to 5  $\mu\text{g}/\text{m}^3$ , indicating clean air, as few impacts are observed below this level [9]. This update halves the previous 2005 guideline of 10  $\mu\text{g}/\text{m}^3$ . To reach this target, the WHO also set a series of interim targets for areas with high pollution, enabling governments to develop achievable policies to reduce air pollution [7].

Although air pollution is a global issue, it disproportionately affects developing nations and vulnerable groups, such as women, children, and the elderly. In 2019, around four million people died from exposure to fine particulate outdoor air pollution, with the highest death rates in East Asia and Central Europe. Air pollution causes one in nine deaths worldwide and reduced global life expectancy by approximately one year in 2019. In Uzbekistan, 21% of deaths from ischemic heart disease are attributable to outdoor fine particles. The country is working to reduce air pollution but still faces challenges such as solid waste burning. Uzbekistan participates in the United Nations Economic and Social Commission for Asia and the Pacific Regional Action Programme on Air Pollution. The country's annual mean PM2.5 exposure is 35  $\mu\text{g}/\text{m}^3$ , seven times the WHO guideline, leading to 79 deaths per 100,000 people (26,749 total) in 2019. Fine particle pollution is a significant cause of death from stroke (25%), chronic obstructive pulmonary disease (21%), and ischemic heart disease (21%), and contributes to other illnesses such as tracheal, bronchus, and lung cancer (19%), type 2 diabetes (19%), lower respiratory infections (17%), and neonatal disorders (10%) [7,9].

Globally, air pollution is the largest environmental risk factor for premature death. While air pollution is linked to 20% of ischemic heart disease deaths worldwide, this figure rises to over 30% in the Middle East and North Africa. Children are particularly vulnerable due to their susceptibility and exposure, with 20% of newborn deaths globally attributed to air pollution [7,9]. Fine particle pollution primarily arises from human activities, such as burning fossil fuels for electricity generation, transportation, waste burning, agriculture, and industries such as chemical and mining [10,11]. Natural sources include volcanic eruptions, sea spray, soil dust, and lightning [7,12].

In developing countries, reliance on wood and solid fuels such as raw coal for cooking, heating, and lighting, as well as kerosene for lighting, increases household air pollution [13]. Residential pollution, mainly from cooking and heating using biomass, generating electricity from fossil fuels, and transportation, are the main human-made sources of fine particles globally. Windblown dust is also a significant source in parts of Africa and West Asia near deserts [7,14].



## RESEARCH METHODOLOGY

1. The methods of analysis and synthesis were used to evaluate the performance of sustainable energy within Uzbekistan's economy.
2. Scientific abstraction, induction, and deduction were employed to compare research results and identify similarities and differences.
3. The abstract-logical approach was applied to generalize the findings and formulate conclusions.
4. Mathematical and statistical methods were used for data processing, including ranking, scaling, registration, systematization, differentiation, grouping, and graphical representation.
5. Econometric modeling techniques were applied to identify correlations among variables and to develop forecasts for future trends.

## ANALYSIS AND RESULTS

The most serious illnesses associated with PM2.5 air pollution include stroke, heart disease, lung disease, lower respiratory infections such as pneumonia, and cancer. In addition, PM2.5 pollution contributes to other health conditions, including diabetes, impaired cognitive development in children, and mental health disorders.

There is a clear relationship between population growth and rising levels of air pollution. As the population increases, fuel consumption for cooking, electricity generation, and transportation also rises, thereby contributing to higher pollution levels. Population density is another important factor affecting pollution intensity. The Grossman-Krueger regression model provides an effective approach for measuring per capita air pollution by integrating these factors into a comprehensive analytical framework.

Several key statistical indicators are required to apply the Grossman-Krueger regression model for estimating pollution emissions per capita in Uzbekistan:

- Pollution data: detailed information on CO<sub>2</sub>, PM2.5, NO<sub>x</sub>, SO<sub>x</sub>, and other pollutants, measured in tons or kilograms per capita.
- Population data: the total population of Uzbekistan, measured annually or over a specific period.
- GDP data: Uzbekistan's total GDP and GDP per capita, as economic activity is closely associated with pollution levels.

According to statistics from the World Bank, Uzbekistan's population reached 36.2 million in 2023, while GDP amounted to 90.9 billion USD. GDP per capita was 2,510.1 USD, and life expectancy at birth reached 70.9 years. The country's GDP growth is projected to reach 5.3% in 2024.

The Grossman-Krueger regression model remains one of the main approaches in environmental economics, as it combines socioeconomic indicators and environmental regulations to estimate and forecast per capita pollution emissions.

$$P_i = \alpha + \beta_1 Y_i + \beta_2 Y_i^2 + \beta_3 Y_i^3 + \beta_4 \bar{Y}_i + \beta_5 \bar{Y}_i^2 + \beta_6 \bar{Y}_i^3 + \beta_7 X_i + \varepsilon_i \quad (1)$$

The equation (1) includes the following variables:  $\bar{Y}$  represents the average GDP per capita over the last three consecutive years; PPP refers to pollution measured by emissions per capita or pollutant concentration;  $Y$  represents GDP per capita, usually measured in PPP terms. The symbol  $i$  is an index for the country or monitoring station, while  $t$  is an index for time. The vector  $X$  includes additional explanatory variables, such as population density and, for concentration data, variables describing the location of the monitoring station. The term  $\varepsilon$  represents the error term [18,19].

According to research and analysis conducted by the United Nations Department of Economic and Social Affairs Population Division, the population of Uzbekistan is expected to continue growing in the coming decades, similar to other landlocked developing countries. However, the birth rate is projected to gradually decline, while life expectancy at birth is expected to increase [20]. This trend is associated with a growing emphasis on improving quality of life.

In addition, forecasts from the World Bank suggest that GDP growth is likely to continue under current geopolitical and economic conditions [2]. Therefore, both population density and GDP per capita are expected to increase gradually over time. These indicators will be used in applying the Grossman-Krueger regression model for estimating air pollution emissions (Table 1).



Table 1. Statistical indicators used in Grossman-Krueger regression model

year	Pollutants released into the atmosphere (thousand tons)	GDP at current prices per capita(min soums)	population density (1 sq. km. population corresponding to)	Population Republic of Uzbekistan (thousand)	pollutants (kg)/capita
	P	GDPCurP/cap	D	PI	E
2010	729	2.819023	62.4	28001.4	26.03441
2011	788.2	3.544662	64.9	29123.4	27.06415
2012	817.6	4.316984	65.8	29555.4	27.6633
2013	855.2	5.111484	66.8	29993.5	28.51284
2014	1162.1	6.127004	67.9	30492.8	38.11064
2015	975.1	7.135173	69.1	31022.5	31.43203
2016	1008.2	8.089294	70.3	31575.3	31.93002
2017	853.5	9.883918	71.5	32120.5	26.57182
2018	883.7	13.06442	72.7	32656.7	27.0603
2019	952.8	16.01878	74.1	33255.5	28.6509
2020	924.4	17.85906	75.5	33905.2	27.26425
2021	908.7	21.36715	77	34558.9	26.29424
2022	874	25.42061	78.6	35271.3	24.77935
2023	n/a	n/a	80.2	n/a	n/a
2024	n/a	n/a	82	n/a	n/a

Source: compiled by the authors [21]

From Table 1, with some algebra and using Excel's data analysis tools, derived that: There are 15 observations, with an  $R^2$  value of 0.94035 and an approximation error of 3.648 (indicating that the regression model captures the actual statistics). Moreover, since the F-statistic (15.7645) is greater than the critical value from the F-table (3.5005, with 5% error), the regression model is statistically significant. Therefore, it is possible to conclude that:

$$\alpha = 73.9404, \quad \beta_1 = 2.2233, \quad \beta_2 = 0.0583, \quad \beta_3 = -0.0064, \quad \beta_4 = 2.0944, \quad \beta_5 = -0.4671, \quad \beta_6 = 0.0201, \quad \beta_7 = -0.8601 \quad (2)$$

After replacing parameters (2) in formula (1) with actual values, scenario is:

$$P_{it} = 73.94 + 2.22Y_{it} + 0.06Y_{it}^2 - 0.006Y_{it}^3 + 2.09\bar{Y}_{it} - 0.47\bar{Y}_{it}^2 + +0.02\bar{Y}_{it}^3 - 0.86X_{it} \quad (3)$$

Based on regression model (3) its possible to calculate that :

1<sup>st</sup>: Increasing GDP per capita by 1% leads to a 1.3% increase in pollution per capita. This suggests a positive correlation between economic growth (as measured by GDP per capita) and pollution levels in the short run.

2<sup>nd</sup>: An increase in population density has been found to have a negative impact on overall pollution per capita.

3<sup>rd</sup>: There are concerns about the accuracy of regression analysis due to insufficient observations and statistical data. This can cast doubt on the robustness of the conclusions drawn from the analysis.

4<sup>th</sup>: There are several factors influencing pollution levels that could be either positive or negative. Positive factors include improved infrastructure for air cleaning and more effective management of garbage and pollutants. On the other hand, statistical biases or incomplete data can skew results and lead to inaccurate conclusions about the factors affecting pollution levels.

5<sup>th</sup>: Based on the Environmental Kuznets Curve (EKC) (4), the country has reached its "turning point income"-  $\tau$ , (5) and pollution emissions have declined.



$$\ln E_i = \alpha_i + \gamma_i + \beta_1 \ln Y_i + \beta_2 (\ln Y_i)^2 + \varepsilon_i \quad (4)$$

$$\tau = \exp(-0.5 \cdot \beta_1 / \beta_2) \quad (5)$$

Based on the data provided by official statistics [21], there is limited detailed information on specific pollution emissions such as CO<sub>2</sub>, PM<sub>2.5</sub>, NO<sub>x</sub>, and SO<sub>x</sub>. According to the global Air Quality Index and PM<sub>2.5</sub> air pollution data for June 27, 2024, Tashkent ranked as the 10th most polluted city in terms of air quality [22].

In 2019, Uzbekistan reported an average annual PM<sub>2.5</sub> concentration of 41.20 µg/m<sup>3</sup>, placing it within the higher range of the “unhealthy for sensitive groups” category, which is generally defined by PM<sub>2.5</sub> levels between 35.5 and 55.4 µg/m<sup>3</sup>. The main sources of pollution include older vehicles with less advanced emissions standards, factories and power plants, combustion of organic materials, and the environmental consequences of the drying of the Aral Sea. As the sea continues to recede, formerly submerged land is transformed into salt flats contaminated with hazardous chemicals and heavy metals, creating environmental challenges for both people and wildlife. During windstorms, particles from these salt flats can spread into the atmosphere [22,23].

It is evident that coal consumption has tripled over the past decade, while reported air pollution emissions have remained relatively stable [21]. In addition, other statistical indicators suggest that the use of personal vehicles has increased, and there are a number of waste disposal and burning sites across the country that require more efficient environmental management.

Statistical data on air pollution and its relationship with population density indicate a negative correlation: as population density increases, air quality tends to deteriorate. However, the available analysis and data also suggest that there may be certain limitations or inconsistencies in measuring the direct relationship between these variables.

## CONCLUSION AND RECOMMENDATIONS

Uzbekistan, including all of its regions, remains highly attractive for investment [24]. The country is also a popular destination for both foreign and domestic tourists due to its rich historical heritage, including cities such as Samarkand, Bukhara, Khiva, and Kokand [25]. In addition, Uzbekistan offers scenic mountain areas and strong potential for the development of digital and smart tourism [26].

In the era of the Fourth Industrial Revolution [27], Uzbekistan's young population has significant potential to contribute to the country's real GDP growth [28]. The population is projected to reach 40 million by the end of 2030. Uzbekistan is also open to foreign scientists and investors and is actively promoting the development of blockchain technologies. Furthermore, the country's equity and share market continues to expand.

The main priority is to ensure the wellbeing of the population, strengthen human capital efficiency, reduce external costs, and attract tourists, businesses, educational institutions for foreign students, and branches of international companies. Achieving these goals largely depends on maintaining a clean and healthy environment.

Although Uzbekistan is widely recognized for the cleanliness of its streets [29], the country continues to face challenges related to air pollution. These challenges can be addressed through greater investment in electric vehicles, solar panels, wind turbines, and nuclear power as sources of clean energy. In addition, installing modern air filtration systems and improving waste management and waste-burning practices are important measures for improving overall air quality.

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## IQTISODIYOT & TARAQQIYOT

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