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ARTICLE

Econometric Modeling and Forecasting of Regional Environmental Conditions and Public Health Issues in Uzbekistan: A Case Study of Navoi Region

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ABSTRACT

In this research work, the problems of connection between various harmful substances emitted into the atmosphere and population morbidity indicators were analyzed in the Navoi region, located in the industrialized and arid climate region of the Republic of Uzbekistan, in the Central Asian region. In today's globalization process, due to the rapid development of the industry, several problems related to the health of the population are also appearing, so it is more important than ever to pay serious attention to solving these problems. Item 11 of the UN Sustainable Development Goals is also dedicated to the sustainable development of cities, and it is especially emphasized that the people living in the cities of the Asian continent have a very low chance of breathing clean air. Issues such as a very thorough analysis of this situation, improving the environmental situation as much as possible, transitioning to a green economy as soon as possible, and strengthening the health of the population are more important. In the implementation of this study, using methods such as statistical

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data analysis, sociological survey, and econometric modeling with the help of R Studio software, an attempt was made to determine the correlation between various harmful substances released into the atmosphere and disease groups of the population. This study's conclusions show a direct relationship between the harmful substances released into the atmosphere and some types of population diseases in the industrialized region of Uzbekistan in Navoi, and their reduction by 2028 forecasts is presented. Decision-making organizations can use these results to prevent this situation from exacerbating.
Keywords: SDGs; Sustainable Cities and Communities; Econometric Modeling; Air Pollution; Navoi Region; ARIMA

1. Introduction

In today's globalization process, due to the rapid development of the industry, several problems related to the health of the population are also appearing, so it is more important than ever to pay serious attention to solving these problems [1]. Item 11 of the UN Sustainable Development Goals is also dedicated to the sustainable development of cities, and it is especially emphasized that the people living in the cities of the Asian continent have a very low chance of breathing clean air. Issues such as a very thorough analysis of this situation, improving the environmental situation as much as possible, transitioning to a green economy as soon as possible, and strengthening the health of the population are more important [2].

Monitoring and modeling of the current environmental situation is an important factor of sustainable environmental management. In the last years, researchers such as Muñiz and Sánchez [3], Lakner et al. [4], and Odekanle et al. [5] have demonstrated this importance. The country of Uzbekistan, which is located on the Asian continent, is located in the arid climate region—central Asia, and this land mainly consists of plains and lowlands up to 200–400 meters in relief [6]. Therefore, the environmental condition of the cities here and the health issues of the population living in them are very important.

In this research work, the ecological condition of the industrialized region of the Navoi, located in the arid climate in the center of Uzbekistan, and the forecast for the future based on econometric modeling of population health problems were considered.

2. Methodology

2.1. Study Area

As an administrative unit, the Navoi region occupies second place among the administrative units of the Republic of Uzbekistan (after the Republic of Karakalpakstan), but it is of great importance due to the high economic potential of the region. However, it should be noted that more than 80 percent of the area of the region corresponds to the desert zone (the area of the region is 111,000 km^2) (**Figure 1**). There are 7 cities and 58 towns in the region. Among the cities, the city of Navoi, which is considered an administrative center and was founded in 1958, and the cities of Zarafshan, which was founded in 1972 based on the Muruntov gold mine, specializing in the non-ferrous metallurgy industry, stand out (**Table 1**).

Table 1. General information about cities in the Navoi region.

Cities	The Year It Received the Status of a City	Population (Thousand People)
Navoi	1958	150611
Zarafshan	1972r	85636
Uchkuduk	1978r	30528
Kyziltepa	1979	12602
Nurata	1976	36014
Yangirabot	1996	18782
Gazgan	2019r	8945

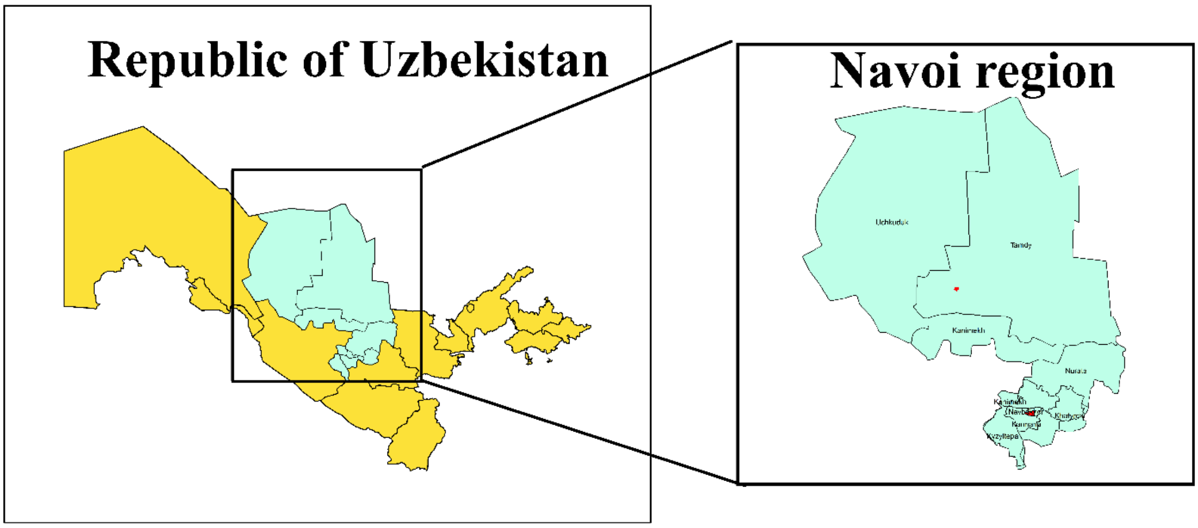

Figure 1. Study area.

2.2. Data Analysis

In conducting this study, a comprehensive methodological approach was employed, integrating statistical data analysis, sociological surveys, and advanced econometric modeling. Specifically, the Autoregressive Integrated Moving Average (ARIMA) method was applied using R Studio to analyze time-series data on atmospheric pollutant emissions and population morbidity rates. The ARIMA model was selected due to its robustness in capturing temporal dependencies and forecasting trends based on historical data. This approach facilitated the identification of significant correlations between the concentrations of harmful airborne substances and the prevalence of various disease groups. Additionally, diagnostic tests such as the Augmented Dickey-Fuller (ADF) test were conducted to assess stationarity, while model validation was performed using residual diagnostics and out-of-sample forecasting. The integration of these methods provided a statistically rigorous foundation for evaluating the long-term environmental and public health implications of air pollution in the studied regions.

2.3. Data Collection

In addressing specific socio-economic challenges, the role of econometric models in providing scientific justification is of paramount importance. Based on our observations and available statistical data, we have developed an econometric model for the Navoi region. The core objective of this model is to scientifically determine whether a correlation exists between various harmful substances emitted into the atmosphere and the prevalence of major disease groups within the population.

This model facilitates the forecasting of key indicators and assesses how changes in the volume of harmful substances released into the atmosphere—measured per ton—affect population morbidity rates. Its significance lies in providing insights into which factors should be prioritized when making policy decisions [7–9].

To begin, we conduct an econometric analysis of the relationship between the most prevalent diseases in the Navoi region and one of their potential influencing factors: the emission of harmful substances into the atmosphere. Additionally, we provide future projections based on this analysis. The econometric study utilizes a time series dataset spanning several years. Specifically, **Table 2** presents the most commonly observed diseases in the Navoi region from 2011 to 2022, while **Table 3** provides data on the volume of harmful gases emitted into the atmosphere during the same period.

Table 2. Incidence rate of main types of diseases in Navoi city.

Years	Diseases Related to Respiratory Organs	Digestive Diseases	Diseases of the Eye and Its Accessories	Diseases of the Blood and Blood-Forming Organs and the Immune System	Diseases of the Circulatory System	Diseases of the Nervous System
2011	160318	76433	23584	72378	21478	24573
2012	158045	75218	22174	70244	20110	23692
2013	156933	73355	20266	68571	19756	23048
2014	154433	72866	19580	67800	19201	22107
2015	152769	71720	19371	66247	18597	21789
2016	153828	72677	18414	64631	18237	21198
2017	149695	76997	18551	62739	18319	20737
2018	154154	76169	17928	62193	19267	20057
2019	124169	74703	14968	53270	17230	17337
2020	121850	53128	19675	44122	19892	14910
2021	112537	54618	20087	36970	19311	14846
2022	123990	98027	52761	43119	28299	18698

Note: The table data was compiled by the author based on the data of the Statistics Agency of the Republic of Uzbekistan.

Table 3. The number of harmful substances released into the atmosphere in the city of Navoi (in thousands of tons).

Years	Harmful Gases Released from Transport	Industrial Waste	Domestic Waste	Total Released Harmful Substances
2011	47738	46013	117.5	93 868,5
2012	48100	46103	117.4	94 320,4
2013	50011	46833	121.9	96 965,9
2014	51318	47074	122.7	98 514,7
2015	53911	47077	122.8	101 110,8
2016	56509	47438	124.6	104 071,6
2017	57749	48777	126.2	106 652,2
2018	58200	61358	128	119 686
2019	56000	49658	130.9	105 788,9
2020	44000	60612	133.5	104 745
2021	46600	57517	136.1	104 253,1
2022	38700	61277	138.4	100 115,4

3. Results and Discussion

Based on the above data, the harmful gases released into the atmosphere in the region of Navoi and the 6 most common types of diseases were examined based on econometric analyses to determine whether or not they are related to each other. These harmful gases and diseases determine the forecast values for the next years (until 2028).

In econometric analysis, the problem of multicollinearity of factors may arise when constructing multifactor regression equations, that is, cases of the high degree of linear correlation of factors. In such cases, the results of multifactor regression make the constructed model unreliable. To check the multicollinearity of the factors, a matrix of pairwise correlation coefficients is created for the factors, and through this, the degree of direct or inverse connection between the factors is determined[10].

Usually, all econometric problems can be handled using several computer programs. In particular, programs such as Stata, Minitab, and R Studio can solve econometric problems and display their solutions in graphs[10–13]. So, in our case, as a result of the harmful gases released into the atmosphere, it is natural that diseases that threaten the health of the population occur, based on this, for the region of Navoi, respectively, it is necessary to determine whether the harmful gases released into the atmosphere are inextricably linked with the 6 types of diseases that we have studied above. we can determine using program (R Studio) by creating a matrix of pairwise correlation coefficients (**Table 4**).

As we mentioned above, the density or strength of the connection between variables in the studied events and processes is estimated by r_{xy} - linear pair correlation coefficient. For linear regression, thxiao'yue value of the correlation coefficient $-1 \leq r_{xy} \leq 1$ lies in the interval[14–17].

Table 4. Pairwise correlation matrix between harmful substances and diseases in Navoi city.

	Harmful Gases Released from Transport	Industrial Waste	Domestic Waste	Diseases Related to Respiratory Organs	Digestive Diseases	Diseases of the Eye and Its Accessories	Diseases of the Blood and Blood-Forming Organs and the Immune System	Diseases of the Circulatory System	Diseases of the Nervous System
Harmful gases released from transport	1.00	–							
Industrial waste	–0.39	1.00							
Domestic waste	–0.37	0.83	1.00						
Diseases related to respiratory organs	0.46	–0.66	–0.91	1.00					
Digestive diseases	–0.07	–0.07	–0.06	0.28	1.00				
Diseases of the eye and its accessories	–0.72	0.41	0.42	–0.27	0.67	1.00			
Diseases of the blood and blood-forming organs and the immune system	0.49	–0.78	–0.71	0.97	0.26	–0.35	1.00		
Diseases of the circulatory system	–0.79	0.44	0.36	–0.22	0.61	0.98	–0.31	1.00	
Diseases of the nervous system	0.24	–0.74	–0.90	0.94	0.46	–0.04	0.94	–0.004	1.00

Note: Factors marked in green are correlated, while those in red are unrelated.

So, let's look at the correlation matrix that we created. There is a solid, medium and weak direct and inverse relationship between the 6 most common types of diseases in the Navoi region and the harmful gases released into the atmosphere in the Navoi region. There are connections. In particular, the strong case of inverse correlation means that: If a factor continues in its current state, it means that the factor that is inversely related to this factor also continues in parallel. From **Table 3**, we can see an inverse relationship between diseases related to respiratory organs and harmful substances released into the atmosphere from domestic waste at a value equal to (–0.91). Also, there is a strong (–0.90) inverse relationship between diseases of the nervous system and harmful substances from household waste. The values of the rest of the inversely related elements of the constructed correlation matrix can be considered almost insignificant due to their density below the average, which, after performing our forecasting exercise, can lead to very large deviations from the current state, that is, unreliable forecasts. In addition, all the remaining elements of the matrix, which showed a correct connection, are only between diseases, so we can consider them as unimportant because the possibility of the occurrence of other diseases due to one disease is an inevitable phenomenon (see the **Table 5**).

Table 5. Interpretation of the scale of correlational connection.

Degree of Correlation	Interpretation
0.91 to 1.00 (–0.90 to –1.00)	Very strong direct (inverse) correlation;
0.71 to 0.90 (–0.70 to –0.90)	Strong direct (inverse) correlation;
0.51 to 0.70 (–0.50 to –0.70)	Average direct (inverse) correlation;
0.31 to 0.50 (–0.31 to –0.50)	Weak direct (inverse) correlation;
0.00 to 0.30 (0.00 to –0.30)	Insignificant direct (inverse) correlation;

With the 2 inversely related factors that we have determined in this way, we will see the dynamics created in the previously observed years (**Figure 1**), the appearance of the model corresponding to the dynamics, and the forecast for the next year from 2023 to 2028.

From 2011 to 2022, domestic waste steadily increased from 117.5 to 138.4, while respiratory disease cases declined from 160,318 to 123,990. This suggests that rising waste levels did not directly lead to an increase in respiratory diseases. Possible reasons for this include improved waste management systems and better healthcare services. Additionally, air pollution control measures may have helped reduce respiratory illnesses despite growing waste production. A sharp decline in disease cases between 2019 and 2021 could be linked to COVID-19 restrictions, such as lockdowns and mask-wearing. The slight increase in cases in 2022 may indicate a return to pre-pandemic conditions. Improvements in medical treatment and preventive measures also likely contributed to the overall decrease in respiratory diseases. While waste production has grown, efforts to mitigate environmental pollution may have balanced its impact (**Table 6**).

Table 6. Domestic Waste and Respiratoriy organs deseases in Navoi Region.

Years	Domestic Waste	Diseases Related to Respiratory Organs
2011	117.5	160318
2012	117.4	158045
2013	121.9	156933
2014	122.7	154433
2015	122.8	152769
2016	124.6	153828
2017	126.2	149695
2018	128	154154
2019	130.9	124169
2020	133.5	121850
2021	136.1	112537
2022	138.4	123990

R^2, shown in **Figure 2**, is a coefficient of determination, and it is a value that shows the degree of correlation between two given factors, i.e., diseases related to respiratory organs and harmful substances from household waste. This value of the coefficient of determination shows that the variation of the resulting *y* is approximately 82.3 percent dependent on the variation of the sign of the *x*-factor. Also, we can see from **Figure 1** that household waste is increasing in 2011–2022, and on the contrary, respiratory diseases are decreasing in 2011–2022.

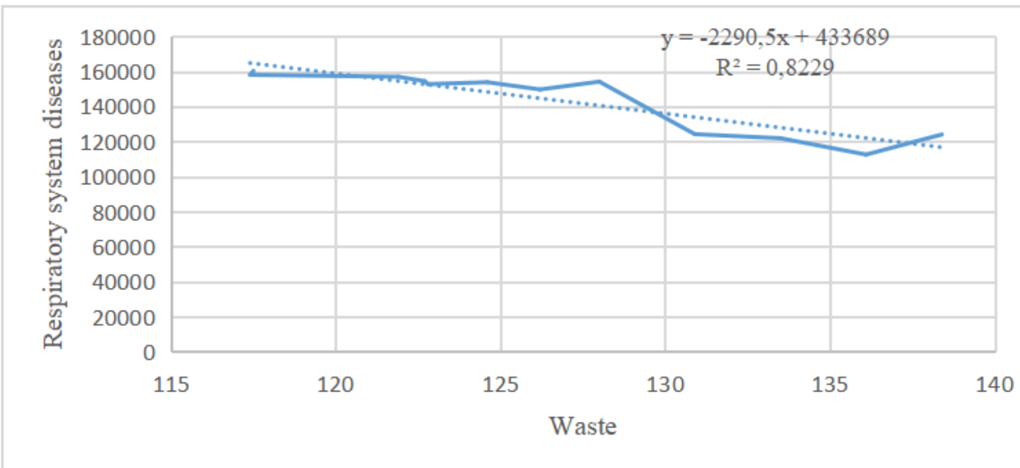

Figure 2. A dynamic connection between the respiratory diseases and waste products.

In addition, the one-factor regression equation $y = -2290.5 * x + 433689$ was also calculated using the Excel program.

here: *x - refers to harmful substances from household waste (free variable)*

y - refers to respiratory problems (involuntary variable)

At the same time, the dynamics of the relationship between *diseases related to respiratory organs* in the Navoi region and *harmful substances released into the atmosphere* in the Navoi region in 2011–2022, its statistical significance, and errors are shown in the Excel program. We will check by creating a multi-factor regression equation $y = a + b_1x_1 + b_2x_2 + b_3x_3$ and find out whether this multi-factor regression equation is important or not to get the forecast for 2023–2028 for *diseases related to respiratory organs* in the Navoi region and 3 categories of factors.

The order of factors here is as follows:

- x_1 - *Harmful gases released from transport;*
- x_2 - *Harmful gases from industry;*
- x_3 - *Harmful substances from household waste;*

Parameters *a*, b_1, b_2 and b_3 are coefficients that indicate the level of factors. The results of the Excel program show that the multifactor regression equation is equal to *y* =

*431304.4 + 0.49792311 + 0.919135*x_2*–2845.86*x_3.

The **Table 7** presents the coefficients of a multifactorial function analyzing the relationship between respiratory diseases and three categories of harmful emissions. The intercept value (a) is 431,304.4, with a standard error of 58,181.7, indicating a significant base level of respiratory diseases. The coefficient for harmful gases from transport (b_1) is 0.497923, showing a weak positive relationship with respiratory diseases. The industrial waste coefficient (b_2) is 0.919135, suggesting a stronger influence on respiratory illnesses. The domestic waste coefficient (b_3) is 2845.86, with a significant negative t-value of −5.0196, indicating a notable inverse effect. The p-value for domestic waste is 0.001027, showing strong statistical significance. The confidence intervals for transport and industrial waste include zero, implying their effects might not be statistically significant. However, the domestic waste confidence interval does not include zero, confirming its significant impact. The negative coefficient for domestic waste could indicate improved waste management reducing health risks.

Table 7. Coefficients of the multifactorial function between respiratory diseases and 3 categories of factors.

	Coefficient	Standard Error	Student's T-Test Real	Table Value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
a	431304.4	58181.7	7.613059	7.52E–05	297137.2	565471.6	297137.2	565471.6
Harmful gases released from transport; b_1	0.497923	0.390864	1.273905	0.238458	–0.40341	1.399257	–0.40341	1.399257
Industrial waste; b_2	0.919135	0.608131	1.51141	0.169132	–0.48322	2.321487	–0.48322	2.321487
Domestic waste; b_3	2845.86	566.9491	–5.0196	0.001027	–4153.25	–1538.47	–4153.25	–1538.47

Note: In order for the results of the t-test to be statistically significant, its actual values must be greater than the table values.

As can be seen from **Table 5**, the actual values of the Student's t-test of unknown parameters are greater than their table values, except for parameter b_3. Therefore, it is important to check this process for the coming years 2023–2028.

We aim to construct a 3-factor (Transportation, Industry and Household) regression equation of this *respiratory disease* trend for 2023–2028 and its statistical significance and reliability tests. It consists of predicting and drawing conclusions.

The **Table 8** presents data on domestic waste and diseases of the nervous system from 2011 to 2022. Over this period, domestic waste increased consistently from 117.5 in 2011 to 138.4 in 2022. Meanwhile, cases of nervous system diseases showed a decreasing trend from 24,573 in 2011 to 14,846 in 2021, before rising again to 18,698 in 2022. This suggests that despite the rise in domestic waste, nervous system diseases generally declined. The sharp drop in cases between 2019 and 2021 could be related to external factors such as healthcare improvements or pandemic-related changes. However, the increase in 2022 may indicate a reversal of that trend. The most significant decline occurred between 2018 and 2020, where cases fell from 20,057 to 14,910. The potential impact of pollution from domestic waste on neurological health is unclear based on this data alone.

Table 8. Diseases of the nervous system and household waste in the cross-section of the years.

Years	Domestic Waste	Diseases of the Nervous System
2011	117.5	24573
2012	117.4	23692
2013	121.9	23048
2014	122.7	22107
2015	122.8	21789
2016	124.6	21198
2017	126.2	20737
2018	128	20057
2019	130.9	17337
2020	133.5	14910
2021	136.1	14846
2022	138.4	18698

The **Figure 3** illustrates the correlation between household waste and diseases of the nervous system. The trend line suggests a negative relationship, where an increase in waste is associated with a decline in nervous system disease cases. The regression equation $y = -419.76x + 73419y$ indicates that for each unit increase in waste, nervous system diseases decrease by approximately 419 cases. The coefficient of determination ($R^2 = 0.8053$) suggests a strong correlation, meaning about 80.53% of the variation in nervous system diseases can be explained by changes in waste levels. Initially, the number of nervous system diseases declined as waste levels increased, showing a downward trend. However, in the later years, there is a slight upward deviation from the trend, indicating a potential shift in the relationship. The downward trend may suggest improved waste management or environmental policies that helped reduce neurological health issues. The increase in cases towards the end of the period could be influenced by other external factors like pollution, stress, or healthcare accessibility. Despite the strong correlation, causation cannot be confirmed without further research. Additional studies incorporating pollution levels and healthcare improvements would provide a clearer understanding of these trends [18].

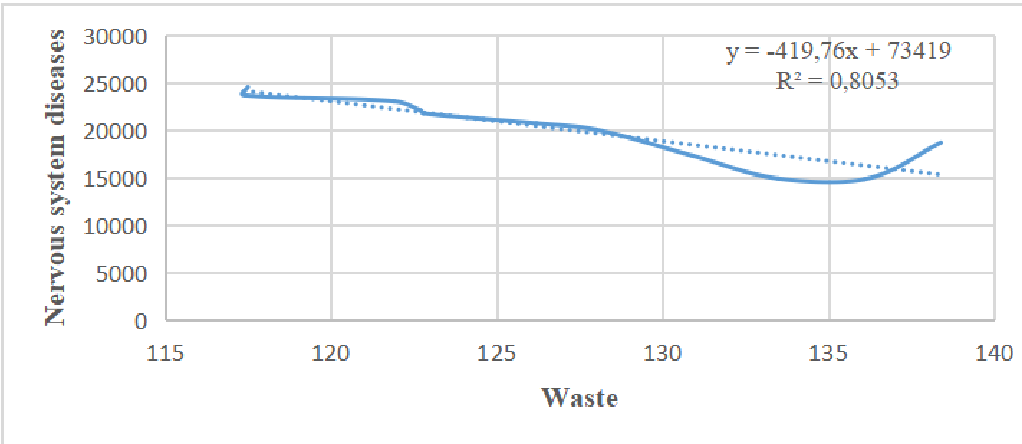

Figure 3. Correlation between diseases of the nervous system and household waste.

If we analyze **Figure 2**, the coefficient of determination shows 0.8053, which means that there is a correlation between 80% of the factors.

The linear regression model is $y = -419.76 * x + 73419$. In general, there was an increase in *household waste* in 2011–2022, and on the contrary, a decrease in *diseases of the nervous system* in 2011–2022. If we make a multi-factor function table using the SPSS program, as we checked above, the coefficients of a regression model analyzing the impact of different environmental factors on a dependent variable, likely related to health (**Table 9**). The intercept is 78,653.61 with a significant t-value, indicating a strong baseline effect. Harmful gases from transport have a negative coefficient (−0.05694) but are not statistically significant, as the p-value is 0.537209. Industrial waste shows an almost negligible effect (0.00028) with a very high p-value (0.998423), suggesting no significant influence. Domestic waste has a significant negative coefficient (−438.394) with a low p-value (0.009064), indicating a strong inverse relationship.

Table 9. Coefficients of the multifactor function between nervous system diseases and 3 categories of factors.

	Coefficients	Standard Error	Student's T-Test Real	Table Value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
a	78653.61	13147.8	5.982264	0.00033	48334.73	108972.5	48334.73	108972.5
Harmful gases released from transport; b_1	–0.05694	0.088327	–0.64463	0.537209	–0.26062	0.146744	–0.26062	0.146744
Industrial waste; b_2	0.00028	0.137424	0.00204	0.998423	–0.31662	0.317181	–0.31662	0.317181
Domestic waste b_3	–438.394	128.1182	–3.42179	0.009064	–733.835	–142.953	–733.835	–142.953

Note: *For the t-test results to be statistically significant, its actual values must be greater than the table values.*

As can be seen from **Table 7**, the actual values of the t-test performed on the parameters of the multivariate regression equation are almost less than the 95% critical value (table), which means that: between *nervous system diseases* and *3 categories of factors* Obtaining the forecast results for 2023–2028 is not statistically meaningful.

Therefore, we will continue the process only by forecasting the future cases of *diseases related to respiratory organs* and *harmful substances* released from household waste at the level of the Navoi region. As we mentioned above, the forecast results of observations given by time series for the coming years can be obtained using computer programs in several different models. Time series obtained using observations satisfy the stationarity property in most cases. Such time series have non-random components that depend on time. If the random residuals of a time series form a stationary series, then the time series forms a non-stationary series. The integrated autoregression and moving average (Autoregressive Integrated Moving Average - ARIMA) model is used to describe such a series [19, 20]. ARIMA models allow integrated time series modelling. In forecasting the total values of harmful gases and diseases released into the atmosphere in the territory of Navoi region with the ARIMA (*p,d,q*) model, *p* is the autoregression procedure of past periods (years), *d* is the changed value (difference of harmful gases and diseases or first difference procedure), *q* is the average represents the sliding order. Since the values and types of the factors differ by year, we use different forms of ARIMA (*p,d,q*) models. Using this ARIMA model, we get the best ARIMA models that correspond to our expected forecasts using the R Studio program (**Table 10**).

Table 10. Econometric models used in forecasting.

№	Types of Harmful Substances and Diseases	The Type of Model Selected for the Forecast
1	Harmful gases from transport	ARIMA(1,0,0)
2	Harmful substances from household waste	ARIMA(1,1,0)
3	Harmful substances from industrial waste	ARIMA(0,1,0)
4	Diseases related to respiratory organs	ARIMA(0,1,0)

Note: *ARIMA models selected for forecasting in* ***Table*** *7 were chosen as the best model based on the data in the given factors using R studio software).*

In the models proposed for forecasting harmful substances and diseases in the Navoi region, the maximum likelihood estimation (log-likelihood), Akaika (AIC), and Bayes (BIC) criteria were used. These criteria were used to select models with the least error in forecasting harmful substances and diseases in the Navoi region (**Table 11**).

Table 11. Statistical criteria for evaluating the quality of econometric models used in the forecasting of harmful substances and diseases in the city of Navoi.

№	Types of Harmful Substances and Diseases	Model	Log Likelihood	AIC	AICc	BIC
1	Harmful gases from transport	ARIMA(1,0,0)	–117.94	241.87	244.87	243.33
2	Harmful substances from household waste	ARIMA(1,1,0)	–18.15	40.3	41.8	41.09
3	Harmful substances from industrial waste	ARIMA(0,1,0)	–107.08	220.15	223.58	221.35
4	Diseases related to respiratory organs	ARIMA(0,1,0)	–109.74	221.48	221.92	221.87

So, based on the statistical criteria for evaluating the quality of the econometric models obtained in **Table 9** above, the results of the lower, middle, and upper forecasts of diseases related to respiratory organs in the Navoi region in the 95 per cent confidence interval for the years 2023 and 2028 are shown in **Table 12** below.

Table 12. Respiratory diseases in Navoi region.

Years	Lower	Medium	High
2011		160318	
2012		158045	
2013		156933	

Table 12. *Cont.*

Years	Lower	Medium	High
2014		154433	
2015		152769	
2016		153828	
2017		149695	
2018		154154	
2019		124169	
2020		121850	
2021		112537	
2022		123990	
2023		116150	
2024	93277	111933	134319
2025	89763	107716	129259
2026	86249	103499	124198
2027	82735	99282	119138
2028	79221	95065	114078

In **Table 10**, dynamic expectations for respiratory diseases in Navoi Region are presented in **Figure 4** below:

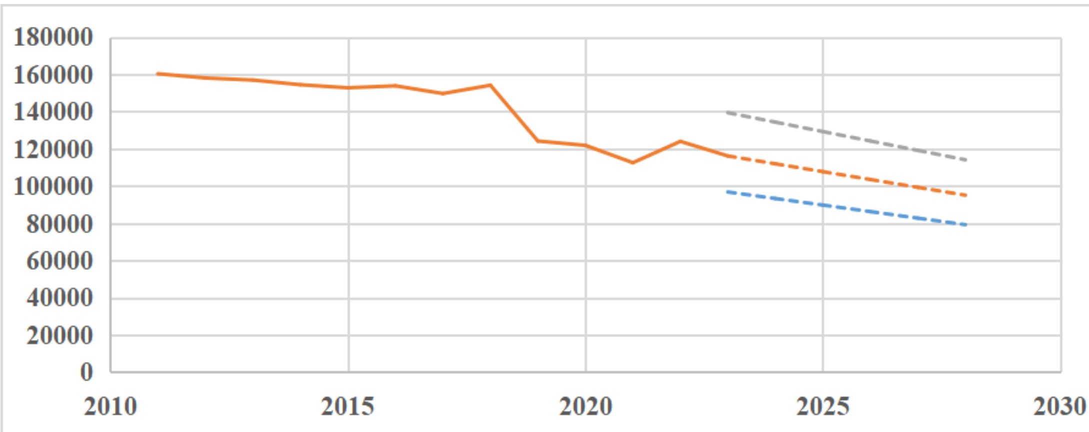

Figure 4. Prognosis graph of diseases related to respiratory organs in the Navoi region.

From the forecasts obtained for respiratory diseases in the Navoi region, we can see that the average number of respiratory diseases in 2023 is expected to be 116,150. This indicator is expected to decrease to an average of 95,065 by 2028. The multifactorial regression of how these disease values are related to 3 categories of harmful gases and their joint forecast dynamics in the coming years 2023–2028, approximation errors we can show the reliability of the parameters by constructing the equation and checking with some criteria such as Student's t, Fisher's F. For this, we need forecasts for the next 2023–2028 years for 3 categories of harmful gases.

We can see the forecast results of 3 categories of harmful substances released into the atmosphere in the Navoi region and the approximate graphs created by them in **Table 11** and **Figures 4**, **5**, and **6** respectively.

In **Table 13** below, the dynamic expectations for the forecasts obtained for harmful gases released into the atmosphere in the Navoi region are presented in **Figures 4**, **5**, **6**, and **7**, respectively. From **Table 13**, we can see that the forecast results obtained for the years 2024–2028 generally do not have significant differences compared to the values of previous years, and to what extent these forecast results are related to diseases related to respiratory organs in Navoi region can be checked to see that it is statistically significant.

Table 13. 3 types of harmful waste released into the atmosphere in the Navoi region.

Years	Harmful Gases Released from Transport			Industrial Waste			Domestic Waste		
	Lower	Medium	High	Lower	Medium	High	Lower	Medium	High
2011		47738			46013			117.5	
2012		48100			46103			117.4	
2013		50011			46833			121.9	
2014		51318			47074			122.7	
2015		53911			47077			122.8	
2016		56509			47438			124.6	
2017		57749			48777			126.2	
2018		58200			61358			128	
2019		56000			49658			130.9	
2020		44000			60612			133.5	
2021		46600			57517			136.1	
2022		38700			61277			138.4	
2023		41361			58816			140.3	
2024	31751	43295	54838	50539	60427	70314	138.5	142.2	145.9
2025	32148	44699	57251	47122	59372	71623	139.6	144.1	148.6
2026	32667	45720	58772	46973	60063	73152	140.8	146.0	151.2
2027	33152	46461	59770	45072	59611	74149	142.1	147.9	153.7
2028	33557	46999	60442	44465	59906	75348	143.5	149.8	156.1

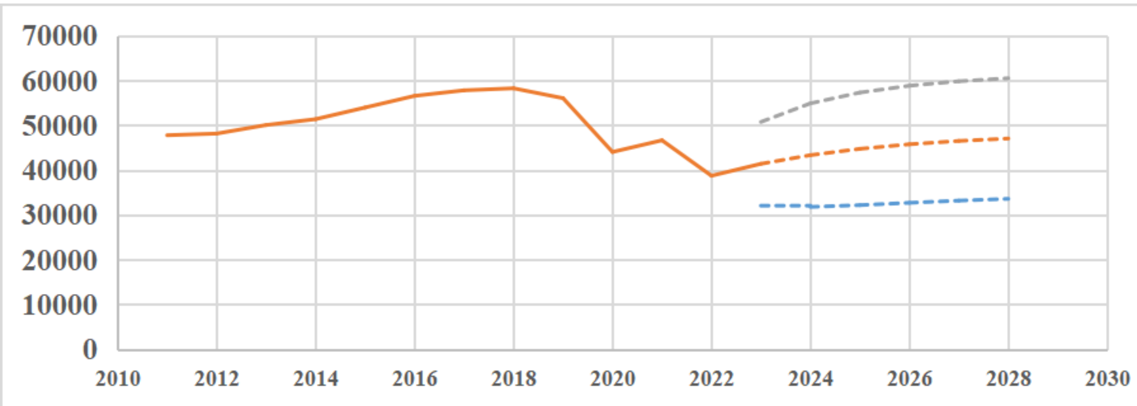

Figure 5. Forecast of harmful gases released from transport in Navoi region (in tons).

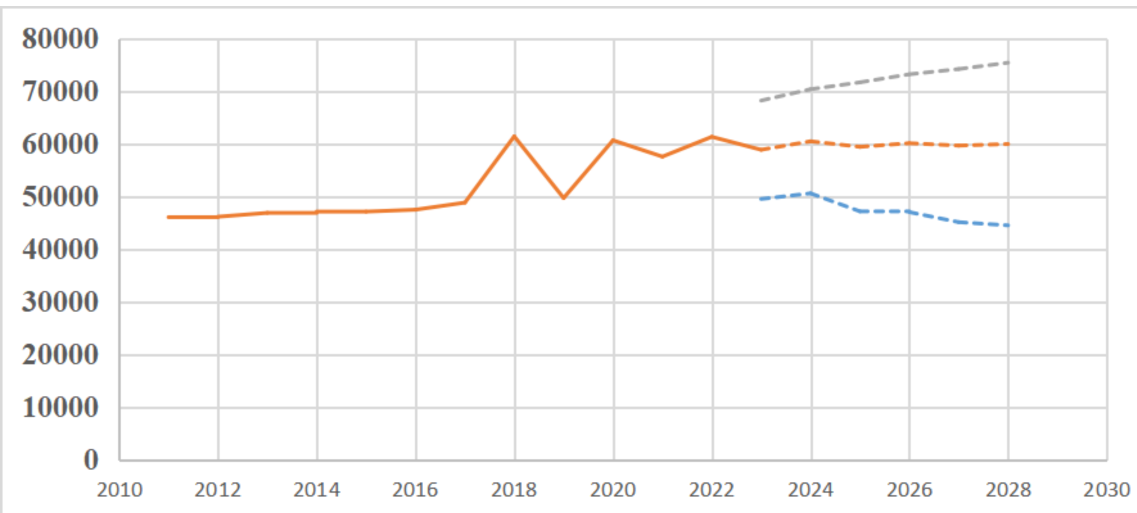

Figure 6. Forecast of harmful gases released from industry in Navoi region (in tons).

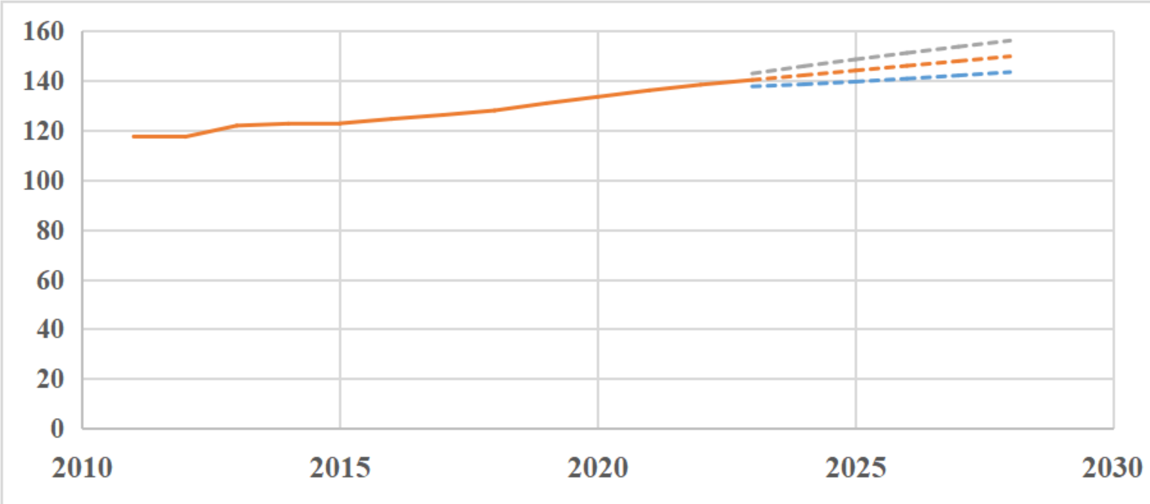

Figure 7. Forecast of harmful substances released from household waste in Navoi region (in tons).

As we noted during our econometric analysis, using the forecast results obtained above, **Tables 12** and **13** show the relationship between diseases related to respiratory organs in the Navoi region and harmful substances released into the atmosphere in the Navoi region in the years 2023–2028. We check the dynamics of disease, its statistical significance and errors by creating a multi-factor regression equation in the form of $y = a + b_1x_1 + b_2x_2 + b_3x_3$ in the Excel program and make a general conclusion for diseases in the Navoi region. The order of factors here is as follows:

x_1 - *Harmful gases released from transport;*

x_2 - *Harmful gases from industry;*

x_3 - *Harmful substances from household waste;*

Parameters a, b_1, b_2 and b_3 are coefficients that indicate the level of factors.

If we look at **Table 14**, we can see the rows where the $y = a + b_1x_1 + b_2x_2 + b_3x_3$ values of this 3-factor regression equation in the original state y_i and $\hat{y}_{x_i}$ in the post-projected state and their absolute differences are calculated. The predicted values of the parameters in this equation are given in **Table 13**, and we can get the following form by replacing them with the regression equation.

$$\hat{y}_x = 384428.6 + 0.426024 \cdot x_1 + 0.561727 \cdot x_2 \\ -2295.3 \cdot x_3 \quad (1)$$

The criteria for the statistical significance of this Equation (1) and its coefficients can be explained as follows. The average error of approximation calculated in **Table 15** means the average deviation of the calculated values of the resulting regression equation from their true values, and it should not be statistically significant greater than 10%. In our accounting books, this indicator is 0.17%, which means that the model is built reliably. In addition, the F-test method calculated in **Table 12** is one of the methods for evaluating the quality of the regression equation. Usually, this method consists of testing the H_0 hypothesis that the regression equation and the link density indicator are not statistically significant. For this, the table F_{table} values of F_{real} and Fisher-criterion are compared. If $F_{real} > F_{table}$, the hypothesis H_0 is rejected and the regression is recognized as having statistical significance or vice versa. This F-test method shows a very good result for our 3-factor regression equation in **Table 14**, and we can assume that our model is statistically significant.

In addition, we can see that the Student's t-test, which evaluates the quality of the coefficients of our regression equation compiled in **Table 15**, is greater than the values of the critical table, except for the household waste factor (see **Figure 8**).

Table 14. Forecasting and Aproximation Standart Error of factors.

Years Observed	Diseases Related to Respiratory Organs; y_i	Predicted Respiratory Diseases with Mean Error of Approximation; $\hat{y}_{x_i}$	$\lvert y_i - \hat{y}_{x_i} \rvert$
2011	160318	160915	597
2012	158045	161349	3304
2013	156933	152244	4689
2014	154433	151100	3333
2015	152769	151977	792
2016	153828	149155	4673
2017	149695	146763	2932
2018	154154	149891	4263
2019	124169	135725	11556
2020	121850	130798	8948
2021	112537	124199	11662
2022	123990	117667	6323
2023	116150	113057	3093
2024	111933	110425	1508
2025	107716	106069	1647
2026	103499	102531	968
2027	99282	98232	1050
2028	95065	94266	799
number of observations: n	*Total:* y_i	*Mean error of approximation %* $\overline{A} = \frac{1}{n} \sum_{i=1}^{n} \lvert \frac{y_i - \hat{y}_i}{y_i} \rvert \cdot 100\%$	*Total:* $\lvert y_i - \hat{y}_{x_i} \rvert$
18	2356366	0.17%	72137
Fisher (F) – test $F_{kq} = \frac{r_{xy}^2}{1-r_{xy}^2} * \frac{n-m-1}{m}$; *m* is the number of factors, *n* is the number of observations		F_{kh} = The critical table value of the F test	
82.93		$3.74 \cdot 10^{-9}$	

Table 15. Average deviation of the calculated values of the resulting regression equation.

	Coefficients	Standard Error	Student's T-Test Real	Table Value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
a	384428.6	32001.85	12.0127	9.23E–09	315791.5	453065.7	315791.5	453065.7
Harmful gases released from transport; b_1	0.426024	0.306892	1.38819	0.186774	–0.23219	1.084241	–0.23219	1.084241
Industrial waste; b_2	0.561727	0.430337	1.305321	0.21283	–0.36125	1.484708	–0.36125	1.484708
Domestic waste; b_3	–2295.3	260.3533	–8.81611	4.34E–07	–2853.71	–1736.9	–2853.71	–1736.9

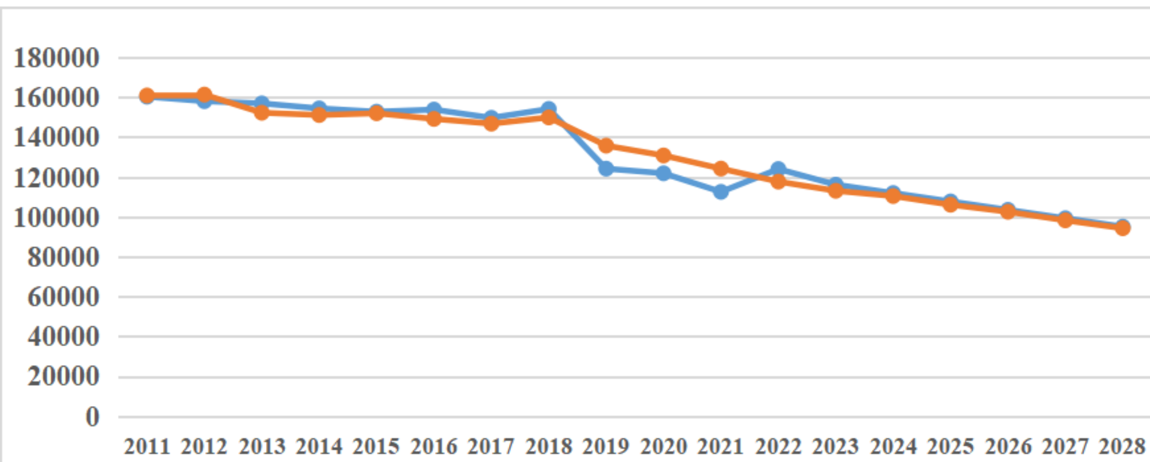

Figure 8. The dynamics of 3 types of mass affect the occurrence of diseases related to respiratory diseases in the Navoi region.

4. Conclusions

In summary, the multivariate regression analysis reveals that the x_1 factor—representing *harmful gases emitted from transportation*—has a significant impact on *respiratory diseases*, with each unit increase in emissions leading to an approximate 0.43% rise in cases. Similarly, the x_2 factor, which accounts for harmful *substances emitted from industrial sources*, is associated with an approximate 0.56% increase in *respiratory diseases* per unit of emission.

However, it is important to highlight that the x_3 factor does not meet the statistical significance threshold, as its t-statistic falls below the critical value from the t-distribution table. This indicates that x_3 does not have a meaningful contribution within the model under the given dataset and conditions. Consequently, the x_3 factor should not be considered a reliable predictor of respiratory diseases in this analysis.

5. Proposed Solutions

- Implement stricter emission controls for transportation: Given the significant impact of respiratory diseases, policies aimed at reducing harmful gas emissions from vehicles should be prioritized. This could include promoting electric vehicles, improving public transportation infrastructure, and setting stricter emission standards for fuel and engines.
- Strengthen regulations on industrial emissions: Since is linked to a notable increase in respiratory diseases, enforcing stricter industrial air quality standards and encouraging the adoption of cleaner technologies is critical. Incentives for industries to reduce emissions and penalties for non-compliance can further support this effort.
- Reevaluate the role of and improve data quality: The lack of statistical significance suggests the need for further investigation. Collecting more comprehensive and high-quality data or examining potential confounding variables may provide additional insights into its potential impact on respiratory health.
- Promote public awareness and health monitoring: Educating communities about the health risks associated with air pollution and encouraging regular health check-ups can help mitigate the impact of emissions. Initiatives to monitor air quality and disseminate real-time information may also empower individuals to take protective measures.

Author Contributions

Conceptualization, N.L. and S.C.; methodology N.K.; software S.C.; validation S.C. and N.L.; formal analysis N.M.; investigation I.K.; resources N.M. and I.K.; data curation S.D.; writing—original draft preparation N.K. and N.L.; writing—review and editing N.L.; visualization S.D. and S.C.; supervision S.A. and N.K.; project administration N.M.; funding acquisition N.L. All authors have read and agreed to the published version of the manuscript.

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Informed Consent Statement

Not applicable.

Data Availability Statement

The authors declare that data will be available on a request.

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Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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